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University of Southampton

Faculty of Physical Sciences and Engineering

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How Technology Can Help Visually Impaired Young Adults Participate in Physical Activity

by

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Abstract

Faculty of Physical Sciences and Engineering

School of Electronics and Computer Science

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Designing new technologies to address daily activities' issues for visually impaired users can be challenging for design and software development teams. Designers and developers often do not know what design approach to undertake. There is currently no guidance on how to design, test, and evaluate design solutions considering the needs of visually impaired users as well as the application of accessibility, usability, and user experience early in the mobile interaction design. The aim of this research was to identify better ways to design a solution to aid visually impaired young adults to seek information and social support to get more active. This aim was addressed by a practical approach to conduct and learn iteratively from the design process and through the research questions. The research questions investigated how relevant design guidelines can be developed that are appropriate for designers and developers who accessibility experts are not. This applied Design Thinking and Agile UX methodologies as the main approaches to guide the design and development of a minimum viable product for a mobile application. This involved adapting methods and techniques for prototyping, testing, user evaluation, and interview with visually impaired young adults, sports coaches, guides, and volunteers to gain insights from their perspectives about the physical activity experience of visually impaired young adults and the service provision. This informed the app features to improve accessibility, usability, and user experience in the design requirements. An affinity diagram was used in the triangulation analysis of the findings, which contributed to the development of the design guidance for creating mobile apps for visually impaired users. The guidance received positive evaluations from designers, developers, and accessibility specialists, along with valuable suggestions for further improvement. The key findings address what designers and developers need to know about design approaches and considerations for mobile application for visually impaired users. Building a minimum viable product and applying Design Thinking as a mindset throughout the design process enabled a deeper understanding of the needs of visually impaired young adults and the mobile app's context of use. This approach not only guides the development of accessible mobile applications but also helps enhance user experiences by addressing key challenges and exploring potential new features.

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Research Thesis: Declaration of Authorship

Print name: Geane De Almeida Fontinele Zadra

Title of thesis: How Technology Can Help Visually Impaired Young Adults Participate in Physical Activity

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University.
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
3. Where I have consulted the published work of others, this is always clearly attributed.
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
5. I have acknowledged all main sources of help.
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.
7. None of this work has been published before submission.

Signature: Date: 20/01/2025

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Definitions and Abbreviations

BBC.....	British public service broadcaster
AHFP.....	accessible high-fidelity prototype
AMFP	accessible mid-fidelity prototype
Alt text.....	alternative text
API	Application Programming Interface
APK.....	Android Application Package
BCW	Behaviour Change Wheel
BDUF.....	Big Design Up Front
COM-B	Capability, Opportunity, Motivation, and Behaviour
COM-B-Qv1.....	COM-B Self-Evaluation Questionnaire
COVID-19	Coronavirus Disease 2019
DT.....	Design Thinking
EU	European Parliament
GPAQ.....	Global Physical Activity Questionnaire
GPS	Global Positioning System
HCI	Human and Computer Interaction
DT.....	Design Thinking
HCI	Human and Computer Interaction
HTML.....	HyperText Markup Language
ICD 11	International Classification of Diseases
IEEE.....	Institute of Electrical and Electronics Engineers
IPAQ.....	International Physical Activity Questionnaire
ISO.....	International Organization for Standardization
JSON	JavaScript Object Notation
LDUF	Little Design Up Front
MET	Metabolic Equivalent of Task

Definitions and Abbreviations

MSc.....	Master of Sciences
MVP.....	Minimum viable product
NHS.....	National Health Service
NoSQL	Not only Structured Query Language
NVDA	Nonvisual Desktop Access open-source screen reader
ONS	Office for National Statistics in the United Kingdom
PE	Physical education
RNIB	Royal National Institute of Blind People
SRQ1	Sub-research question 1
SRQ2	Sub-research question 2
SRQ3	Sub-research question 3
SRQs	Sub-research questions
SUS	System Usability Scale
UCD	User Centred Design
UI	User Interface
UK	United Kingdom
URL	Uniform Resource Locator
UX.....	User experience
VI	Visually impaired
W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WAVE	Web Accessibility Evaluation tool
WCAG	Web Content Accessibility Guidelines
WCAG-EM	Website Accessibility Conformance Evaluation Methodology
WHO	World Health Organisation
XP	Extreme Programming

Chapter 1 Introduction

Information and communication technologies - ICT are essential to allow communication, work, leisure, education, socialising and it is important to make these technologies accessible and usable to everyone for daily activities (Paiva et al. 2021). The EN 301549 European standard supports this by providing a framework for accessibility requirements for ICT products and services. It aims to ensure that ICT (e.g., software, hardware, websites and mobile applications) are accessible to all users. This is relevant in technology development, given that 16 million disabled people in the United Kingdom could benefit from the daily use of technology that accommodates their needs (Scope 2023).

It is well recognised across several studies the importance to include the different users' needs for technology (Savidis and Stephanidis 2004; do Carmo Nogueira et al. 2019). Most research on accessibility have been focused on education and government areas, highlighting the need to address accessible systems in other sectors as well (Paiva et al. 2021), such as physical activity information. Although the Web has been considered useful for knowledge about physical activity among disabled people, they perceive it as inaccessible and not appealing (Jaarsma et al. 2019; Smith and Sparkes 2019; Smith and Wightman 2021). Inaccessible physical activity information is one of several barriers for visually impaired (VI) people to get active. They are less likely to be physically active compared to other disabled groups and sighted people, especially the young adults due to the challenging period of transition into adulthood (Haegele and Porretta 2015; Middelweerd et al. 2015; National Disability Sports 2015).

Several studies have focused on creating and evaluating accessibility guidelines (Paiva et al. 2021) and recently considering accessibility (Horton S. and Sloan 2014; Krainz 2018) together with usability and user experience (Kim et al. 2016; de Godoi et al. 2020; Rosa and Valentim 2020) to enhance the quality of the system (de Godoi et al. 2020; Rosa and Valentim 2020). However, there is a lack of awareness among developers and designers about combining these three concepts (i.e., accessibility, usability, and user experience) and how to integrate them in software development (Rosa and Valentim 2020). This is relevant for development of new technologies in which innovative ideas become prototypes to be explored and evaluated with users' feedback (Camburn et al. 2017).

1.1 Research aim and objectives

The aim of this study was to investigate how to design and develop an accessible and usable technology to aid participation of visually impaired (VI) young adults in physical activity. In order to achieve this aim, the following objectives were identified:

To design and develop an accessible and usable mobile application to help VI young adults to seek information and support in physical activity.

To evaluate accessibility and usability of the proposed mobile application for physical activity information and support.

To explore the experience, barriers, and requirements of VI young adults to participate in physical activity.

To explore the coaches' perspectives of the experience of VI young adults in physical activity and the service provisioning.

To review the perceptions from VI young adults and coaches about the proposed mobile application for physical activity information and support.

To formulate a set of recommendations to guide designers and developers when designing technology in the context of physical activity information.

To evaluate the recommendations through expert review.

This study was an opportunity to undertake and learn from the steps of mobile application development. Mobile technology was chosen to be studied due to its popular use of functionalities at any time, portability (Jabangwe et al. 2018). This along with the context of use drive particular and specific requirements in the user experience design (see Chapter 2) (Almeida et al. 2021).

In summary, the aim and objectives were to evolve both the design process and the system solution as part of the research, which could contribute to extend and improve the knowledge base of software development methodologies and technology design implications for the related physical activity participation of people with impairments.

1.2 Research conjecture

Previous research in physical activity information indicated that mobile technology may be one of the communication channels useful to assist people with VI in finding information about physical activity (Jaarsma et al. 2014; Jaarsma et al. 2019; Smith and Sparkes 2019; Smith and Wightman 2021). The use of mobile technology could help users, especially VI young adults, who seem to make an effort to identify appropriate physical activity after leaving compulsory education (National Disability Sports 2015) while facing different changes in their lives, in terms of occupation, whether finding employment, further education, depression, and social aspects (Gowin et al. 2019). Such aspects may lead to low physical activity participation or none at all (National Disability Sports 2015; Wrzesińska

et al. 2018). Moreover, few studies have addressed the physical activity experience and the related needs of VI young adults (Haegele 2018; Wrzesińska et al. 2018). By considering all these aspects, there is an opportunity to find ways to help the target audience to seek information and support them to get more physically active.

This is where Interaction Design, as a discipline in Human and Computer Interaction (HCI), offers an important approach in focusing on the user's interaction and the social and cultural context with the principal aim to minimise the negative effects of the user experience, such as frustration and confusion, and to enhance the positive ones, such as enjoyment and usefulness (Preece et al. 2015). Therefore, this study defines the research conjecture as follows:

Technology can help VI young adults (partially sighted or blind) to participate in physical activity in the UK.

In this study, a research conjecture is used as an idea or opinion presumed on incomplete information which needs further investigation (Deamer 2017). This argument is based on the potential scenario considered to develop a mobile app to provide information services and support in physical activity to VI young adults. This conjecture has the focus on the service provision of VI physical activity in the UK because the most relevant literature and the research participants were UK based.

1.3 Research challenges and research questions

The literature review (Chapter 2) identified that there is little support to help interdisciplinary teams to decide on a design approach and how to include people with learning or sensory impairments in the design process of technologies (Seale et al. 2020). In this context, the literature review identified several research gaps to be addressed in this study as follows:

Lack of an approach on how to consider people with impairments in the software development process while combining accessibility, usability, and user experience.

Lack of integration of accessibility and user experience into Design Thinking and Agile methodologies.

Lack of adapting the prototyping stage for people with VI.

Lack of knowledge on how the existing automated tools can support accessibility checking.

Lack of knowledge on how to select and apply methods for accessibility testing in Agile development process.

Lack of research on specific usability evaluation method or technique focusing on users with VI.

These challenges shaped the focus of this thesis, which aims to implement an approach for designing a mobile application and draw insights from each step. Based on these challenges and the research conjecture, the main research question and sub-research questions (SRQs) are as follows:

Main research question:

How can guidelines be developed to support designers and software developers to design and develop a mobile application to aid VI young adults to take part in physical activity?

This is a question about the design process and how designers and developers can work together in designing and developing an accessible mobile application for VI young adults in the context of physical activity. The research opportunity is to develop iteratively a design guidance, including recommendations for the design process and design requirements for an accessible mobile application for physical activity information and support. Chapter 13 and Chapter 15 describe the development and review of the design guidance. In order to answer the main research question, the following sub-research questions were formulated:

SRQ1: How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?

This question aims to identify the key considerations and approaches for building an accessible mobile application, with the goal of generating guidance to help verify whether designers and developers without accessibility experience can understand and implement the design requirements. Results in Chapter 13 address this question.

SRQ2: Does the design guidance developed provide all accessibility requirements?

This is a question to verify if the design guidance provides all accessibility considerations. This question is directed to accessibility experts as they can evaluate the design guidance according to their knowledge and experience. Chapter 14 informs the results of this question.

The following questions are related to the design requirements in the design process.

Question 1: What are the needs and perceived barriers and facilitators for VI young adults to take part in physical activity in the UK?

The aim was to understand the experience of VI young adults in physical activity.

Question 2: What are the perspectives of coaches about physical activity experience of VI young adults in the UK?

This is about understanding the coaches' perspectives about the experience of VI young adults in physical activity and the service provision.

1.4 Research contributions

This work provides new research contributions because it offers recommendations to overcome some challenges faced by designers and developers when designing an accessible technology and insights on what is necessary to consider in mobile application development in the context of physical activity for VI young adults.

Given that how to involve VI people in the design process of mobile application is overlooked in the literature, this work describes the design guidance A and B. The design guidance A refers to an iterative design process of an accessible mobile application and B regards to the detailed design requirements to design an accessible mobile application for physical activity information retrieval for VI young adults and support from VI sports coaches. This work aimed to identify the strengths and weaknesses of developing the design guidance A and B and identify the potential improvements through expert review. The research contributions related to the main research question and sub-research questions are:

Main research question: How can guidelines be developed to support designers and software developers to design and develop a mobile application to aid VI young adults to take part in physical activity?

The design guidance A and B can be a potential resource to help designers and developers to involve VI participants in the design process and elicit design requirements regarding physical activity information and support. The design guidance was developed with developers by combining approaches to develop iteratively the design process and requirements for an accessible mobile application. This entailed applying and adapting methods and approaches to design and develop an accessible mobile application.

This work comprised the combination of Design Thinking and Agile methodologies, and considerations of accessibility, usability, and user experience approaches from the beginning of the project. The Affinity Diagram was developed for triangulation of the data analysis resulted from literature review, online survey, user evaluations and interviews. This helped to identify the key themes to create the design guidance A and B. This design guidance still needs to be evaluated in a comparative evaluation or case studies in practical settings. It was not possible to undertake these evaluations due to the limited time and resources for the PhD study.

SRQ1: How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?

The design guidance was developed from the outcomes of the triangulation methodology applied after the simultaneous development and conduction of the iterative and participatory design approach with developers and VI participants. This process involved continuous learning and communication between the author and developers at all stages of the design process. This process combined accessibility, design thinking and user experience for agile approaches. Throughout this process the steps were reviewed and adapted when necessary to involve VI participants. This resulted in adaptations to accessibility considerations across co-design, rapid prototyping, creation of accessible mobile app, accessibility testing and user feedback.

SRQ2: Does the design guidance developed provide all accessibility requirements?

The expert review pointed out the strengths and weakness of addressing accessibility considerations in the design guidance A and B. This guidance covered almost all accessibility aspects for mobile application. This was perceived as useful to encourage thinking about digital accessibility and usability during implementation stage of the software development as often accessible elements are ignored by software developers. Therefore, the design guidance presents a simple language and detailed information about accessibility considerations appropriate to designers and developers without expertise in accessibility. The expert review by designers, developers and accessibility specialists revealed that the design guidance A and B are understandable, and they may be a potential resource to aid the design and development of an accessible mobile application and consider the context of physical activity information and support for VI young adults. Design guidance was considered easy to understand and helpful to designers, software developers and organisations.

1.5 Structure of the thesis

This thesis's structure is presented as follows:

Chapter 2: the literature review outlines the background of the physical activity experience of people with VI and the related Human Computer Interaction (HCI) and software development methods, mobile accessibility, and related work in the mobile technology design.

Chapter 3: describes the research methodologies adopted in this study. It details the research strategy and steps used to answer the research questions in order to achieve the research aim and objectives.

Chapter 1

Chapter 4: describes the design and development of the mid-fidelity prototype and reports the findings of the user evaluation.

Chapter 5: describes the design and development of the minimum viable product (mobile app) and reports the findings of the user evaluation.

Chapter 6: explains the process to update the mobile app and the manual and automatic accessibility testing.

Chapter 7: describes the interviews with VI young adults about their physical activity experience.

Chapter 8: describes the think aloud user evaluation of the mobile app with VI young adults.

Chapter 9: describes the interviews with coaches on experience of physical activity and sport for people with VI.

Chapter 10: describes the coaches and guides' feedback on the mobile app.

Chapter 11: details the design and developments of an accessible online survey design.

Chapter 12: reports the analysis and results of the accessible online survey.

Chapter 13: describes the method used to develop the design guidance.

Chapter 14: details the experimental design on the expert review of design guidance.

Chapter 15: reports and discusses the results of the expert review of the design guidance.

Chapter 16: presents the discussion about the studies conducted in this thesis and the important findings to designers and developers.

Chapter 17: presents the overall conclusions from the different aspects of this research and informs how the work could be further developed.

1.6 Methodology scope

This thesis shows how the research was carried out through the design, development, testing and evaluation of the proposed mobile app. This was an iterative and concurrent practical approach to develop both the mobile app and design guidance. Therefore, it was not possible to undertake the next iteration and further develop the mobile app based on the latest findings due to limited time and resources of a PhD study. Further work would be necessary to test and evaluate the design guidance in realistic settings. The methodology scope of this thesis is presented in the following diagram.

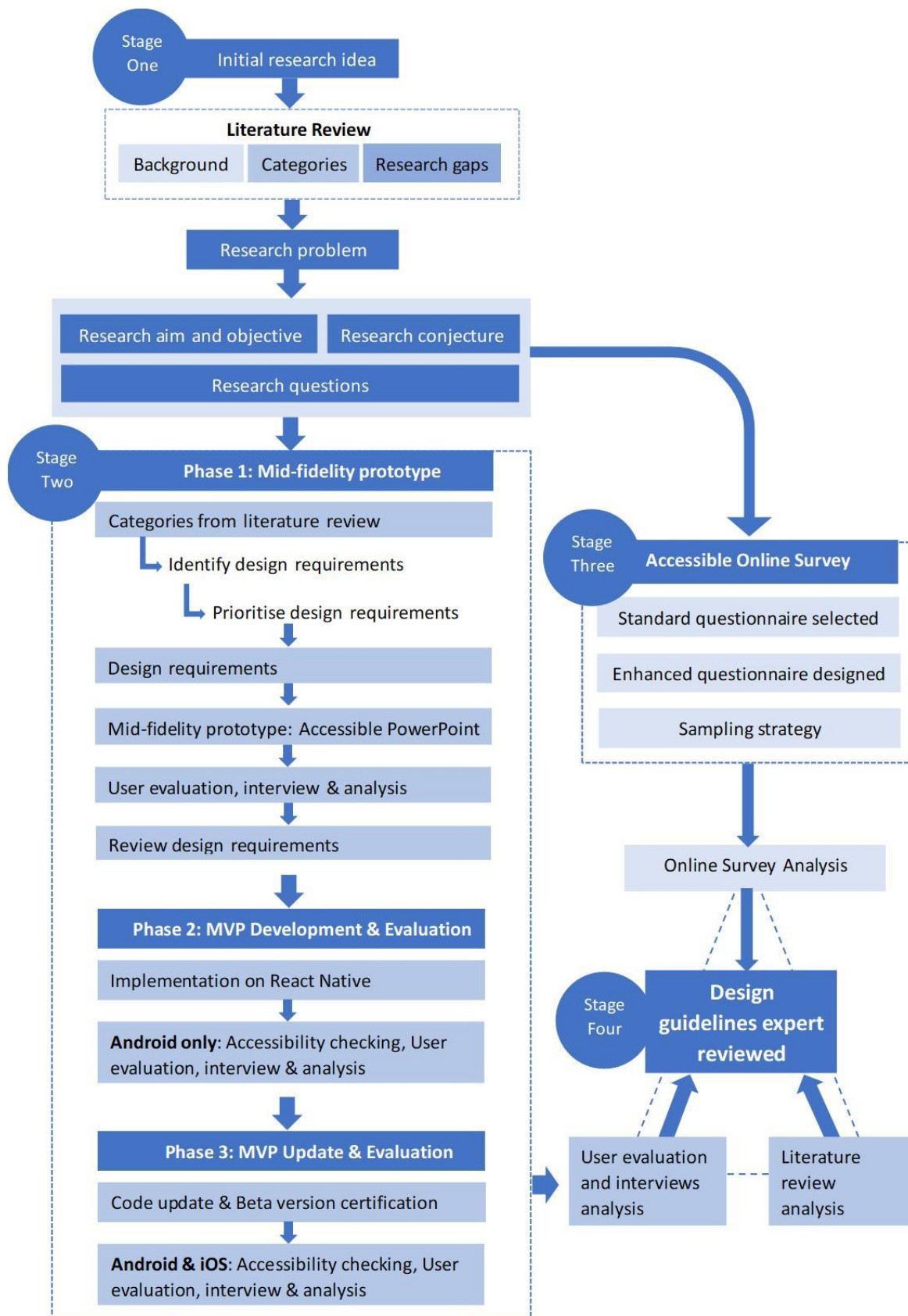


Figure 1.1 Research methodology scope

Chapter 2 Literature review

2.1 Introduction

This chapter establishes the basis for this thesis by covering the topics to address the main research question - *How can guidelines be developed to support designers and software developers to design and develop a mobile application to aid VI young adults to take part in physical activity?* This literature review sets the research problem based on the findings from secondary research on low physical activity participation among VI people, especially young adults, and the importance to tackle it through the support of mobile technology. It determines definitions and identifies relevant research previously conducted on accessibility, usability, user experience, Design Thinking, and software engineering development processes. This chapter finishes by summarising the review and gaps in the knowledge to confirm the rationale and aims of this research.

2.2 Physical activity and visually impaired people

A healthy lifestyle for all includes regular physical activity (Haegele et al. 2017b). Physical activity means ‘any bodily movement produced by skeletal muscles that requires energy expenditure’ across different types of activities such as aerobic, strength, flexibility, balance, and sport (World Health Organization 2010). The physical activity levels can vary by moderate and vigorous intensity rates of energy expenditure in Metabolic Equivalent of Task – MET (World Health Organization 2010) and insufficient levels can increase the risks of developing chronic diseases (e.g., cardiovascular disease, stroke, cancer) and risk factors (e.g., diabetes, hypertension, depression, and obesity) (World Health Organization 2018a).

These levels are diverse across countries and groups of population. VI people are more likely to do less physical activity than other disabled groups and sighted people (Haegele et al. 2018). According to the International Classification of Diseases - ICD 11, VI refers ‘to deficits in the ability of the person to perform vision-related activities of daily living, such as: reading, orientation and mobility, and other tasks.’ (World Health Organization 2018b). This thesis uses the two classifications from the National Health Service – NHS and Royal National Institute of Blind People – RNIB: Blind or severely sight impaired and partially sighted or sight impaired (NHS 2018; RNIB 2018).

The barriers in physical activity for people with VI may range from diverse aspects, such as summarised in Table 2.1.

Table 2.1 Physical activity barriers for visually impaired people

Barriers	Description	Citation	Research addition
Safety concerns. Difficult to identify how safe physical activity is.	Some VI people face fear of getting injured when doing physical activity.	Haegele et al. 2017a, Haegele et al. 2018, Women in Sport et al. 2016, Wrzesinska et al. 2018	This research aims to add resources to reinforce the sense of trust and safety.
Lack of self-confidence.	VI people present low self-confidence to take part in physical activity and concerns on level of ability.	Colgan et al. 2026, National Disability Sports 2015, Women in Sport et al. 2016	This research is not focusing on this. This may be tackled directly at physical activity sessions.
Lack of motivation.	Low levels of motivation prevent VI people to get active.	Wrzesinska et al. 2018, Augestad & Jiang 2015, Salminen 2014	This research is not focusing on this. There are existing physical activity apps on this matter.
Transport	Lack of transport for VI people. They may find it difficult to move around and rely on others to take them to sport or leisure centres.	Haegele et al. 2018, Haegele et al. 2017b, Women in Sport et al. 2016, Jaarsma et al. 2014	This research can facilitate access to transport information.
Costs	The costs of physical activities may be unaffordable for VI people.	Jaarsma et al. 2014, Women in Sport et al. 2016	This research is not focusing on this.
Inaccessible places and exercise equipment.	Gyms and sport venues and equipment can be inaccessible for VI people.	Haegele et al. 2018, Rimmer et al. 2005, Smith and Sparkes 2019, Thomas Pocklington Trust 2018	This research is not focusing on this.
Few opportunities.	Little information on sport websites about local opportunities.	Haegele et al. 2017b, National Disability Sports 2015, Haegele et al. 2015, Wrzesinska et al. 2018, Jaarsma et al. (2019)	This research can facilitate search of physical activity opportunities.

Table 2.1 Continued

Barriers	Description	Citation	Research addition

Lack of trained professionals.	Physical activity professionals have not enough training in how to make accessible and engaging activities for VI people.	Activity Alliance 2019, Haegele et al. 2015, Wrzesinska et al. 2018	This research will aid physical activity providers to connect and find out about training.
Dependence on others.	VI people need help from others to do exercises.	Haegele et al. 2017b, Haegele et al. 2018, Jaarsma et al. 2014	This research can facilitate the search for company for physical activity.
Lack of peers.	Not having company to do physical activity.	Jaarsma et al. 2014, Salminen & Karhula 2014, Women in Sport et al. 2016	This research can facilitate the search for company to do physical activity.
Lack of accessible information about physical activity. Inaccessible posters and flyers.	Physical activity information provided in inaccessible format. Some physical activity providers share posters and flyers inaccessible to VI people.	Jaarsma et al. 2014, Rimmer et al. 2005, Jaarsma et al. (2019)	This research is going to fix this by developing an accessible mobile application.
Difficult to find sport opportunities after leaving compulsory education.	VI young people find it difficult to identify adapted physical activity feel responsible to make an effort to identify activities adapted to them.	National Disability Sports 2015	This research can facilitate the searching a VI physical activity.
Little alternatives to social media posts	Not all VI people access social media and physical activity information is not spread widely.	Jaarsma et al. (2019)	This research will enable an accessible place focused on physical activity information.
Lack of personalisation on social media's algorithms	Algorithms do not ask users if they have disabilities and seek for physical activity to target them.	Jaarsma et al. (2019)	This research adds the opportunity to personalise the searching and booking for VI physical activity.

Table 2.1 Continued

Barriers	Description	Citation	Research addition

Physical activity providers lack confidence.	Lack of confidence among physical activity providers in opening a dialogue with VI people.	(Women in Sport et al. 2016).	This research is going to enable physical activity providers to know more about VI people and allow online contact between them.

Previous studies have suggested to improve how knowledge is shared about physical activity information for people with impairments (Jaarsma et al. 2014; National Disability Sports 2015; Women in Sport et al. 2016; Jaarsma et al. 2019; Smith and Sparkes 2019). These include developing a good flow of information within a communication network which needs credible messengers (i.e., sport providers, social workers) to target the right audience with specific and tailored information (e.g., location, age, disability group, physical activity level). Also, more information can be provided on mainstream and disability specialist sport websites, and the current network of offers need to be more accessible to young people with impairments by using mobile technology, social media, online communications, as well as the development of a social system of VI peers to organise common activities.

2.2.1 Physical activity service providers

Physical activity providers (e.g., service providers, sports leaders, instructors, coaches) currently are using websites, social media, newsletters, and emails to spread the information about their physical activity sessions. The most used channel by providers is the social media. However, the information about physical activity may not reach everybody in the visual impairment community. This is because not everyone accesses social media and its algorithms do not ask users if they have disabilities and seek for physical activity to target them, or they do not follow the physical activity pages and groups. Also, there is little information on sport websites about local opportunities and Google searches may not provide useful information. Traditional media (e.g., flyers, posters, television, radio, newspaper) is another way of promoting information, however, inaccessible posters and flyers are issues for VI people (Jaarsma et al. 2019).

Services providers often lack confidence in opening a dialogue with VI people about what they can do and what things they need help with. This often means contact made with difficulties and miscommunication. Therefore, there is a need to ensure that all experiences with physical activity are positive to maintain the behaviour (Women in Sport et al. 2016). Service providers need to be more aware of where disabled young people and their families can find information on inclusive opportunities (National Disability Sports 2015) and communication between health professionals with direct contact with disabled people, sport organisations and charities needs improvement

(Jaarsma et al. 2019). To improve communication in physical activity domain, Murray (2012) suggested a combination of online physical activity information, interaction between users and provision of services which can be used to offer behaviour change, decision, peer, and social support.

2.2.2 Physical activity related technologies for visually impaired people

Mainstream physical activity and fitness apps, along with wearable devices, have gained popularity due to their versatile features and the convenience of use anytime, anywhere. These features may include general guidance on physical activity, user input tracking, feedback on behaviour and progress, and the ability to share exercises or achievements on social networks. The combination of these capabilities with health promotion initiatives likely contributes to the increasing number of both free and paid fitness apps available. In general, VI users see mobile health apps as a support that helps to improve information access about health (Thompson et al. 2019). However, not all physical activity apps are fully accessible, and some of them may be used depending on visual impairment level. Even though mainstream physical activity apps may become more accessible, there would still be a need for tackling the barriers in the physical activity participation of VI young adults, mentioned in the previous section. This can be related to the need of investigating the how to conduct the design of an accessible system and considering the user experience and the context of the use, capability and access to technology and knowledge, especially related to the physical activity information and support barriers for VI population.

A few studies have investigated the use of mainstream mobile apps and wearable technologies for health promotion and physical activity among VI people (Colgan et al. 2016; Thompson et al. 2019). These mainstream technologies can improve physical activity levels and socialising, while competition can enhance life skills of VI youths and young adults (Colgan et al. 2016). Despite these advantages, these technologies may not provide features such as encouragement through gamification, contact to experts, adaptation to user's goals, some sort of punishment and integration with external sources, for example, user's calendar or weather forecast. This indicates the possibility to expand the functionalities and utility of physical activity apps (Mollee et al. 2017). This thesis is not only addressing the accessibility and usability, but also aims to identify the needs and preferences of VI young adults to get active, which may require additional functionalities to help improve their participation.

2.2.3 Current technologies to aid VI people to get active

Some existing technologies, such as Jooay and Accessercise became available recently to help disabled people to identify inclusive leisure activities. Jooay is a mobile app for disabled children and

youth to find inclusive activities such as sports, arts, and other activities in Canada, as part of a research project at the McGill University. Accessercise is a commercial physical activity app launched in the UK in 2020. It offers disabled adults inclusive workout videos, a directory map of gyms and sport clubs ranked by users, a social hub, and a calendar to schedule and track workouts (Houston 2020).

According to Shikako et al. (2021), the Jooay presented lack of enough, accurate and comprehensive information about activities which made it difficult to engage users. In terms of accessibility, the Jooay website was tested on the Web Accessibility Evaluation Tool - WAVE which pointed out 2 errors (e.g., language missing or invalid and empty link) and 2 alerts (e.g., no heading structure and no page regions) in the finding activity webpage and lack of colour contrast. It also was not accessible while using Narrator, a built-in screen reader in Microsoft Windows, which did not provide enough information on buttons, links, and headings and incorrect reading order.

The author used the Accessibility Scanner to assess accessibility on both Jooay and Accessercise apps. The identified issues are red outlined areas in the Figure 2.1, Figure 2.2, Figure 2.3, Figure 2.4 and Figure 2.5, such as low colour contrast, text and target size and scaling. Also, some UI elements were not readable by TalkBack, the Android screen reader.

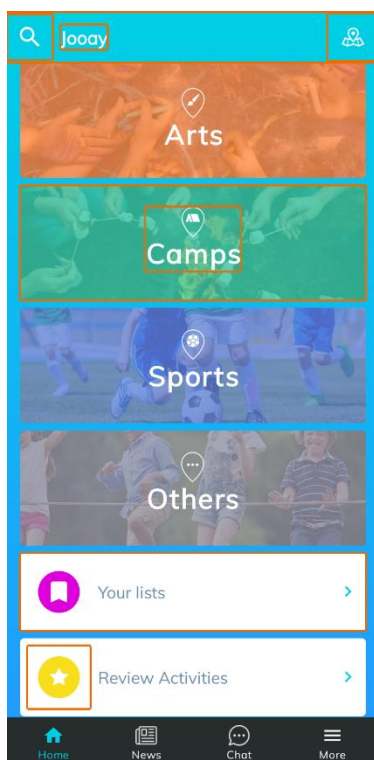


Figure 2.1 Screenshot of Jooay app Home screen

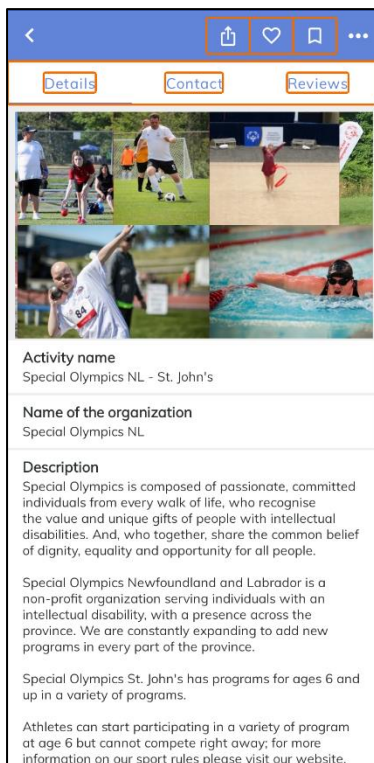


Figure 2.2 Screenshot of Jooay app Activity screen

Both Jooay and Accessercise apps do not provide specific features identified (see Appendix R) in this thesis to overcome the barriers for VI people, e.g., one-to-one support, images of the venue and staff, and coaches' certifications checks, direct link to transport information. These technologies could have prioritised the accessibility and the needs of disabled people from the early stages of the design process following the existing accessibility standards (see 2.5.1) and conducting iterative cycles for co-designing and improving the MVP with disabled people. Therefore, the design guidance from this thesis would have the potential to guide the design team in the design process, features and considerations for accessibility, usability, and user experience.

For instance, if the Jooay app had implemented the design guidelines proposed in this thesis, it could have kept the navigation bar consistently visible across all screens to facilitate access to the main tabs (Figure 2.1 and Figure 2.2), succinct information, offered users a selection of navigational apps to choose their preferred and most accessible option, enabled automatic saving of information of the booked physical activity session to the phone's calendar app or braille notetakers, and included buttons to facilitate sessions' booking and payment. The map in the Accessercise app was not accessible (Figure 2.4). Similarly, if the app had followed the thesis' design guidance, it could have allowed users copy and paste the address of a venue (Figure 2.5) to paste it on a navigational app, or it would have offered users a selection of navigational apps to choose and open their preferred app, or buttons to make sessions' booking and payment.

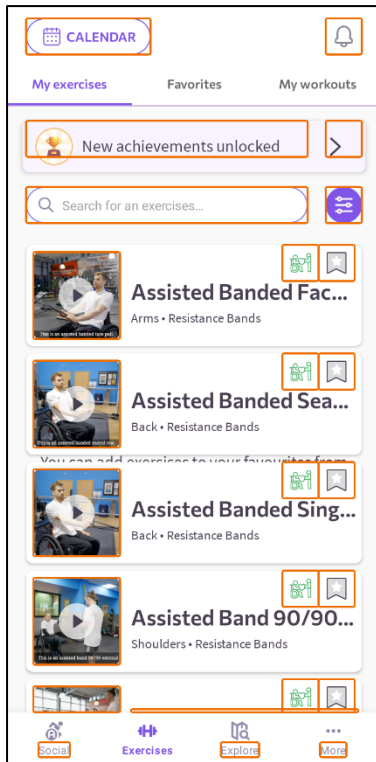


Figure 2.3 Screenshot of Accessercise app Exercises screen

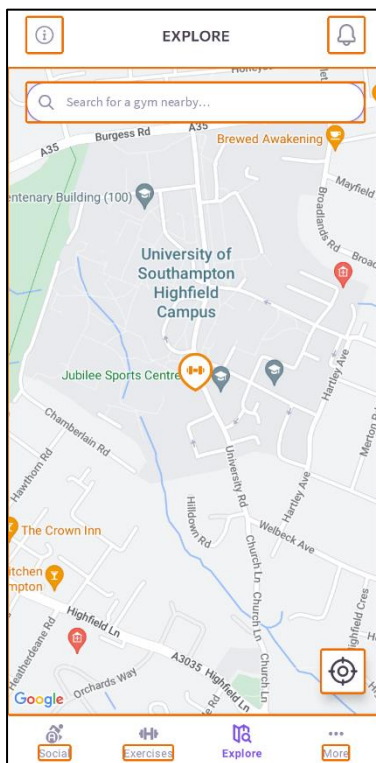


Figure 2.4 Screenshot of Accessercise app Map screen

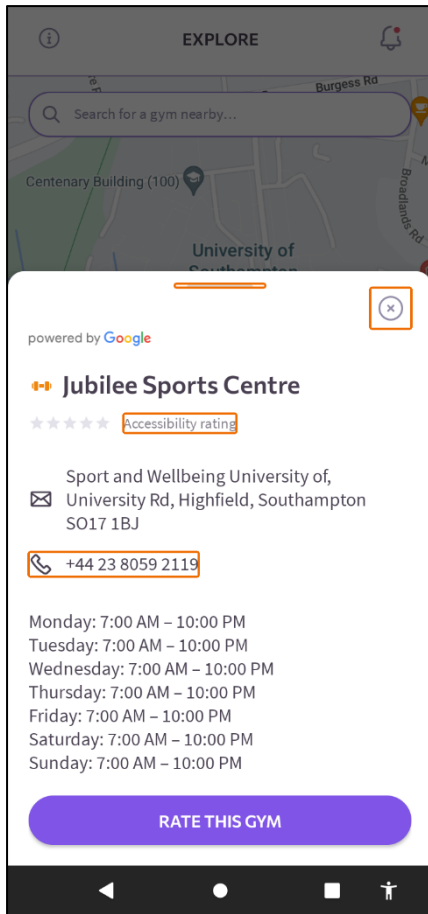


Figure 2.5 Screenshot of Accessercise app location screen

There are also some other UK based physical activities directory websites which include filters by disability and special needs, such as Energise Me, British Blind Sport Activity Finder, Every Body Moves. Energise Me and Every Body Moves include links to workout videos. These websites, Jooay and Accessercise app are categorised on (Table 2.2) according to the main elements identified in this thesis. For example, none of the existing apps or websites for physical activities do not offer a space for coaches to contact other coaches or disabled users, to obtain attendees booking list and other features identified in this thesis.

Table 2.2 Categories of physical activity websites and apps for VI users

Categories	ActiveVI	Jooay	Accessercise	BBS	RNIB	Energise Me	Every Body Moves
Technology	app	app	app	website	website	website	website
VI profile creation	yes	yes	yes	no	no	no	yes
Set activity type preferences	yes	no	no	no	no	no	no
Recommendations	yes	no	no	no	no	no	no
Physical activity search by location	yes	yes	yes	yes	no	yes	yes

Chapter 2

Session description and details	yes	yes	yes	yes	yes	yes	yes
Number of booked attendees	yes	no	no	no	no	no	no
Cost	yes	yes	no	yes	no	yes	yes
Contact details	yes	yes	yes	yes	no	no	yes
Chat coaches	yes	no	no	no	no	no	no
Calendar (phone/brailnote touch)	yes	no	yes	no	no	no	no
transport information	yes	no	no	no	no	yes	no
Booking	yes	no	no	yes	no	yes	no
Search for members/similar peers	yes	yes	yes	no	no	no	no
User stories	yes	no	no	no	yes	no	no
Help to find content	yes	no	no	no	no	no	no
Coach and organisation profile creation	yes	no	no	yes	no	no	no
Accredited checks	yes	no	no	no	no	no	no
Reviews	yes	yes	no	no	no	no	no

Table 2.2 Continued

Categories	ActiveVI	Jooay	Accessercise	BBS	RNIB	Energise Me	Every Body Moves
Images of the venue and staff	yes	yes	no	no	no	no	no
Upload self-introduction video	yes	no	no	no	no	no	no
Contact other coaches and VI users	yes	no	no	no	no	no	no
Chat VI clients and coaches	yes	no	no	no	no	no	no
Influence other coaches	yes	no	no	no	no	no	no
Advertise sessions	yes	yes	no	yes	no	no	no
Search for volunteers	yes	no	no	no	no	no	no

Induction inclusive training	yes	no	no	no	no	no	no
Sharing practices (videos, docs)	yes	no	no	no	no	no	no
Send session updates	yes	no	no	no	no	no	no
Promote online sessions	yes	no	yes	no	yes	yes	yes

2.3 Accessibility legislation

The international human rights agreement created for disabled people the United Nations Convention on the Rights of People with Disabilities. This Convention requires that governments implement strategies to eradicate barriers for disabled people and promote inclusion through recognition that all are equal and have the same rights, respect, and dignity. This also promotes awareness among disabled people about how they are protected (EHRC 2010).

The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018 are the UK regulations introduced on the 23rd of September of 2018. These regulations apply to all public websites and mobile applications, for internal or public use, which need to be accessible. This aligns with the European Standards which adopts the latest version of the W3C's Web Content Accessibility Guidelines (WCAG) (CDDO 2023).

Similarly, The Equality Act 2010 in Great Britain and Disability Discrimination Act 1995 in Northern Ireland establish laws and duties on public bodies, employers, and service providers to treat everyone equally in society, including making accessible information for people with impairments (Government Equalities Office 2011). Accessibility legislation can endorse the rights of disabled people and encourage organisations to make and offer accessible services and products to everyone. This can imply that accessible technologies are more likely to be used for as much people as possible, which can determine the uptake and continuous use of the technology. As a result, more people can be able to access more services and products. In this sense, the provision of physical activities services through accessible technologies can impact potential increase in the physical activity participation of VI people.

2.4 Accessibility, usability and user experience

According to W3C, accessibility is necessary for usability. The primary focus of accessibility is on people living with some impairment to allow their access to user interfaces which in turn may improve the usability for all. Both concepts overlap in their definitions.

Accessibility is defined by ISO 9241-171:2008 as *“usability of a product, service, environment or facility by people with the widest range of capabilities”* (ISO 9241-171) and the Web Content Accessibility Guidelines - WCAG is more specific as the possibilities to use the Web by people with impairments as they *“can equally perceive, understand, navigate, and interact with websites and tools.”* The ISO 9241-11 defines usability as *“extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”* (Henry et al. 2016).

Moreover, there is an intersection between usability, accessibility, and user experience (UX) design (Henry et al. 2016; de Godoi et al. 2020). The definition of UX by ISO 9241-210:2019 is *“user’s perceptions and responses that result from the use and/or anticipated use of a system, product or service”*, which researchers have considered it more subjective towards the users’ feelings, preferences, and all perceptions about a system as compared to the more objective measures of usability (e.g., effectiveness, efficiency, and satisfaction) (Bevan 2009; Rosa and Valentim 2020). Moreover, UX focuses on an in-depth understanding of the user and the related context of product use in order to improve the user experience (Adikari et al. 2013).

In this context, there is recognition that design of systems needs to combine accessibility, usability, and UX from the beginning of the project. This can ensure pleasurable UX by prioritising the layout of a user interface with enough essential amount of information and elements, eliminating unnecessary actions, and decreasing the time and effort to perform them (Park et al. 2014; de Godoi et al. 2020; Rosa and Valentim 2020).

Otherwise, often when usability and user experience are applied from the beginning of the design process without considering VI people, both are implemented for sighted people, and accessibility is an afterthought in the last stages of the practice. As a result, it can lead to a negative user experience (Park et al. 2014). In fact, the needs of users that live with some impairments are often missed in practice and research (Silva et al. 2019b).

2.5 Mobile accessibility

2.5.1 Accessibility Guidelines Overview

The recommended accessibility standard is the Web Content Accessibility Guidelines (WCAG) 2.1 to make Web content accessible for people living with impairments. These guidelines present three levels of compliance (i.e., ‘A’, ‘AA’ and ‘AAA’), where the level range from minimum ‘A’ criterion for a website to be accessible to ‘AAA’ as an excellent criterion, and four main principles (i.e., *Perceivable, Operable, Understandable, and Robust*). The W3C argues such guidelines covers recommendations

for mobile accessibility and released a working draft based on the WCAG principles, guidelines and criteria to mobile content and applications, *Mobile Accessibility: How WCAG 2.0 and Other W3C/WAI Guidelines Apply to Mobile* (Patch et al. 2015). The principles are described briefly as follows:

Perceivable – this requires the content to be recognised by people with impairments, for instance, by this audio and image should offer alternatives to be perceivable by users with impairments.

Operable – concerns all features that should be available and usable by everyone, for example, an alternative control input to allow the use of a mobile application.

Understandable – this regard to the user's cognitive ability to understand the meaning of content. As an example, consistent and predictable elements in an order format.

Robust – refers to the flexibility of content to be interpretable and compatible across several user agents, including assistive technologies, and remains accessible regardless of current or future technological evolution.

Mobile accessibility concerns “to making websites and applications more accessible to people with disabilities when using mobile phones and other devices” (Shawn Lawton and Brewer 2021). A growing number of people living with VI have used mobile applications for daily activities due to technological advances of mobile devices (Di Gregorio et al. 2022).

The EN 301 549 v3.2.1 is the European standard for accessibility of Information and Communications Technology (ICT), such as software and hardware bought or built by public sector bodies in Europe. In the UK, the equivalent to this law is the Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018. Therefore, organisations applying these regulations will also meet the EN 301 549. Also, the EN 301 549 presents relationship with the essential requirements of European Web Accessibility Directive (Directive 2016/2102/EU) (CEN et al. 2021). The Directive 2016/2102/EU, created by the European Parliament and the Council of the European Union in 2016, requires the public sector bodies to offer accessible websites, mobile apps, and accessibility statements for the websites. It refers to the technical requirements of EN 301 549, and it mentions other requirements for non-technical reasons (Kollotzek et al. 2021).

The EN 301 549 incorporates the WCAG 2.1 level AA and covers mobile accessibility, including content, whether it is documents and forms in the software or offered by the software. The EN 301 549 provides the ‘Table A.2’ with 162 requirements related to mobile accessibility (CEN et al. 2021), including the biometrics criteria, which was not included in the WCAG 2.1. However, it has been added in the WCAG 2.2 in the Success Criteria 3.3.8 Accessible Authentication (Minimum) in 2023 (W3C 2023). While WCAG 2.1 focuses on web content and digital accessibility, the EN 301 549

extends beyond the web to include other ICT, for instance, telecommunications, software interface and hardware.

Although there are regulations and standards in place, there is still many inaccessible mobile applications. There are several reasons for this, which may vary in terms of awareness among professionals in the field, organisations mindset, lack of adequate educational curricula, confusing accessibility guidelines, and so on (Silva et al. 2019b). In general, existing accessibility standards focus mainly on how to make the Web content and its websites accessible. Then, most of accessibility guidelines related to mobile applications derived from organisations, such as Apple, Google, Microsoft, and BBC (Correia et al. 2019).

2.5.2 Accessibility for iOS

Apple devised the Human Interfaces Guidelines for Accessibility (Apple 2023) to offer developers several built-in accessibility features, APIs, and tools. The features can vary such as Zoom to enlarge the screen, White on Black to invert the screen colours, and VoiceOver, a gesture-based screen reader, which allow users to navigate the mobile applications, which is addressed to VI people. VoiceOver has been the primary assistive technology, which provide spoken feedback, for blind users available in iPhone, iPad and MacOS devices. Users can interact with VoiceOver using gestures such as tapping, swiping, and dragging.

2.5.3 Accessibility for Android

Similarly, Accessibility Developer Checklist (Android 2023a), presents recommendations about describing the controls in the interface, to ensure navigation through its screen reader, TalkBack, and how to provide colour contrast, size of controls, touch targets, labelling of User Interface – UI elements and so on. Accessibility regulations and guidelines are very difficult and confusing for developers to implement and validate a software product, such as mobile application, due to specific technical jargons (Paiva et al. 2021). Hence, developers may still need skills to use guidelines when designing and testing accessible software (Silva et al. 2019b; Di Gregorio et al. 2022).

2.6 Accessibility and software engineering

Several studies have recognised the importance to consider the needs of diverse users in the software engineering process, however, the focus had been given mainly to guidelines' proposals, discussions, and evaluations (Paiva et al. 2021) instead of also integrating accessibility and '*inclusive thinking*', centred on the user needs into all software life cycle (Zimmermann and Vanderheiden

2008). This integration is very important to enable planning and designing of accessible software products (Zimmermann and Vanderheiden 2008; Paiva et al. 2021).

2.6.1 Designing user interface for VI users

Previous studies have conducted investigations on the needs of VI users of mobile apps and proposed design guidelines for mobile design and development. For example, Park et al. (2015) provided a list of heuristics such as logical focus flow and focus on every user interface element, use of operating system's native user interface components to provide compatibility with assistive technologies, simple layout, and consistent placement of component, which need to be less than 30 components in the screen, various methods (e.g., sound and vibration) for notification functions, non-text should receive alternative text.

Another study (Kim et al. 2016) proposed design guidelines based on accessibility testing of 140 health apps: support for zoom in and out for the content and colour combinations, provide intuitive navigation to find components and to avoid narrow area for touch input, highlight main images to access distinguishing adverts and content, and highlight of action-triggering media in the interface. Also, Kulpa et al. (2013) created a model of colour contrast of user interfaces in websites for VI users. They identified categories of colour contrasts which were satisfactory and efficient for VI users, such as the most appreciated colour contrasts that provided more efficiency for reading. The Table 2.1 summarises the categorisation of colour contrast proposed by (Kulpa et al. 2013).

This thesis aimed to address the design process and guidelines for creating accessible mobile applications, as there is a lack of studies in this area despite the increasing number of visually impaired individuals using mobile apps for daily tasks, driven by advancements in mobile technology (Miao et al. 2009; Albouys-Perrois et al. 2018). Moreover, this research started in 2019 when React Native was bringing useful accessibility components for developing accessible apps, which allowed automated testing and evaluation with VI people.

Table 2.3 Summary of the categories of colour contrast (Kulpa et al. 2013)

Category	Background	Foreground
More efficient for reading	dark blue	white, yellow, light blue, light yellow.
Several types of low vision	black	white, yellow, light blue, light yellow
More aesthetically appreciated	purple, light purple, magenta	white, yellow, purple

Allow the use of other colour combinations in the same screen	grey	white, yellow, light blue
Identification of icons, topics, and titles	yellow or red	blue, black, purple for yellow background; white for red background
Light sensitive users	Light grey or light yellow	dark blue, black, purple, red, orange, dark green
Easier reading of long texts	White	dark blue, black, purple, red, orange, dark green

2.6.2 Prototyping techniques for VI users

There is a need to adapt the prototyping stage of the design process for VI people (Metatla et al. 2015). The typical visual paper prototyping technique prevents their participation in the early stages of the design process (Metatla et al. 2015; Miao et al. 2016; Albouys-Perrois et al. 2018) and tactile paper prototyping does not approximate them to the real experience of using a technology. Both techniques do not allow the use of screen readers (Miao et al. 2016).

During the creation phase of the design process, when content, products, or services are prototyped or developed, there has been limited effort to include VI users. This is because there is little research on making visual content creation accessible, such as creating presentations, developing wireframes, designing posters, or sketching storyboards. Different studies addressed the prototyping of digital products for VI users in varied modalities, including non-visual interactions (i.e., audio, tactile, haptic, multimodal) (Zhang and Wobbrock 2023). The studies attempted to identify the best approach for prototyping for VI participants, such as multisensory augmented reality map through a participatory design approach, comparison between tactile prototype and computer-based prototype of a mobile application in local and synchronous remote tests with blind users (Miao et al. 2009; Albouys-Perrois et al. 2018) and design of a voice user interface for VI children at school (Metatla et al. 2015).

Accessible prototypes and the prototyping process are imperative to enable the participation of VI people in the early stages of the design process (Billi et al. 2010). This thesis aims to identify the appropriate and adapt a technique and resources for prototyping for and testing with VI users. Table 2.4 provides the existing methods in the literature that has been applied for prototyping for VI users.

Table 2.4 Methods used to prototype for VI people

Prototyping method	Prototype	Materials/Platform	Positive points	Negative points	Citation

Low-fidelity	Map building and exploration	Magnets and modelling clay as tokens	Satisfactory interaction for testing	Not mentioned	Albouys-Perrois et al. (2018)
High-fidelity	Multisensory augmented reality map	Projection, audio output and tactile tokens	Satisfactory interaction for testing	Not mentioned	Albouys-Perrois et al. (2018)

Table 2.4 Continued

Prototyping method	Prototype	Materials/Platform	Positive points	Negative points	Citation
Tactile paper	Mobile application	Paper	Useful for complex user interfaces. Only provides an overview of the artifact.	Do not provide realistic experience.	Miao et al. (2009)
High-fidelity	Mobile application	Microsoft Visual Basic	More intuitive for participants.	Time-consuming due to required good programming skills.	Miao et al. (2009)
Low-fidelity	Voice User Interface	Lego construction and Wizard-of-Oz simulation	Effective for sharing design ideas.	Reduced quick overview of alternatives	Metatla et al. (2019)
High-fidelity	Voice User Interface	Live coding an Alexa Skill application	Effective to progress the design	Not mentioned	Metatla et al. (2019)
High-fidelity	Mobile application	Android. Voice commands and multi-touch	Satisfactory interaction for testing	Not mentioned	Ghidini et al. (2016)

Low-fidelity	Audio-tactile mock-ups of interface display	Foam paper, basic audio recorders, label tags and electronic tag readers	Require minimal training	Disrupted communication and interrupted the spontaneity of shared experiences.	Metatla et al. (2015)

Table 2.4 Continued

High-fidelity	Highly malleable digital display	Specialised control panels	Made it easier for people to learn together and take a closer look at the design details.	Not mentioned	Metatla et al. (2015)

In mobile application design, low-fidelity prototyping using non-visual interactions remain inaccessible, while high-fidelity has been directly linked to coding a mobile application which can be time-consuming and require good programming skills. Therefore, it can restrict the participatory approach with people with disabilities. They should not only be consumers of design outputs; they deserve to be creators as well.

However, the lack of accessible creative tools highlights the need to empower them during the prototyping and development phases of the design process (Zhang and Wobbrock 2023). For instance, the prototyping tools (e.g., Sketch, Adobe XD, Balsamiq, UXPin) evaluated by Li et al. (2021) were mostly incompatible with screen readers. While some user interface control elements could be accessed, the control functions were not, making it impossible to manipulate prototyping elements effectively for users relying on screen readers. The Figma prototyping tool, the most popular mobile application interface templates, is not accessible as a prototyping technique. In addition, it presents accessibility issues across all templates and consequently in all generated applications, such as ‘inadequate implementation of accessibility practices that assist component identification and navigation was a common challenge’ (p. 320) (Holanda Muniz et al. 2024). Moreover, recent research presented a multimodal multi-device system for making digital artboards or canvas accessible to VI users (Zhang and Wobbrock 2023).

There are other approaches to facilitate the practice in early stages of ideation, prototyping and quick evaluations in the design process, such as the Microsoft PowerPoint, as a low-cost and readily available software (Kokate et al. 2022). Engelberg and Seffah (2002) stated that ‘PowerPoint fits well

into the gap between low-fidelity and high-fidelity prototyping tools' (p.214) as it is simple and easy to apply for rapid prototyping. In this thesis, this is the opportunity to use this software for the early prototyping stage to produce an accessible prototype for VI people to give feedback. It is not possible to use PowerPoint to prototype with VI participants due to the lack of accessibility. It seems that no previous study has investigated the use of PowerPoint as a tool to make accessible prototypes for VI users.

2.6.3 Manual and automatic accessibility testing

Automated tools do not substitute for the usability/accessibility testing with users or heuristics evaluations, then it is not recommended to evaluate mobile accessibility through automated tools only (Vigo et al. 2013). This is because these tools check limited number of accessibility properties and do not support evaluation of such aspects as audio, video, images, links, etc. However, relying only on manual checking can be time-consuming and costly, considering the large number of 50 accessibility requirements to comply with accessibility guidelines, for instance, WCAG 2.1 (Siebra et al. 2018). Manual testing can lead to insufficient evaluation and be hard to reproduce due to limited time of short release cycles and financial resources (Silva et al. 2018). Therefore, (Siebra et al. 2018) recommended to use automated tools alongside the mobile app development phase to support the accessibility testing early in the process to reduce the costs and development time.

Previous studies used different approaches in mobile accessibility testing for Android apps, web platforms and serious games, including automated tools such as Android Accessibility Scanner, MATE (Mobile Accessibility Testing). MATE is an open-source tool that addresses most accessibility guidelines. It supports both manual and automatic exploration, generating inputs to navigate through app screens and simulate real user interactions related to visual impairments (Eler et al. 2018). Moreover, the Website Accessibility Conformance Evaluation Methodology (WCAG-EM 1.0) is a methodology to define the scope of accessibility testing of a website through 5 main steps (i.e., define scope, explore website, select sample, audit sample, report findings). This can be used for evaluating existing websites and web applications and during early stages of website design and development (Velleman and Abou-Zahra 2014). The WCAG-EM 1.0 is rarely mentioned in the methods for accessibility testing and both automated and manual testing are not always applied in the same study Table 2.5). This is addressed in the Chapter 6 regarding the use of iOS Accessibility Inspector and Android Accessibility Scanner automated tools and manual checking in the early stage of the design process.

Table 2.5 Automated and manual testing approaches

Approach	Steps	Platform	Automated tool	Manual checking	Analyses	Citation
Adaptation of the WCAG-EM 1.0 (9 phases)	1. Define the Evaluation Scope 2. Explore the Destination Website 3. Select the Representative Sample 4. Evaluate the Selected Sample 5. Record the Results of the Evaluation 6. Analyse the Results 7. Manually Check for Errors 8. Suggest Improvements 9. Correct Errors	Web platform	WAVE	Yes (following WCAG 2.1)	Results were checked against WCAG 2.1	Acosta-Vargas et al. (2020b)

9 phases	1. select serious games 2. define the type of user 3. define the test scenario 4. explore each game to evaluate 5. list the barriers based on WCAG 2.1 6. evaluate with automatic tools and manually 7. record evaluation data 8. classify and analyse data 9. provide suggestions to improve accessibility	HTML5	Colour Contrast Analyser (CCA) and Photosensitive Epilepsy Analysis Tool (PEAT)	Yes (following some WCAG 2.1 criteria)	Based on the pre-defined 29 barriers related to WCAG 2.1 (step 4)	Salvador-Ullauri et al. (2020)

Table 2.5 Continued

Approach	Steps	Platform	Automated tool	Manual checking	Analysis	Citation
Performing tasks	Tests run on notebook with the Android Studio program	Android	Accessibility Scanner and MATE	No	Results were checked against WCAG 2.1	Mateus et al. (2020)

7 phases	1. Select apps 2. Install apps 3. Install and activate Accessibility Scanner 4. Evaluation 5. Record the results 6. Analysis 7. Suggestions to improve accessibility	Android	Accessibility Scanner	No	Results were checked against WCAG 2.1	Acosta-Vargas et al. (2020a)
7 phases	1. Randomly select mobile apps 2. Explore each application 3. Define the test scenario 4. Establish the barriers based on WCAG 2.1 5. Define the users according to the barriers 6. Apply the combined method 7. Register and analyse the data	Android	Accessibility Scanner	Yes (following some WCAG 2.1 criteria)	Based on the pre-defined 14 barriers related to WCAG 2.1 (step 4)	Acosta-Vargas et al. (2021a)

Table 2.5 Continued

Approach	Steps	Platform	Automated tool	Manual checking	Analysis	Citation

7 phases and Barrier Walkthrough	1. Select apps 2. Select the type of users 3. Identify the user scenarios 4. Evaluate the app with Barrier Walkthrough 5. Record the results 6. Analyse the results 7. Suggestions to improve accessibility	Android	No	Yes (following some WCAG 2.1 criteria)	Barrier Walkthrough based on the pre-defined 18 barriers related to WCAG 2.1 (step 3)	Acosta-Vargas et al. (2020c)

2.6.4 Related Work on Accessibility and Software Engineering

There is limited research focused on incorporating accessibility into agile methodologies and open-source development and mobile applications (Paiva et al. 2021). In addition, there is the need to enhance knowledge of developers and designers on how to consider disabled people in the software development process while combining accessibility, usability, and user experience (Di Gregorio et al. 2022; Rosa and Valentim 2020; Almeida et al. 2021). User involvement methods, such as co-design, participatory design, and patient and public involvement and engagement (PPIE) and responsible research and innovation (RRI), are important in this matter.

Kleinsmann and Valkenburg (2008) define co-design as ‘the process in which actors from different disciplines share their knowledge about both the design process and the design content. They do that in order to create shared understanding on both aspects, to be able to integrate and explore their knowledge and to achieve the larger common objective: the new product to be designed’ (p.370). This definition emphasises the importance of knowledge sharing and developing a mutual understanding. These are key themes explored in this thesis. Participatory design involves the collaborative practice of creativity in the design process (Sanders and Stappers 2008). ‘Patient and Public Involvement’ (PPI) and ‘Responsible Research and Innovation’ (RRI) approaches have been developed to guide health-related initiatives that draw on the lived experiences and expertise of young people. PPI is primarily focused on the concept of active and transformative participation by patients and the public and RRI is considered as research and innovation efforts that responsibly promote creativity in science and technology by anticipating and addressing potential risks or unintended consequences. It focuses on what is socially desirable and in the public interest, while taking into account the perspectives and needs of key stakeholders (de Alcântara Mendes et al. 2024).

Studies have shown that participation offers benefits such as knowledge sharing and skill development. Additionally, these methods give end-users a direct voice in the design of products or services (Muller and Druin 2002; Vallentin-Holbech et al. 2020). However, by applying co-design with disabled people is challenging regarding communication, discussion, and producing artifacts, particularly with VI people. This is because the limitations on engaging in co-design techniques, such as tactile representation due to inability to visualise the artifact at the moment of interaction by another group member (Brewer 2018).

2.7 Design Thinking

There are many models and definitions of Design Thinking (DT), and the common view is its user centred design approach. According to (Brown 2009), DT is “a methodology that imbues the full spectrum of innovation activities with a human-centred design ethos”. This involves innovation enhancement through understanding of people’ needs, preferences or dislike about a product or service.

DT has been widely used among software companies and described as a toolkit for innovative process, centred on final users and business, which involves understanding of stakeholders’ needs and technological aspects to solve problems. The scope is exploratory as designer thinkers gain initial insights to ideate solutions and iteratively further explore and refine the problem and solution (Gurusamy et al. 2016); it is used when the problem is not clear (Nedeltcheva and Shoikova 2017). Its characteristics are empathy, definition, and fast prototyping (Pereira and Russo 2018) and this has often been used with Behavioural Science to foster development of mobile health, e.g., related to diet and exercise, considering relevant behavioural change techniques, theories, and frameworks to help understand the behavioural problem and target behaviour (Altman et al. 2018).

DT has been presented as an organisational resource in three levels: mindset, process, or toolbox (Brenner et al. 2016). In general, the DT mindset refers to DT principles of solving complex problems and innovate with a focus on user needs in divergent and convergent thinking through empathy, test, collaboration, and creativity early in the design process, which reduces redesign, costs and time to development (Dobrigkeit and De Paula 2019). Developers predominantly understand DT as a process or toolbox and typically use methods (e.g., sketching and brainstorming) or small workshops depending on the needs of the project, while more experienced designers and managers see it as a mindset. Those with the DT mindset apply DT not only to improve the software product but also the process or workspace (Dobrigkeit and De Paula 2019).

There are different DT processes or models and its respective methods in the literature described by Brown (2008), d.school Stanford (2010), Wölbling et al. (2012), (Brenner et al. 2016) and IBM Design Thinking (Lucena et al. 2017). Other models mentioned by (Pereira and Russo 2018) are International Organization for Standardization (ISO): Human-centred design for interactive systems, Google Design Sprints, Austin Center for Design, Design Council UK: Double Diamond. The Stanford Design School and Brown processes are the most common applied in software development.

Brown’s Design Thinking has three phases: ‘inspiration, ideation and implementation’, in which Inspiration refers to understand the problem or opportunity to find the solution; Ideation is the

generation of ideas to address the solution, and Implementation involves developing prototypes and obtaining users' feedback (Brown 2009; Parizi et al. 2022).

Stanford Design School's Design Thinking comprises of five phases: 'empathy, define, ideate, prototype and test'. The empathy describes an investigation on the users' behaviour in the context of their lives, the define phase synthesises the findings from the empathy's phase; Ideate is the process to create design solutions; Prototype is when the artifacts are produced based on the solutions developed to be evaluated by users in the Test phase (Parizi et al. 2022).

DT main difference compared to a traditional concept creation phase, which relies on companies to make decisions based on trade studies, is that Design thinking explores others' ideas who are less constrained to envision new concepts and diverse solutions. Thus, the ideate phase can add value to its conceptual design phase (Darrin and Devereux 2017). Researchers have discussed the implementation of Design Thinking and Agile methodologies in software development and identified the added value to its process (Dobrigkeit and De Paula 2019).

2.7.1 Related Work on Design Thinking and Accessibility

Incorporating accessibility throughout the entire software life cycle, alongside user interaction, is essential (Zimmermann and Vanderheiden 2008; Gupta and Bruce 2021; Horton 2021). The lack of comprehensive documentation on accessibility in software design processes often leads designers in different directions, highlighting the need for more practical, applied knowledge to be documented (Gupta and Bruce 2021).

2.7.1.1 Empathy building through accessibility personas

Accessibility should be incorporated into all DT phases. The Empathy and Define phases of DT are essential to create and use accessibility personas to inform technology development. Personas are defined as a tool in which fictional characters are described based on user research to aid designers to better understand the users' needs, preferences and enable their empathy towards the target population (Brown 2009). They are used to maintain the focus on the users on the project and to find out about the users based on the generated personas (Schulz and Fuglerud 2020). The accessibility personas can help designers and developers to identify barriers to technology access, improve the understanding of users' needs, goals, use of assistive technologies and make user-centred design decisions (Heitmeier et al. 2023) based on realistic accessibility requirements (Zimmermann and Vanderheiden 2008). Further, accessibility personas development's stage can help to add the needs of disabled people and reduce the burden of recruiting disabled people for all steps of the project (Schulz and Fuglerud 2020) as a result it can be "just one example of a user in this user group",

however designers need to consider that all users use products in different ways (Henry 2003). Moreover, Zimmermann and Vanderheiden (2008) suggested an integrated approach for accessible design and testing in the development of applications by combining use cases and scenarios, personas and accessibility guidelines. They proposed that personas can describe the user interfaces needs and requirements of disabled users across the stages of the development process, in which multiple personas need to represent one user group. This can help to understand the range of diverse assistive technologies and its usage and context.

The description of how designers can develop personas and user scenarios considering inclusion and accessibility factors are scarce in the HCI literature (Friess 2012; Hill et al. 2017; Edwards et al. 2020; Schulz and Fuglerud 2020; Heitmeier et al. 2023). In general, personas are less often mentioned as part of the decision-making process and as focus during cognitive walkthroughs (Friess 2012). This is especially true in literature related to disabilities and identities (e.g., gender, race, class) (Edwards et al. 2020) and how designers can build empathy to accurately transfer knowledge around the context of lived experiences of users, including social, cultural and experiences of the product use over time (Bennett and Rosner 2019).

There has been criticism about how empathy is performed by designers through a variety of empathy-building activities, such as empathy exercises of simulation or persona creation (Horton 2021). The creation of personas depends on available time and resources to the design team (Heitmeier et al. 2023). It is time-consuming and requires great effort to create accurate personas, otherwise poorly designed personas can amplify stereotypes and misleading conceptions (Hill et al. 2017; Schulz and Fuglerud 2020). Bennett and Rosner (2019) argued that empathy in design process built through immersion, when designers make use of disability simulations, can be a problematic task as it can re-produce designers own perceptions rather than actual experiences of disabled people when using technology. For example, it is not enough and accurate to use one-time simulations to aid the construction of personas, rather strategies such as simulations guided by and co-design sessions with disabled people can enhance the creation of personas. Co-design is “collective creativity that is applied across the whole span of a design process” (Nielsen 2011).

In addition, Horton (2021) emphasises that although there is value of integrating empathy in the design practice, it is still not clear how empathy can influence professionals and companies to act in considering accessibility and the experiences of the end users. This can impact on how companies and professionals can perceive accessibility as a requirement or “the right thing to do”, instead of perceiving it as an obligation by law to inhibit discrimination, or they completely ignore it in the design and development processes. Despite the adoption of empathy and inclusive design approaches, their impact on improving digital accessibility remains limited. This is because of not

giving importance to the legal obligations, lack of focus on accessibility standards in learning programs and professionalism (Horton 2021). In this context, this thesis brings the attention to the creation of accessibility personas as the initial steps towards an inclusive design thinking.

2.7.1.2 Personas' creation, credibility and use

In the tech industry, the Empathy phase appears to be having a lack of practitioners' belief on the potential of personas as a tool for empathising and understanding real users. Designers must justify their personas because developers and those who do not create personas do not believe that personas are relevant and reliable (Hill et al. 2017). In general, personas are not believable due to their fictional-based data, or they are not well presented in projects (Pruitt and Adlin 2006). As Schulz and Fuglerud (2020) states, 'one should not create personas out of thin air to replace gathering input from users' (p. 3) and Pruitt and Adlin (2006) recommends creating personas based on user research, facts, case studies and market information.

A common approach in agile teams is the use of qualitative data (e.g., interviews, focus groups) to create personas (Heitmeier et al. 2023), also teams can use survey and observation methods or conduct a persona workshop (Schulz and Fuglerud 2020). Persona workshop can be used to create personas based on assumptions (e.g., quotes, opinions, and goals) and factoids (e.g., small facts, information from literature, research, or data from the project's user research) developed by participants (Neate et al. 2019; Schulz and Fuglerud 2020). This is a way to know the users' needs and to grab the attention of the project team (Schulz and Fuglerud 2020).

Although there are many ways to create personas there has been a crescent use of quantitative approach to gather large data available from user analytics to cluster user types to develop personas. This identifies key factors of the user type, but it may not construct the nuances and contexts that back up the use of the technology (Fuglerud et al. 2020; Heitmeier et al. 2023). The same issue appears in several research projects, e.g., the Ubuntu operating system, made their accessibility personas available online as a shortcut in the design process (Schulz and Fuglerud 2020). However, this practice of re-using specific personas from other projects is not recommended (Pruitt and Adlin 2006) because it is important to involve the stakeholders and developers in creating personas to gain knowledge about the personas and empathise with them (Schulz and Fuglerud 2020).

2.7.1.3 Ideate phase and accessibility

Participatory design and co-design sessions approaches have been included in the design process with disabled people, where their participation is not only necessary in testing or evaluating technology solutions, but also it is important to have their involvement as early as possible in the ideation phase where the decision-making is relevant to advance the design process (Bennett 2018;

Reyes Cruz 2021). The Ideate phase, also known as brainstorming, needs to be crucial to enable accessible methods to facilitate communication and generation of insights and refinement of products and services with disabled people during co-design sessions (Bennett et al. 2016; Brewer 2018).

Few studies have made ideation design methods accessible to disabled participants, as traditional methods can present challenges for communication and ideation. For instance, participation in group conversations is difficult for deaf or hard of hearing participants and it is particularly challenging for VI participants who cannot access the sketches on papers and handwritten on sticky notes (Bennett et al. 2016) and cannot engage with high level tactile representations, which may involve individuals creating their own designs (Brewer 2018). Therefore, Williams et al. (2015) identified that VI participants prefer to discuss ideas instead of building low-fidelity prototypes.

2.7.1.4 Accessible prototype and testing

Prototyping is a key part of the user-centred design (UCD) process, as it creates user interfaces for testing. This allows for user feedback, helping to improve and refine the designs (Buxton 2007). Creating prototypes in stages requires tools that allow users to try them out and give feedback. With each iteration, simple sketches are improved and turned into detailed, high-quality prototypes (Stephanidis et al. 1998). This thesis follows the definition of prototypes as formulated by Lim et al. (2008) as ‘tools for traversing a design space where all possible design alternatives and their rationales can be explored [...] Prototypes stimulate reflections, and designers use them to frame, refine, and discover possibilities in a design space’ (p. 2). Prototypes allow designers to naturally learn, explore, create, and refine their ideas. They are essential to the design-thinking process, deeply integrated into design practice, rather than just tools for evaluating or validating the success or failure of a design (Lim et al. 2008).

Paper prototyping is a commonly used low-fidelity method for evaluating early-stage product design drafts, however this is not accessible for VI participants to give feedback on the design alternatives (Miao et al. 2009; Shinohara et al. 2016). More recently, developers noted that development tools and its templates (e.g., Android Studio) are neglecting accessibility considerations. For example, Figma prototyping tool is a commonly used tool for designing web and mobile interfaces and it presents accessibility issues on designed prototypes, such as low contrast and touch target size (Holanda Muniz et al. 2024). This is one of the concerns of this thesis on how to allow VI participants to access the prototype of a mobile application in order to provide feedback that can help to improve the prototype for the next iteration. More details on this concern are described in the Chapter 3.

Not only prototyping can be challenging, but also testing with VI participants. In general, accessibility audits are usually conducted during the quality assurance and user acceptance testing phases (Horton and Sloan 2014). Although various accessibility testing resources are available on the market, it remains essential to integrate co-design and continuous feedback mechanisms throughout the design process, refining them with each iteration (Gupta and Bruce 2021). That is why the prototypes need to be accessible for VI participants, but the existing prototyping tools (e.g., Figma) cannot offer adequate accessibility features during the design of the prototype Holanda Muniz et al. (2024).

The disability simulation is a common practice of accessibility testing among designers, especially simulation related to VI, due to the difficulties in recruiting disabled people, limited resources, and lack of designers' awareness about the issues of this practice (Goodman-Deane et al. 2007; Tigwell 2021). This can lead to misleading findings from testing as disabled people interact with digital systems differently than a person without impairment (Goodman-Deane et al. 2007; Tigwell 2021). Several authors argued the importance of user evaluation with disabled people rather than simulations (Tigwell 2021). Instead, simulations can be a resource for empathy and learning among designers about users' impairments (Goodman-Deane et al. 2007; Bennett and Rosner 2019).

2.8 Agile Development

The Agile development can enhance and ensure the quality through many test cycles (Flora et al. 2014) of incremental mini releases with a set of features in each of them to create a working version during regular iterations or sprints (e.g., usually two to four weeks long) (Sy 2007), iterations are a period to develop and test a prototype (Kieffer et al. 2017). This also applies experimentation and adaptation of mobile apps with each release. The first release is a minimum viable product – MVP which offers prioritised features and further versions are incremented with additional features (Flora et al. 2014). This process runs in the most popular frameworks such as Scrum, Extreme Programming (XP), Lean and Kanban (Pellegrini et al. 2020). XP, or Extreme Programming, is a software development methodology blends all the activities (e.g., analysis, design, implementation, test) to the shorter and iterative development cycles throughout the entire software development process (Beck 1999). The XP is a method addressed to small teams and values communication between all people involved in the project, simplicity, early and often feedback, with focus to deliver high quality functionality as quick as possible (Maurer 2002). The focus of Lean is continuous learning and enhancement of the project, which applies lean manufacturing principles of reducing waste by eliminating unnecessary or unclear code and functionalities and delays in the process (Flora et al. 2014). Kanban is an approach to help development teams to visualise and limit the project's progress at each workflow phase and measure the project's cycle and communicate priorities and things preventing the flow of activities (Ahmad et al. 2013).

Although its popularity, the phase of requirements engineering is not well defined which increases the time for development and costs, therefore the suggestion is its integration with Design Thinking to improve the comprehension of the users' needs (Alhazmi and Huang 2020). Integrating UCD with agile development has the potential to assist agile developers in the challenging task of involving end-users. Beck and Andres (2008) recognised the complementary strengths of Interaction Design and XP that could be combined. Various approaches have been proposed to merge HCI and agile practices. For example, Kane (2003) suggested integrating 'discount usability' with agile development, while Ambler (2002) offered models to facilitate interaction between users and developers in agile projects. This potential suits well in mobile application development to improve and speed up development, to work with high volatile requirements and uncertainty levels, to encourage active stakeholder involvement, feedback, and suggestion of new features, to help discover risks at early stage, to build more quality and reliability through iterative tests, to enhance the user experience.

In general, User Centred Design - UCD process has been extensively applied in Agile development, however, with limited explanation on how usability evaluations are integrated in Agile (Kieffer et al. 2017), as UCD relies on observing user behaviour in usability evaluation methods and contextual inquiry before a software implementation (Sy 2007). In order to overcome this issue, usability and UX methods have been integrated in Agile practices, called Agile UX. This allows a UX team to conduct iterative and incremental activities involving users, where upfront activities are set to obtain a product solution vision, user, and functional requirements. This aids the coordination of formative usability testing and agile iterations in design and development. That means the formative usability tests refines requirements in the beginning of design process, which matches the iterative nature of Agile activities (Kieffer et al. 2017).

2.8.1 Related Work on Agile Development and Accessibility

Pellegrini et al. (2020) argued that agile teams often delay the integration of accessibility into the development of MVP. This is because of lack of knowledge about accessibility and how to implement it. Little research has been done to make the accessibility integration into Agile UX (Bai et al. 2017).

There are challenges to design and test for accessibility due to the difficult access to people with impairments, limited automatic accessibility checking tools and developers are not aware of how the existing automated tools can support accessibility checking (Silva et al. 2018) and scarcely use accessibility testing tools, such as Accessibility Inspector for iOS and Accessibility Checker for Android (Leite et al. 2021). As a result, these constraints lead to increased time and cost for implementation. Accessibility testing methods can be integrated into the Agile development process. However, there

are few guidelines on how to select methods for accessibility testing and apply them in the Agile process considering economic feasibility. Accessibility testing does not require large financial investment, instead it can reduce costs of redesign (Bai et al. 2017).

2.9 Design Thinking, Agile UX Software Development

DT can enhance agile development by supporting the agile activities and its values and principles. In the agile activities, DT especially supports the initial phase of design requirements through interviews and observations. It also supports development of the software product in the ideation, prototyping and testing phases, which include co-creation and validation with users (Dobrigkeit and De Paula 2019) and focus on human behaviour (Nedeltcheva and Shoikova 2017).

DT contributes with agile' values of collaboration with stakeholders through DT activities (e.g., interviews, co-creation), and supports the agile principle about customers' satisfaction through early and frequent deliveries with DT techniques (e.g., visualisation and prototyping) to offer the software concepts. In addition, DT visual techniques such as personas and user journeys can enable communication and clarification of requirements to support the Agile empirical process control principle (Dobrigkeit and De Paula 2019). In addition, some Agile methodologies based on DT principles have included the collaboration of end-users, such as Lean UX, Design Sprints and IBM Design Thinking.

Lean UX is a user centred and fast software development framework developed from Agile software development, DT and Lean production. This starts by defining the problem and assumptions, create solution hypothesis, sketches and a prototype which is further developed to create an MVP reviewed by end-users in micro-testing and interviews every week. The Design Sprint is a structured framework with limited time in which teams define product and business goals and scope prior development phase, identify the audience, business opportunity and competitors, which is used to develop a value proposition for a new feature, product, or service. Prototypes are also tested with end-users representing the target users (Lucena et al. 2017). IBM Design Thinking differentiates from other models by the addition of the *Hill* concept, a new way to write user needs and customer perspectives, describing the user, the problem to be solved and goals, *Sponsor Users* as real end-users and *Playbacks* are reviews of the project by the project team and Sponsor Users (Lucena et al. 2017; Parizi et al. 2022).

Research on both DT and Agile approaches have been applied throughout the software lifecycle ensuring the user needs and usability of the product, which can promote user satisfaction and project success (Darrin and Devereux 2017; Pereira and Russo 2018). DT seeks to understand the problem and find a solution to tackle the users' needs, while Agile aims for simplicity, continuous and

fast deliveries, numerous feedback cycles, and quick changes (Gurusamy et al. 2016). Essentially, this is about how solutions are delivered (Nedeltcheva and Shoikova 2017).

Nedeltcheva and Shoikova (2018) argued that there are few studies and books about how to incorporate DT, UX Design and Agile development process. Both DT and UX are similar approaches, although DT is problem and solution focused, whereas UX is more focused towards the user interaction, reactions, context of product use (Adikari et al. 2009) and formative usability methods, which complements the iterative cycles with user feedback by using releases as prototypes during usability testing (Kieffer et al. 2017). Thus, the three methodologies' complementarity enhance the problem definition and clarification of requirements through DT, while iteratively requirements change in Agile, and UX methods are present in all iterations to foster innovation, creativity, and profitability advantages (Nedeltcheva and Shoikova 2018). The DT, UX design and Agile complementary offers the advantage of obtaining the contextual requirements efficiently from stakeholders' shared knowledge and opinions in the context, including product functionalities and the whole user experience (Adikari et al. 2009).

2.10 Summary and Motivation for Research Program

A body of evidence has indicated that innovative ways using online technology, such as mobile application, may lead to improvements on how physical activity information and social support can effectively reach VI young adults. This population may need more support as they are less physically active than other disabled groups and sighted peers, while they face new life challenges of employment, higher education during the transition into adulthood. This research has also indicated that existing methods of physical activity information need to be more detailed and personalised with a good flow within a communication network, which includes physical activity service providers and peers for arrangement of physical activity together. In order to enhance the information and support for physical activity behaviour change, there is a need to identify how to devise an accessible mobile application as a potential way to tackle those needs.

Developers and designers need support on how to design and evaluate an accessible and usable mobile application for VI people. Research on this matter in the modern software engineering lifecycle, such as Agile model, has not been addressed. Moreover, the nature of the research problem of this thesis requires the integration of other methodologies, such as Design Thinking and User Experience to guide the development of mobile application centred on its users. There is evidence that a few studies have been conducted by integrating Agile UX or Design Thinking with mobile accessibility, the combination of these three methodologies and its techniques have not given focus on accessibility (Figure 2.1), as a result developers and designers face challenges when dealing

with the development of new products for people with VI where the problem is complex or not clear, as it is the case of physical activity information and support for VI young adults. This thesis aims to explore how developers and designers can devise a technology by integrating methodologies to help to elicit the requirements with focus on further understanding the needs and experience of young adults with VI and from the physical activity providers' perspectives on the service provision of physical activity information.

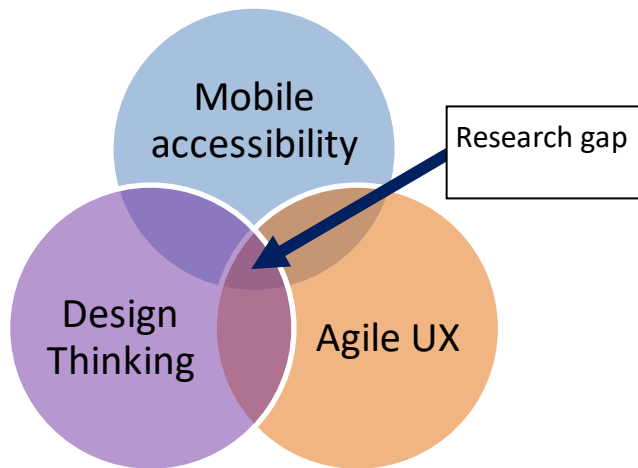


Figure 2.6 Research focus in the intersection of mobile accessibility, design thinking and agile UX

Chapter 3 Research Methodology

3.1 Introduction

The previous chapter reviewed relevant literature to provide context for the research problem, focusing on the lack of guidance for designers and developers regarding approaches and methods for creating accessible mobile technology. The current chapter discusses the key methodological concepts, theories, and the planned steps of the research design, explaining the rationale behind the studies aimed to answer the research questions. It provides a brief overview of the data collection and analysis methods used, with detailed information presented in the subsequent study chapters.

3.1.1 Stage One

The research methodology started from exploratory research through the literature review presented in Chapter 2. This stage aimed to identify the research gaps, previous studies in mobile accessibility, and related software development processes' publications, and behavioural theories. The research gaps revealed the main areas to be addressed in this study. As a reminder, these gaps referred to the initial identified needs of a communication network to offer more detailed physical activity information and support for VI people, lack of studies with VI young adults and lack of knowledge on designing and testing accessible and usable mobile application among developers and designers in Agile environments.

To this end, the literature addressed the sub-research question SRQ1 - *How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?* The literature review used several keywords, such as “accessibility and software development”, “accessibility and mobile application development”, “design thinking and agile”, “accessibility and design thinking”, “accessibility and agile”, “user experience and mobile application development” in databases of search platforms (Association for Computing Machinery-ACM, Web of Science, Google Scholar, Science Direct, Institute of Electrical and Electronics Engineers-IEEE Xplore). A content analysis was carried out to identify the key categories (see Chapter 4) to serve as insights to design an accessible mobile application in the Stage Two, which corresponds to the DT's *Empathise* phase. Literature search was conducted to identify mobile development processes, methods and tools adapted to VI people, although there are limited studies and sometimes methods were not well described. This stage led to establish the research conjecture, objective, aim and refine the research questions.

3.1.2 Stage Two

Since the research questions and identified gaps in the literature required further exploratory research, the methodology employed a practical strategy to design and develop an accessible and usable mobile application. This stage comprises of the *Define, Ideate, Prototype* and *Test* of DT's phases, which are divided in Phase 1, 2 and 3 (see diagram 1 in Chapter 1) and overlaps with Agile UX releases. The Stage Two aimed to consider the user in all test phases, reframe the context and identify usability and accessibility problems, as well as user and coaches' insights. This stage aimed to answer the sub-research question SRQ 1 - *How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?*, as it intended to, respectively, collect data about the needs and physical activity experience of young adults and their feedback on the proposed app; coaches' perspectives on physical activity participation of young adults with VI and feedback on the app; and the accessibility, usability and user requirements to improve the app.

In Stage Two, a Software Engineering MSc student joined the study to develop the mobile app, as the author lacked programming skills. Her involvement also formed the basis of her master's dissertation project, with both students working under the guidance of the same supervisor. The MSc student and author worked together in the Phase 1 (mid-fidelity prototype) and Phase 2 (high-fidelity prototype); For Phase 3 she was no longer available and so another developer was used. The stage 2 aimed to identify a potential solution in order to help the target audience, young adults with VI between 18 to 30 years old, to find physical activity information and support. This age range was determined based on previous research (Gowin et al. 2019), as there is no common agreement in international or national demographic data systems or policies designating an age range for young adults (Walker-Harding et al. 2017). The next sub-sections describe the methods and approaches used in the Phases 1, 2 and 3.

3.1.2.1 Phase 1: Mid-fidelity prototype

The Phase 1 (see diagram 1 in Chapter 1) aimed to set the context of app use, define the design concept, and validate the initial requirements in terms of accessibility, usability and features by VI young adult. This phase was based on the *Little Design Up Front* (LDUF) approach (Adikari et al. 2009) where essential user centred requirements are determined to support the design in agile projects. (Meszaros and Aston 2006) support the use of LDUF and paper prototype in early user evaluations, as opposite to the *Big Design Up Front* (BDUF), as the LDUF elicit early feedback to guide the agile development differently of BDUF which requires extensive and long research about the user needs (Meszaros and Aston 2006; Da Silva et al. 2011). As paper prototyping is an inaccessible technique,

another technique was identified and applied in the DT's prototype phase. This technique is more explained in Chapter 4. The author had not identified a similar published technique with VI people.

The *Define* phase aimed to synthesize and empathise through development of personas and user stories from categories of the content analysis of the literature review. This step was important for the author and therefore the MSc student to better understand the user needs, context of app use, accessibility and usability requirements, the technical feasibility, and prioritise the features described in Chapter 4, which set the initial requirements for the development of the MVP. Additionally, the *Ideate, Prototyping and Testing* phases were carried out as part of the LDUF approach. Both MSc student and author produced sketches, discussed ideas, and decided to proceed with one solution to create and evaluate the mid-fidelity prototype in Microsoft PowerPoint following the Engelberg and Seffah (2002) *rapid prototyping method* approach and user evaluation method (Chapter 4). The evaluation aimed to validate and obtain feedback from VI young adults about the app's concept and usefulness, identify accessibility and usability requirements and more potential functionalities. This phase also provided the author with a good understanding of the best way of communicating about usability and accessibility with a developer.

3.1.2.2 Phase 2: Minimum Viable Product Development and Evaluation

The Phase 2 consisted of the development of the mobile app, the MVP, in React Native, a cross-platform development framework, after refinement of design requirements of the mid-fidelity prototype. In addition, the implementation used a database provided by Metro Blind Sport, a VI sport charity based in London. This phase related to the *Prototyping* and *Test* from DT phases, which overlaps to some extent to the Agile UX iteration. The app was built for iOS and Android, but only the Android version was released for accessibility manual checking and think-aloud user testing due to the immediate availability of author and MSc student's Android mobile phones. This phase aimed to evaluate the app's accessibility, usability, and usefulness of its features with young adults with VI. More details about this phase are in Chapter 5.

3.1.2.3 Phase 3: Minimum Viable Product Update and Evaluation

The phase 3 comprised the code update and release of both iOS and Android Beta versions, automated and manual accessibility checking (Chapter 6); online think-aloud user evaluation and interviews with VI young adults (Chapter 7 and Chapter 8) and online sessions of app demonstration and interviews with physical activity coaches (Chapter 9 and Chapter 10). All participants took part in the study via online video sessions. To the authors' knowledge no other study has undertaken user evaluation online with VI participants. This phase aimed to further evaluate the accessibility, usability and features and obtain feedback and suggestions of improvements or new ideas from participants.

The aim to involve coaches was to obtain their perspectives about the physical activity experience of VI young adults, understand their work experience with them and elicit their feedback if the app would be useful for them to improve the service in physical activity and new insights for the mobile app.

Pilot studies were conducted online with VI testers and a coach invited to test the user evaluation and interview protocol prior the online user evaluation with recruited VI young adults and coaches. The automated and manual checking was carried out during the author's internship at Microlink PC with the assistance of a Digital Accessibility Consultant. It used the Web Content Accessibility Guidelines Evaluation Methodology - WCAG-EM to evaluate the app and adapted its report tool in Microsoft Excel. A similar approach was conducted by (Acosta-Vargas et al. 2020c; Acosta-Vargas et al. 2020d; Acosta-Vargas et al. 2020b; Acosta-Vargas et al. 2021a; Acosta-Vargas et al. 2021b), however, they did not use the WCAG-EM report tool and provided no detailed clarification about the phases of their proposed method.

3.1.3 Stage Three

This intended to answer the question 1 related to the design requirements in the design process, mentioned in the Chapter 1. This stage was conducted simultaneously with stage two for time efficiency and to be used in the triangulation analysis. This stage aimed to help identify the needs, barriers, and facilitators of physical activity among VI young adults. This applied an accessible online survey to collect the data for descriptive statistics analysis, to gauge the physical activity level, barriers to physical activity, and physical activity preferences of VI young adults. The survey used a standard physical activity self-report questionnaire, the Global Physical Activity Questionnaire (GPAQ), and was based on the COM-B model (see Chapter 2) using the COM-B Self-Evaluation Questionnaire (COM-B-Qv1). The COM-B model is a simple behavioural framework of three elements: Capability (physical and psychological), Opportunity (physical and social) and Motivation (automatic and reflective) which can help to understand behaviour in the context in which it happens, where Capability and Opportunity affect Motivation and, therefore the behaviour (Michie et al. 2011; Howlett et al. 2017). Due to low number of respondents this survey was kept open longer to obtain more responses for data analysis. Detailed explanation of study design and method is in Chapter 12.

3.1.4 Stage Four

This stage aimed to answer the sub-research questions SRQ2 - *Does the design guidance developed provide all accessibility requirements?* This intended to answer the question 1 related to the design

requirements in the design process, mentioned in the Chapter 1. This stage was conducted simultaneously with stage four for time efficiency and to be used in the triangulation analysis. Triangulation methodology was applied to merge the findings from the literature review, user evaluation and interviews, and online survey analyses using Affinity Diagram technique to help make sense of the raw data (Hartson and Pyla 2012). This study followed the same approach used by Amershi et al. (2019) when they created design guidelines based on the design guidelines from diverse sources. They synthesised it through affinity diagram process.

In this study, the affinity diagram was used to help synthesise and propose design guidance for accessibility considerations when designing mobile app for physical activity for VI young adults. Additionally, the design process was also created based on this PhD study. Affinity Diagram was applied with the purpose to help develop the guidance for accessible and usable mobile application design and development to be reviewed by designers, developers, and accessibility specialists.

This review used a questionnaire with 5-point Likert scale to evaluate the guidance understanding and potential use by designers and developers. The questionnaire was based on the questionnaire developed by Qbilat et al. (2021) to evaluate their proposed design guidelines from designers and developers' perspectives on accessibility guidelines for human-robots interaction. After data analysis, the design guidance was updated with the suggestions from experts. The ideal evaluation of the design guidance would be through a case study where a design and development team could undertake a project to apply the design guidance in a practical setting. This would assess whether the process and outcomes support accessibility, usability, and user experience. Another alternative is a small task where developers create a prototype using the design guidance and conduct usability testing with VI users. This approach would evaluate whether the design guidance can help to design solutions that meet the user needs. These approaches would allow participants to evaluate how well the proposed design guidance would be useful in a realistic Agile setting with satisfactory outcomes. This was not possible to conduct in this PhD study due to limited time. This can be a future work. More details about the method and analysis are in Chapter 13.

3.2 Summary

This chapter presented the methodologies, methods and techniques used throughout the study in order to answer the research questions. The study was presented based on four stages of the research methodology. The Stage One aimed to set the research scope through literature review and to progress the study in the next stage. The Stage Two involved practical design studies aimed to identify methods, techniques, and design and evaluate an accessible and usable mobile app in Android and iOS. The Stage Three aimed to examine the physical activity levels, barriers and

Chapter 3

facilitators for VI young adults participate in physical activity. The Stage Four aimed to synthesise the findings to create and evaluate the design guidance for accessible and usable mobile app aimed to help VI young adults to participate in physical activity and general considerations for design process and mobile accessibility. Overall, this chapter discusses the research methodology strategy used to conduct the studies through literature review, accessible online survey, design and evaluation methods, and the triangulation as a methodology approach to design guidance for expert review.

Chapter 4 Study 1: Design and user evaluation of mid-fidelity prototype app with VI young adults

4.1 Introduction

The last chapter was about the Research Methodology, which informs the research design of this PhD study and discussed the applied key methodological concepts and theories, for instance, to undertake the research and design and development of the mobile application, ActiveVI, and the accessible online survey (Chapter 3). In this study, the literature review provided insights on the research problem which seemed that VI young adults may need extra support to participate in physical activity and sport. This participation may involve building knowledge on how to do physical activity or play a sport, planning activities and to know how to get to venue, and social support in a way that may help to build their confidence to do physical activity and sport. These may be the major elements of a service provision that could be implemented through a mobile application. A combination of online physical activity and sport information and interaction between users and service providers could be used to offer behaviour change support, decision support and peer support (Murray 2012).

This chapter presents the first phase of the app design and development. This describes the design plan, development, and user evaluation of the mid-fidelity prototype app. A few studies with VI people developed and explained the process of designing an accessible prototype of digital products (Miao et al. 2016; Albouys-Perrois et al. 2018), as described in the literature review (Chapter 2). Therefore, this chapter discusses the development of the mid-fidelity prototype app, highlight its contributions to inform designers and software developers on how to design it for an accessible mobile application to assist VI young adults to participate in physical activity and sport. Although, the design of the mid-fidelity prototype app was specific for VI young adults and physical activity and sport experience, the contributions can help to build general knowledge of designing accessible mobile applications for VI people in any context. In addition, it reports and discuss the methods and results of the think-aloud user evaluation with VI young adults.

4.2 Aim

The design and development of the mid-fidelity prototype app aimed to help to validate and explore the design requirements of a mobile application to assist VI young adults in participating in physical activity and sport in the UK. The prototype design study was an instrument to help to answer the

sub-research question SQR1 - *How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?*

4.3 Method

In a broad viewpoint, the design strategy of this study corresponds to the application of the UCD method which aligns with the lens of the Design Thinking methodology. The Design Thinking can help to expand or narrow the potential solutions by allowing the discussion and sharing of ideas among different stakeholders, which can be achieved through rapid prototyping and testing what is feasible (Shahrasbi et al. 2021). The Design Thinking has been recognised as an adequate methodology to develop usable and engaging mobile applications due to the active participation of all stakeholders in the design process and its iterations. In addition, the decision to undertake this research on mobile application was due to the increased use of mobile applications among VI users (Shoaib et al. 2023), and the mobile technology was recommended as an innovative way to offer information about VI physical activity and sport (Women in Sport et al. 2016).

The Agile methodology was also applied in the UCD method of this study to develop a Minimum Viable Product - MVP. MVP is a working and functional version of a new product or service with the lowest possible resources aimed to test the users' reactions and understanding of the idea prior to further investment (Pellegrini et al. 2020). This approach known as Agile UX integrates both human-centred and cyclical approaches (Jurca et al. 2014). This is important for a set of design activities that involves iteration, early user feedback, and management of emergent requirements and provides flexibility and structure to the project (Preece et al. 2015). Thus, this approach helps to increment the work by developing a subset of required features of the final product, in which is necessary also to include accessibility in the early stages of the design process (Pellegrini et al. 2020).

The early stages of the design process of this study included steps for the identification of the research problem, development of personas and user stories, draft of the design concept and MVP requirements in the prototyping phase. In the phase 1 of the research design, the author created strategies to design a mid-fidelity prototype app. The author uses the term 'mid-fidelity' as opposite to 'low-fidelity' because of the characteristics of the mid-fidelity prototype. The 'mid-fidelity' characteristics are referred as a wireframe form of simulated interactive functionalities and navigation, with lower cost and time than high-fidelity when creating a prototype at the early design stage (Engelberg and Seffah 2002). These characteristics seemed to be adequate to allow the use of assistive technologies, such as screen reader, to use a functional prototype app.

On the other hand, the low-fidelity prototype is typically a paper prototype which is recognised as not accessible to VI people (Miao et al. 2016) and for this reason it was not considered for use in this

study. Paper prototyping has different modalities e.g., visual, haptic and tactile, although the visual is the most simple and common type of prototype, and as it just uses paper and pen, it prevents its use by VI people, especially screen reader users. Even though the haptic paper prototyping can use cardboard and simulate interaction, it is also inaccessible. While tactile prototyping of mobile application allows interaction, it does not allow use of screen readers and does not provide a realistic user experience (Miao et al. 2016).

The author elaborated the design requirements of the mid-fidelity prototype app based on the findings from the literature review (Chapter 2). Throughout the phase 1, a MSc student in Software Engineering at the University of Southampton helped develop the prototype app for the author as part of her Master dissertation project. Recommendations on accessibility and usability were consulted during the prototype development, such as the WCAG 2.1 guidelines and Nielsen's usability heuristics. Although, the focus of these recommendations is on websites, they can however also be applied to mobile development (Patch et al. 2015).

Regarding the usability guidelines, this study attempted to apply the heuristic rules of thumb proposed by Nielsen and Molich (1990). These rules are the visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; help users recognize, diagnose, and recover from errors; help and documentation. By using a mid-fidelity prototype it would not be possible to be consistent with all the heuristics because it was not realistic as a fully functioning mobile application. However, some recommendations could be followed such as making the language used in the prototype familiar to the user, keeping consistency of elements and layout between screens, instructions for use of the system easily recognised, possibility to tailor the actions according to user needs and speed their actions; and maintaining necessary information displayed.

4.3.1 Design strategies

4.3.1.1 Categories from literature review

The first phase of Design Thinking methodology, the Empathise phase, aims to gain understanding of the problems faced by the target public. Inductive content analysis was applied to obtain insights from the literature review on the experiences of VI people in participating in physical activity and sport. This method is used to obtain a broad description and knowledge of the phenomenon, facts, and new insights to guide practical actions (Elo and Kyngäs 2008).

Although, the interview method is the most common method to gather user needs, and design thinkers also may engage in other different methods, such as ethnographic observations (Shahrasbi et al. 2021), the objective was to obtain insights about the problems and solutions (Manjunath et al. 2021). Hence, the literature review was enough to gather these insights and make the process quicker instead of recruiting participants for interviews at this early stage.

In the literature review, the categories were identified across the literature that showed evidence of the research problem and potential solutions. As mentioned previously in Chapter 1, the research problem was the low participation of VI young adults in physical activity and sport. From the inductive content analysis, the author created categories which synthesise the main topics and identified potential ways to help VI young adults to overcome the barriers in physical activity and sport. As discussed in the literature review (Chapter 2), these barriers are lack of company to get active, few sport and physical activities available to them, environmental barriers, need to know of available physical activity and sport, lack of independence and transport to the venues, costs, lack of information physical activity opportunities, level of ability and safety concerns and low self-confidence to take part (Rimmer et al. 2005; Jaarsma et al. 2014; Berit Augestad and Jiang 2015; Women in Sport et al. 2016; Haegele et al. 2017a; Haegele et al. 2018; Wrzesińska et al. 2018).

The identified categories were planning, social and motivation. Planning was a category about facilitating mobility, finding physical activities and events, peers, and coaches. Social was about needed support from online communities and organisations such as charities, gym, sport clubs, and motivation regarded the behaviour change and knowledge about VI physical activity and sport.

All these categories were around services in physical activity and sport to address the research problem and gaps, such as the need to improve the network support and information sharing about opportunities in physical activity and sport for young adults with VI. These categories were the foundation for the concept design and requirements to develop the accessible mid-fidelity prototype.

4.3.1.2 Definition of preliminary design requirements

The goal of design requirements is to determine what needs to be built before system development begins, reducing the risk of expensive rework later on (Paetsch et al. 2003). The concept of the accessible mid-fidelity prototype was regarding services on information seeking for transport, physical activities, peers, and coaches' support. The initial design requirements were based on the themes identified in the literature review on physical activity information and experience of VI people. These themes are the most relevant issues that prevent their participation in physical activity.

Therefore, the initial requirements aimed to address these issues to some extent to enhance the user experience when searching physical activity information and support and required simple interfaces with large text and buttons. This means to facilitate the search and provide detailed information about what accessible exercises or sports are available, how to take part in them and what support is available. This would help to overcome the lack of support and knowledge on inclusive physical activities. For example, information on transport and group pick-ups for activities may provide assurance and easy to find where and how to get to the sport venues without the need to swap applications to search the venue's location or to ask others.

The following initial design requirements extracted from the literature review analysis:

- Transport planning
 - Finding public transport for a specific event directly from the application.
 - Organise group pick-ups at a specific location by sports clubs.
- Physical activities and sport planning
 - Finding information about physical and sports activities.
 - Finding events for a specific physical and sport activity.
 - Finding events at a specific location, time, date.
 - See information for a specific event.
 - Schedule your timetable with your events.
- Knowledge about physical activity and sport
 - Benefits of physical activity.
 - audio description of specific physical activity.
 - stories from others.
- Social
 - Communication with organisations and charities.
 - Communication between user and coach for assistance.
 - Create personal profile (name, email, favourite activities).
 - Finding a partner for a specific event.
 - Social networking features such as posts, comments, share stories.
- Motivation techniques
 - Promotion of competitions with awards.
 - Track progress for a specific activity exercise.
 - Show recommended workouts based on user interests.
 - Ranking based on individual progress.
 - Reminders of physical activity and sport sessions.

The initial design requirements were developed, reviewed and improved through continuous requirements activities and iterative phases of Design Thinking, which are summarised in the Table 4.1. The feedback from VI young adults and sport coaches were relevant for validation of the design requirements and co-design ideas and improvements in the stage 2 (phase 1, 2 and 3), which are described in the Chapter 1.

Table 4.1 Summary of requirements activities and design thinking phases

Requirements Activities	Empathy	Define	Ideate	Prototype	Test
Elicitation	yes	yes	yes	yes	yes
Analysis		yes	yes	yes	yes
Validation				yes	yes
Update/review		yes	yes	yes	

To move forward with the ideation, prototyping, and testing phases, a master's student in Software Engineering from the University of Southampton joined the study. She and the author worked together in close collaboration on the design project. This collaboration and work had practical advantages for both students – the master student worked on this research as part of her master's dissertation. Her and the author received guidance by the same supervisor, and she coded the mobile application prototype to overcome the author's limited programming skills. Her role was to assist the author in decision-making in technical feasibility and coding the mobile application. She and the author had several meetings to discuss the project, schedule, and work plan. The author's initial ideas and accessibility, usability and user experience considerations were discussed with her. The author had to guide her about WCAG 2.1 accessibility standards and assistive technologies to help build her awareness of the accessibility foundations and implications for the prototype. Her involvement focused on the stage 2 (phase 1 – mid-fidelity prototype design and phase 2 – MVP development and evaluation) and another software engineer worked on the phase 3 (MVP update and evaluation).

4.3.1.3 Prioritising design requirements

In the Agile process, design requirements are outlined in sufficient detail to begin software implementation, with development proceeding based on prioritised requirements. (Preece et al. 2015). Prioritisation is a key aspect of all agile methodologies. In general, agile teams often focus on implementing the highest-priority features first, ensuring the delivery of maximum business value (Paetsch et al. 2003; Alhazmi and Huang 2020). The author and the master student conducted requirements analysis based on the prioritisation technique (Kotonya and Sommerville 1996; Paetsch et al. 2003) of the initial design requirement list to evaluate the necessity, consistency, completeness, and feasibility of the requirements (Alhazmi and Huang 2020). The list of design

requirements made from the analysis of the literature review was ranked from 1 (most important) to 5 (least important) related to the technical feasibility of implementation and most relevant features to be evaluated as early as possible, especially with restricted schedule and resources. The feasibility analysis resulted in a list of agreed requirements (Table 4.2).

Table 4.2 List of prioritised design requirements

Name	Definition	Priority (1-5)
Finding activities	Users will be able to find information about physical and sports activities.	1
Finding events	Users will be able to find events of physical and sports activities. They will be able to find events based on location, date, and time.	1
See event information	Users will be able to choose an event and view its information such as description, address, and cost, among others.	1
Finding coach	Users will be able to find coaches and communicate with them.	2
Finding public transport	Users will be able to find public transport for a specific event.	2
Finding other ways of transport	User will be able to find other ways of transport for a specific event such as volunteer drivers or group pick-ups.	5
User Profiles	Users will be able to create their profiles with their details and interests.	3
Recommendations	The app will be able to suggest activities or events to the users based on their interests.	4
See users' profile	Users will be able to see the profile of other users. For example, users will be able to view the coaches' profile and vice versa.	3
Organise agenda	Users will be able to add the activities to their plan and organise their agenda.	4
Promote competitions	The app will be promoting competitions based on user requirements.	5

This analysis was a ranking of priorities for the features that were based on the technical feasibility and time for the development during the student's Master dissertation project (3 months). Some features were excluded such as the tracking user's progress because it would make the app to become too complex. As suggested by the MSc student these types of features could be provided through a separate fitness app. Also, it was not possible to add a fully functional social network in the app due to its complexity and the short amount of time during the MSc project.

Therefore, both author and MSc student decided to include only basic social features such as the use profile of VI young adults and communication between VI young adults and coaches. Initially, the author wanted to create two distinct user profiles, one for young adults with VI and the other for

coaches. However, the MSc student explained that would be difficult to implement during the phase 2. Hence, the VI young adults' profile and the functionalities regarding to this profile were the focus of the prototype design.

After prioritising the design requirements, personas and scenarios, and user stories (Appendix A) were created for better communication between the author and MSc student about the user characteristics, requirements, goals, and accessibility features to be considered during the implementation of the application the technical capabilities for the development of the application.

4.3.1.4 Computer-based prototyping

The author decided to use Microsoft PowerPoint to develop an accessible mid-fidelity prototype to enable VI participants to use assistive technologies such as screen reader and magnification. The decision to use Microsoft PowerPoint was driven by its availability as a convenient tool for creating realistic mobile app interface prototypes. It also allowed for easy integration with assistive technologies, making the prototypes accessible for user evaluation. Computer-based prototypes designed in Microsoft PowerPoint are widely used and accepted to produce a mid-fidelity level of prototype (Hosseini-Khayat et al. 2011; Latiff et al. 2019) and recommended for simple user interfaces (Miao et al. 2016). At this level of prototyping and early stage of design, designers can easily create screens with enough detail to provide usable and direct navigation and manipulation of interfaces, without spending a lot of time and money to build a high-fidelity prototype (Engelberg and Seffah 2002).

4.3.1.5 Rapid prototyping method

There are two approaches to produce prototypes, namely top-down and bottom-up (Wilson and Rosenberg 1988). In this study, the author used a mix of both approaches where although the functional requirements are known in advance, as it is defined in the top-down approach. There is also the bottom-up approach as incorporation of a 'best guess design' that can iteratively progress and refine until achieving the usability requirements because it applies to the design of new products to support new tasks, and it is not heavily based on task analysis or needs (Engelberg and Seffah 2002).

Prototyping relies on the selection of a design method and a prototyping tool, which depends on the nature of the simulated product (Wilson and Rosenberg 1988). Engelberg and Seffah (2002) suggested the 'generic rapid prototyping method for mid-fidelity prototypes' for websites and they presented it with the application of Microsoft PowerPoint to build mid-fidelity prototypes. This method is presented as a framework, instead of a step-by-step guide, to easily develop prototypes with usability considerations applied at early stage of the design. Although this is an adequate

method to apply principles of usability early into the design, no recommendation was given about the opportunity to apply accessibility as well.

In this context, the author created the mid-fidelity prototype in Microsoft PowerPoint by structuring the slides according to mobile screen size, text box as user interface elements like buttons. The creation process was discussed and revised with the master student for considerations of the feasibility features for the implementation phase.

4.3.1.6 Manual testing

The author conducted quick tests of the mid-fidelity prototype using the 'Check Accessibility' function of Microsoft PowerPoint while designing it. By checking for accessibility in 'Accessibility Checker' several shapes were highlighted to add alt text, such as arrows. However, if those elements did not have a function, then they were marked as decorative. In this way, the screen reader read it as decorative which meant that it was not significant.

After completed the prototyping, the author and MSc student both later checked accessibility manually on their Android mobile phone. All links and navigation were tested in the Android mobile phones through the Microsoft PowerPoint slideshow mode. The author chose to conduct the accessibility check prior to the user evaluation with VI users and opted to use only two Android mobile phones for testing and user evaluation in Phase 1 of the PhD study, based on the availability of their personal devices. The mid-fidelity prototype was reviewed by the author, MSc student and another PhD student in their final year in Digital Accessibility at the University of Southampton.

4.4 Mid-fidelity prototype app: Design and development in Microsoft PowerPoint

Both author and MSc student elaborated and discussed the preliminary sketches of design ideas for the interface screens before starting the rapid prototyping by following the generic and rapid prototyping method. The discussed and agreed drawings involved the main decisions for the preliminary concept design and information architecture. The content and navigation screens followed the design requirements and user stories, which defined the main screens and functions such as the user profile, home screen and so on.

The overall design and navigation were defined in paper sketches by setting the main tasks, such as the creation of user profile, searching physical activity events or sessions and coaches, accessing a list of descriptions of VI physical activities. This list of physical activities was aimed to help users that needed quickly to find out what a specific VI physical activity or sport was and how to play it. This

had the aim to prepare simple, accessible, easy, and fast to use screens by making using of some common design patterns in the user interface of mobile applications. This is because users might have familiarity with the existing type of navigation in mobile applications, such as the bar navigation on the bottom of the screen.

By defining the overall design, functionalities and navigation helped to visualise the tasks to be performed by the VI young adults and it also made sure that essential functions were not missed in the design.

The development of the mid-fidelity prototype in Microsoft PowerPoint went through an initial stage to prepare the mock-up screens to be adapted to the screen size of Android mobile phones (Appendix B). Both author and MSc student started the design by reviewing the drawing screens and sequence of navigation from the paper sketches and user stories. Moreover, it was necessary to download the Microsoft PowerPoint app in their Android mobile phones for initial testing of the mid-fidelity prototype app. The design progressed by following the paper sketches ideas and the framework proposed by Engelberg and Seffah (2002) in building a rapid mid-fidelity prototype in PowerPoint, although their recommendations was focused on the design of websites, the author and MSc student used it as reference for guidance to create the mid-fidelity prototype app.

4.4.1 Defining the screens, font, and elements size

The first recommendation in the generic rapid prototyping method was essential to determine the screen size of the screen, font type and size before progressing with the design. The background and foreground colours selected were white and black, respectively. The first decision was to make each screen as one slide presentation and determine the screen size and font to simulate the final screen visualisation in the Android mobile phones. In Microsoft PowerPoint, the slides were set in portrait layout and adapted to a custom size (width: 10.05 cm, height: 18.402 cm) for Android mobile phone's screen. As it was not possible to set the screen resolution in Microsoft PowerPoint, instead the size of the font and other elements was set and adjusted by visualising it on the Android mobile phone's screen.

Text and button sizes are critical for the accessibility of mobile interfaces because they directly impact the usability and ease of interaction for all users. The font type is important in the design of accessible interfaces because it affects readability and legibility, which are essential for VI users. Readability plays an essential role with clear, distinct characters to help prevent confusion and legibility can significantly impact how easy characters in a font are to identify (Nielsen 2015). The type of font selected was Calibri and its size was set according to the size of elements, for instance, text size of buttons: 16 and 20, text size in the general space of the screen was 18 and in the main

navigation bar was 16. Large touch target size of buttons, especially in mobile interfaces, provide easy interaction to tap accurately buttons and links, decreasing the errors and frustration (Harley 2019). Accessibility guidelines recommend a minimum touch target size of around 44x44 pixels to ensure buttons are large enough for all users (Gudhka 2022). The size of buttons and other elements were set to be large whenever possible to fit into the content area. As a result, the buttons had three different sizes, such as smaller (height: 1.85 cm, width: 8.30 cm), medium (height: 2 cm, width: 4.50 cm) and larger (height: 3 cm, width: 8.30 cm).

Therefore, initial checks for the size and font size were done in the available Android mobile phones. However, the vertical position of mobile phone presented the prototype in a landscape view, the custom portrait layout was not ideal to visualise the screen vertically due to the reduced visualisation of the entire screen in landscape view (Figure 4.1).

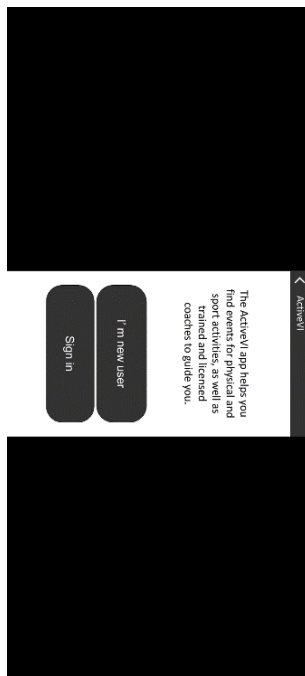


Figure 4.1 Vertical mobile phone position of a landscape view of the slide.

The portrait layout could lead to the potential issue for visualising the screen during the user testing. To avoid this inconvenience, the MSc student identified an application to keep the slides presentation fixed in the vertical position of the mobile phone and the young adult with VI would test the interface.

Both author and MSc student installed this application in their Android mobile phones for testing the issue out which was satisfactory. Therefore, the mid-fidelity prototype only offered the portrait visualisation for the user testing with participants.

4.4.2 Defining main areas and navigation

The main areas and screens of the mobile application was set in the customised slides, for example, the welcome page with the logo and the main screens with fixed areas. All screens, unless the sign-up screens, had the top bar header with a back button and the horizontal navigation bar on the bottom of the screen. Those were repeating elements in the screens. In the welcome page, the area for sign up were placed above the introduction text with two larger buttons, one to new users and the other to sign in to registered users (Figure 4.2).

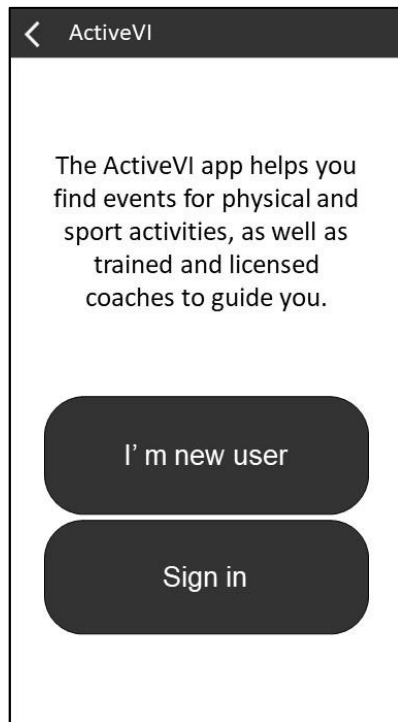


Figure 4.2 Sign up and sing in screen

There were two buttons for sign up and in for young adults with VI and another one to coaches, even though the coach profile and functionalities were not added in this study. The coach sign-up button was an example of other user profile. The horizontal navigation bar had three fixed buttons, such as 'find event', 'find coach', 'activity list' (Figure 4.3); such buttons aimed to open their respective screens and the sub-screens.

Find Event

Enter the location, the activity and time of event that you would like to find below:

Location:

Activity:

Activity Start Time:

Activity End Time:

Find

Find event	Find coach	Activity List

Figure 4.3 Bottom navigation bar in the find event screen

It used a text box and hyperlink approach to allow opening the sub-screens from main screens. For instance, from the 'find event' screen (i.e., slide 5) the user could select the 'find' button, which was a rectangle, and it was linked to open the find event list screen (i.e., slide 6), in which the first option of the list had a link to open the next screen. The same approach was applied to the three text boxes of the horizontal navigation bar and other rectangle boxes that acted as buttons and selectors. Regarding the rectangle as selector, the selection of options was simulated for the 'find event' screen, in which by selecting the location (rectangle) it opened a partial screen with the location options to select from, which opened over a greyed out copy of the 'find event' screen. In this case, the first option was already selected, and the back button (arrow) was linked to the main screen 'find event' (Figure 4.4). The same structure and approach were applied to 'find coach' function.

Find Event
Enter the location, the activity and time of event that you would like to find below:
← London
London UK
London Road Southampton, UK
London Heathrow Airport Longford, UK
London Euston London, UK
London Luton Airport Airport Way, Luton, UK

Figure 4.4 Screen of a list of location options to search a sport event

Those buttons, selectors and arrows that had no hyperlink received an alternative (alt) text. For example, the back button (arrow) had alt text as 'back button' (Figure 4.4). Each element that had a functionality as a button or selector and had its individual text box or shape, hyperlink, and alt text. These elements had to be single items to add its hyperlink when necessary.

All the text boxes and shapes that represented the headers, buttons, selectors, arrows and so on had to be given a sequential reading order by changing their order in the 'Selection Pane' function. This function allowed the elements to be read by screen reader in a logical and correct order. The slides then were following the logical order using elements with hyperlinks to redirect the user to another screen.

Moreover, it was decided to present bold and large text in all screens. The content was aimed to provide succinct and detailed information about the physical activities' events and sessions, coaches as well as the transport information. For example, the transport information was given directly by the hyperlink button from the selected physical activity event's screen (Figure 4.5) to help the user to easily have access to the information in another screen where the sport or leisure venue is and how to get there by showing bus, train and both options (Figure 4.6).

Event Information

Event Details

Find coach for this event Find transport for this event

Time: 6.00pm - 8.00pm Add to Calendar

Cost: £4.00

Address: Islington Tennis Centre (ITC), Market Road, London

Phone: Phone Number Call Now

Find event Find coach Activity List

Figure 4.5 Event details screen

Find Transport for Event

Event Time: 6.00pm - 8.00pm

All Bus Train

	Bus Number 2 Departure Time: 4:00 pm Arrival Time: 5:20 pm Southampton to London
	Train 1 Departure Time: 4:30 pm Arrival Time: 5:30 pm Southampton to London
	Train 12 Departure Time: 4:40 pm Arrival Time: 5:45 pm Southampton to London

Find event Find coach Activity List

Figure 4.6 List of public transport options

4.5 Study 1 - Phase 1: User evaluation of the mid-fidelity prototype and interviews with VI young adults

The study 1 refers to the first user evaluation of the phase 1 in the iterative design process of this research. The aim of the study 1 was to obtain the feedback about the concept and validate the design requirements of the mid-fidelity prototype app from VI young adults' perspectives, as well as to obtain their suggestions for improvements and ideas to further develop the app.

4.5.1 Method

In this study, semi-structured interview and think-aloud user evaluation were conducted in July 2019. This research has ethical approval from the University of Southampton Research Ethics Committee, reference number ERGO/FEPS/51929. The author collaborated with the MSc student to prepare the ethics application and review the work schedule, ensuring it was submitted as part of the student's dissertation project. This was done to secure approval for the study in time to align with the MSc project timeline. Upon receiving ethical approval, the author identified and contacted via email some organisations, such as VI sport centres and charities in Southampton and nearby.

4.5.2 Sampling and recruitment

The sample size was 3 participants. The author requested support to recruit participants to a few local organisations, but only one was able to assist with the request as they had some VI young adults taking part in some of their activities. Other organisations replied that they did not have VI young adults as members, often their members are VI children and elderly. Through a purposive sampling 4 participants were recruited through a local charity on a voluntary basis. However, one participant was under 18 and not eligible in the age criteria. The inclusion criteria were young adults between 18 to 30 years old with visual impairment, regardless of being physically active or not. It is known that researchers can face challenges in getting access to hard-to-reach populations (Faugier and Sargeant 1997).

4.5.3 Procedure

The think-aloud user testing and semi-structured interview took place at a local VI charity. Both author and MSc student conducted the evaluation sessions and audio recorded the interviews. Participants first tested the mid-fidelity prototype and then they were interviewed. Firstly, they were asked about demographics and lastly about participants' views about the prototype (Appendix C). Some notes were taken for later analysis.

The scheduled testing and interviews lasted one hour. The author and MSc student were informed at the local charity, Southampton Sight, that the time available was one hour for user testing because participants had another programmed activity. One individual session and another session with two participants together were conducted due to limited time left to complete the sessions.

4.5.4 Data analysis

The transcriptions of audio recordings were obtained from Otter, a speech to text transcription application, and revised by the author. The author conducted a deductive content analysis of the transcripts. This was based on the author's aim to validate the design concept and requirements. (Robson 1993).

The content analysis was used because it is more concerned to analyse intentions, consequences, content or contextual meaning of the text that is easily identifiable without the need to find deeper meaning (Hsieh and Shannon 2005; Kleinheksel et al. 2020). In addition, this method has been used in the early prototyping stage of mobile application, for instance, the Latiff et al. (2019)'s user evaluation study of a mid-fidelity prototype app produced in Microsoft PowerPoint with two evaluators.

In this current study, the coding procedure was guided by pre-defined categories, such as useful, facilitators and barriers, in which the data were coded according to these categories to form the final categories described in the next subsection.

4.5.5 Results

4.5.5.1 Participant characteristics

Three participants, identifiable as P1, P2 and P3 (mean age = 23.6), self-reported that they were severely sight impaired (blind) (n=2), sight impaired (partially sighted) (n=1), physically active (n=2) and inactive (n=1) and had very high confidence level in using iOS mobile phone.

4.5.5.2 Categories

- **Category 1: Useful to learn and find sport activities**

In general, participants appreciated the options to find sport events and its details including the features to find transport and coaches. Also, the possibility to obtain detailed knowledge about what a VI physical activity or sport is and how it is provided by learning beforehand how to play a specific sport.

'...things that would happen during like when you get there.' (P3)

It also meant the need to know about the support offered by the sport organiser and the number of participants attending a VI sport session or physical activity. In the support, it was appreciated the idea of support of an experienced coach when someone is starting or for suggesting a new activity that may help to gain knowledge about VI sports.

'How many people are going to be there? Things like that. So, if you're going to have people there to support you'. (P3)

There was interest to learn more about workouts rather than sport activities. This preference was expressed because the mid-fidelity prototype provided only information about sport, as examples. Therefore, one participant expressed they would not be interested to look at sports in the app, instead the gym and workouts that offer VI activities may be the preferred activities to search for.

'Ah, personally, I wouldn't. Ah...It is..., I, you know, exercise is cool for me, like gym and stuff like that, but not any kind of sports to be honest, that's just me.' (P1)

The usefulness of the app may be regarded as providing information for those young adults with VI that do not have knowledge about VI sport and that are already motivated to start a sport. However, P2 expressed that the app would not be something to encourage physically inactive people to become active.

'But I think if you're that way inclined and you wanted to, then would be very good.' (P3)

'I think if you're new to sport in terms of visual impairment, I think it would be useful.' (P2).

Active people would not use the app on a regular basis, as they know already what is happening in their sport or leisure venues, instead they would probably use it to identify new activities to try.

'I don't think I would personally use on a regular basis. To introduce me to new activities may be'. (P2)

- **Category 2: Design improvements**

This pointed out some of participants identified flaws in the interface and suggestions for improvements or additional user interface elements and features.

Blind participants (P1 and P2) did not appreciate the option to input the phone number, instead preferred to sign in using social media or email address with a password, as the password would add security. On the other hand, the partially sighted participant (P3) enjoyed the options to sign up with social medias and phone number as it seemed a quick process.

'I think you, ideally, probably, want the option because not everybody would want to give a mobile phone number, but equally I really wanted to give an email address. But then you have got other options to sign up with Google and Facebook. Which is actually quite good.' (P2)

I'd say maybe for security reasons, you know, a password should be required. (P1)

'I was excited that there was...ah...like, you can sign up with your Google account or Facebook. Like, that's quicker usually to do. So that was really good [...] I think this move the registration in process the better is...yeah.' (P3)

Participants appreciated the option to search for transport and add the event details to a calendar app in the mobile phone. Although, the two blind participants do not use wayfinding apps, they liked the idea of the 'inbuilt' feature in the sport event details' screen for transport and calendar related features.

'That's a good idea. I think having inbuilt is helpful.' (P1)

'That would be useful. So, to have reminders, yes.' (P2)

Screen readers users (P1 and P2) perceived that the labels of buttons were informing too much content. This is because TalkBack was describing the elements in the slide. For instance, after reading the alt text (e.g., sign in button) TalkBack announced that the button contains links (i.e., the hyperlink to open another screen) and repeated the alt text and informed 'double tab to edit text and actions available'.

'I think there are limitations. I don't know if it's an Android thing or something like that with some of the labelled buttons.' (P1)

The partially sighted (P3) expressed the prototype would need more focus on allowing changes in the colour contrast, enable magnification and provide bold fonts in the interface.

'I think you should have something that can enable magnifier for the app...and something that basically just change the fonts in the app [...] The majority of people with visual impairments use Arial. But I would say use something that's bold, to make the actual font itself really, really bold, so special...because so, it's invisible with eh..., like a different background, like high contrast.' (P3)

In this sense, the suggestion was to provide an accessibility setting to the potential mobile app, as it is easier to adjust the interface as it can be done in websites with these settings. It was suggested to include a link to enable magnification and changes to font size and the background and foreground colours, such as black and yellow, respectively or keeping the white and black with bold black font.

'...generally, with websites and stuff, you can have an accessibility section. And if you include that will be a lot easier, because then it will be tailored for other people. So, you can either increase the text or decrease the text [...] You can use magnifier, maybe just a link to the magnifier [...] maybe if change it to yellow and black and black and yellow, just the opposite. So those two and options to keep it black and white [...] when I was using it, I would have yellow writing on black. So, it just depends on...But I prefer normal writing just having something that's with high contrast. So black bold writing and white background for me, but everyone's different. That's why it's useful to have.' (P3)

Although P3 was expecting to have the options in the navigation bar at the top of the screen, it was perceived that it was easier at the bottom since the user can memorise that or zoom in to see the options.

'I think everything is just towards the bottom. So, once you memorise that, all the different screens were at the bottom, then it's easier for...Yeah. [...] Usually, sorry, they are to the top that's why I found a bit different, but it's on the bottom. So yeah, it was a bit...Yeah, that's why I found that difficult with it. Then, when zoom in, go to the bottom. It's easier, I think.' (P3)

In addition, P3 expressed that the location feature in the find event screen was useful and it was easier in the top area of the app. The location was perceived as the most important filter to find an activity, especially those nearest to the user.

'I think the search is useful because you can pick the location. And I think for most people, it's going to be locations, going to be main things it's close to where you are. So then, you wouldn't have to think about things such as transport or things like that. Because guessing around for visually impaired it is difficult. So, eh...definitely, location being in the top is easier.' (P3)

More information was required by P3 to explain what would happen during and after the sport events, what time the event starts and finishes, and more details on how to get to the venue, and the number of participants attending the activity.

'It is best to have more information to explain, like the details of the event and [...] like what would happen, maybe like and scenario of things that would happen during like when you get there, what time you get there. And what happens afterwards? What time they start, they finish, things like. Like an accessible football. How many people are going to be there? [...] So, if you're going to have people there to support you. If you need that help, things like that, like getting there.' (P3)

However, there was a concern regarding the potential idea to provide personal information in the user profile. It was more acceptable to inform only the interests in the sports or physical activities.

'I think...I'm not really like into giving my personal information too much.' (P3)

4.6 Discussion

The early stages of design process of systems require iterative methods to allow refinements and improvements through the involvement of the target users (Shneiderman and Pearson Education 2014). The rapid prototyping method and an adequate user interface tool are even more important when users are VI people, as they need accessible and usable interface for interaction during the evaluation phase in the design process.

The identified categories from the literature review helped to devise insights of services in a mobile application to aid VI young adults to overcome the barriers in physical activity and sport. This needed validation and suggestions of improvements of the concept and requirements. The concept design was centred in combined services of information seeking and support for physical activity and sport for VI young adults. This aimed to allow easy search by selecting a physical activity, sport and access to details related to each VI physical activity and sport session or events, such as location, date, time, cost, transport information and facilitate the addition of details into phone's calendar app and contact coaches via chat and email address, and venue organisers via phone call and email address.

From this, the author and a MSc student at the University of Southampton designed a mid-fidelity prototype using Microsoft PowerPoint. The rapid prototyping method allowed faster development of simulated screens compared to building a high-fidelity prototype and facilitated checking for accessibility and usability which is not possible with low-fidelity paper prototypes. The mid-fidelity prototype allowed the use of assistive technologies such as screen readers (TalkBack) and magnification tool.

The prototyping advantages of using Microsoft PowerPoint were threefold. One was the possibility to use assistive technologies and applying important accessibility attributes. These were the use of large and bold text, drawing large buttons, and adding alt text to buttons, selectors and arrows that had a function, and selecting the reading order of items in the slides. This aimed to help screen reader users during the user evaluation to understand what each item was in the interface. The second advantage was the use of Accessibility Checker throughout development of the mid-fidelity prototype app, which helped to identify and fix some issues and understand the implications in the simulated interfaces. The third advantage was the creation of a simple interface with enough details to simulate the user tasks. The hyperlinks added into individual shapes and text boxes to open another slide worked well to provide a workflow. This helped to approximate the interaction to realistic tasks. Moreover, the copy and paste of items provided consistent sizes and shapes across the slides.

However, two main accessibility concerns were identified while designing the mid-fidelity prototype. One is regarding the Microsoft PowerPoint slide show mode that presents the slides in landscape view on a mobile phone even when the rotate function was on. The landscape view is a standard presentation mode for mobile phones and desktops. Hence, the custom portrait layout of the mid-fidelity prototype app had its visualisation scaled down to match the landscape view's height in the Android mobile phone. The solution was to find and download a rotation lock app to prevent this issue during the user evaluation. The second concern was about the several elements in the slides, such as rectangles, arrows, etc. that were read by TalkBack and had no attributed function. These elements were marked as decorative to reduce the number of unnecessary items to listen to while using the screen reader.

As a result, the strength of this study was to follow the generic rapid prototyping method and adapt it to mobile application and assistive technologies such as the Android's screen reader, TalkBack, and magnification. Defining the main areas and navigation was essential to plan the space and arrangement of large items to accomplish the usability and accessibility considerations and not only the content and usability.

This could help to answer the research questions by informing designers and developers of the needs of VI young adults to access the services related to physical activity and sport and accessibility considerations mentioned above, as well as the need to check for accessibility throughout development of mid-fidelity prototype app. This was not highlighted in the generic rapid prototyping method because the focus was only given to usability and website development for a desktop.

The user testing also helped to obtain the feedback on acceptability, usefulness and improvements of the design requirements. These were the considerations for the next iteration of the project. There were limitations in this study due to the small number of participants and the inexperience of interviewers, especially due to short time for user testing and interviews at a local charity, which resulted in less amount of feedback from participants.

4.7 Summary

The development of prototypes at the beginning of design process depends on the method, type of prototype and the needs of the target users for evaluation. In this sense, this study provided the main contributions to inform designers and developers about the importance of: 1) adapting the rapid prototyping method to mobile application and assistive technologies; 2) some accessibility considerations to undertake the development of a mid-fidelity prototype app; and 3) to acknowledge the insights for the design requirements to build the information seeking and support service for

Chapter 4

physical activity and sport participation of VI young adults. The next chapter describes the next iteration of design and implementation with the high-fidelity prototype app.

Chapter 5 Design and user evaluation of mobile app with VI young adults

5.1 Introduction

The previous chapter discussed the design and development of the mid-fidelity prototype in Microsoft PowerPoint and its evaluation by VI young adults. The results provided insights into the design and development of the next design iteration described in this chapter. This chapter addresses the high-fidelity prototyping and the first round of user evaluation of the Android and iOS mobile application, called ActiveVI. The aim of the prototype was implemented to test accessibility and usability as well as to continue the co-designing of the proposed application, validation, and improvement with VI young adults by taking the feedback and suggestions to enhance the design requirements. Thus, the description and contributions of the design development and evaluation is discussed and set the initial assessment of the design requirements, accessibility, and usability of the mobile application.

5.2 Design steps

The MSc student in Software Engineering, who helped in the first phase, continued in this second phase, as part of her master's dissertation project, by building a mobile application regarding the service and support for VI young adults to take part in physical activity and sport. The author guided the MSc student in accessibility considerations, and both learned how to apply the accessibility components during the implementation. The high-fidelity prototype helped to check its feasibility and validate the design requirements. The implementation phase was divided into four parts, in a non-sequential order, as follows.

Refinement of the design requirements based on the findings in the previous Chapter 4.

This involved reviewing the findings from the user testing of the mid-fidelity prototype created in Microsoft PowerPoint. The feedback was prioritised to guide the implementation of features in the mobile application, with details provided in the following subsections. (5.4.1.1 and 5.4.1.2).

Selection of a user interface software platform to build the mobile application.

The author consulted the MSc student to choose what cross-platform framework to build the mobile app on both Android and iOS for accessibility by enabling user evaluation with VI young adults. Thus, React Native had the most accessible framework by 2019 to create more inclusive applications with

built-in support for a variety of accessibility features. This included improved accessibility properties (e.g., `accessibilityLabel`, `accessibilityHint`, `accessibilityRole` and `accessibilityState`), and related Android specific improvements for accessibility, as well as support for custom actions, screen reader, colour contrast and focus. The implementation on React Native allowed the use of the same codebase to apply the platform's accessibility components. More details about React Native is in the subsection (5.4.2).

Literature review of accessible mobile applications for VI people (Chapter 2).

Previous studies about design of accessible user interface for VI people were identified as references concerning user interface design and visual aspects, such as colour contrasts, simple and consistency of user interface.

Identification of existing database as source of information on VI physical activity and sport in the UK.

This focused on getting access to an existing database of VI physical activity and sport from a UK based organisation. These four parts were the basis for the implementation phase's development of the accessible and usable minimum viable product, ActiveVI app, which are described in the next subsections.

5.3 Minimum Viable Product: Implementation Development in React Native

5.3.1 Refinement of design requirements

The author analysed the design requirements, from the previous Chapter 4 and discussed them with the MSc student, to check for necessity, consistency, and feasibility. In the requirement analysis, necessity regards what requirements are needed, consistency is about not implementing contradictory requirements, while feasibility refers to requirements that are within the budget and timescale. In this sense, the prioritisation technique was applied, which is presented in all agile methods, in the entire development process of this study (Paetsch et al. 2003). This technique is suitable to projects with limited time and resources to allow the implementation of the most prioritised features first.

Once the understanding of the project improves and more requirements are gathered from stakeholders, the prioritisation technique needs to be used again to refine the requirements (Paetsch et al. 2003). Thus, the benefits of this approach outweigh the traditional requirement analysis in software development due to its flexibility to the changes of the project. Hence, the current design

requirements were analysed and divided into two categories functional and non-functional which were ranked from 1 (most important) to 5 (least important).

5.3.1.1 Functional requirements

This refers to the specification of features and its capability in which a system needs to perform (Becker et al. 2019). For example, VI young adults suggested in the previous feedback to add minimum requests of personal information in the user profile (e.g., name, email address and physical activity and sport preferences), recommendations related to their interests added in their profiles and a direct link to transport information was appreciated and more details were requested, such as step by step of route details from the Google Maps routes' results.

Table 5.1 Functional requirements

Item	Functional requirement	Definition	Priority (1-5)
1	Sign Up and Sign In	Users should be able to sign up or sign in via a preferred method (e.g., Google, Facebook, or Email address)	1
2	Find events (physical activity or sport sessions)	Users should be able to find events by location, activities, and date.	1
3	View event (physical activity or sport session)	Users should be able to select and obtain the information of an event.	1
4	Add calendar	Users should be able to add an event information to their mobile phone's calendar app.	4
5	Call organiser	Users should be able to start a phone call with the event organizer through the app.	5
6	Find transport	Users should be able to find public transport for a specific event on a specific day.	2
7	View Route	Users should be able to choose a transport route and view its details.	2
8	Start Navigation	Users should be able to start navigation to the event location through the app using Google or Apple Maps.	5
9	Find Coach	Users should be able to find a coach for a specific activity.	1
10	View Coach	Users should be able to select a coach and view its details.	1
11	Call Coach	Users should be able to start a phone call with a coach through the app.	5
12	Message Coach	Users should be able to send messages to coaches using the in-app chat.	4

Table 5.1 Continued

Item	Functional requirement	Definition	Priority (1-5)
13	Users Profile	Users should be able to create and update their profiles.	2
14	Coach Profile	Users should be able to create and update their profiles.	1
15	Message User	Coaches should be able to reply to user messages using the in-app chat.	4
16	Recommendations	Users should be able to get recommendations based on their interests.	3
17	Approve Coach	The administrator should be able to approve newly registered coaches so that users can find them.	3

5.3.1.2 Non-functional requirements

Although, the definition of non-functional requirements can be unclear in the literature (Paetsch et al. 2003) these requirements regard the features and capabilities constraints in the implementation design (Becker et al. 2019).

Table 5.2 Non-functional requirements

Item	Non-functional requirements	Definition	Priority (1-5)
1	Authorisation	The system should not allow unregistered users to access the app features.	1
2	Assistive Technologies Support	The system should support assistive technologies (e.g., TalkBack, VoiceOver, Magnifier).	1
3	Compatibility	The system should be able to run in both Android and iOS mobile phone.	2
4	Response Time	The system should respond to the action in less than 3 seconds.	3
5	Simple UI	System UI layout should be simple.	1
6	Internet Connection	The system should notify users that there is no internet connection.	4

5.3.2 React Native and accessibility attributes

The React Native is a cross-platform native development framework used to develop mobile apps using JavaScript in the same codebase. By using one codebase, the JavaScript elements are matched to native Android and iOS's code of user interface components to offer a mobile application functioning in both operating systems. This matching uses the React Native bridge to build a mobile application with native performance. In the case that some elements cannot be implemented

through JavaScript, the developer can use the native code from Android and iOS into the same codebase.

Moreover, React Native allows the accessibility attributes to be applied in both operating systems (Brito et al. 2018). Each component was built to receive focus, had a label and reading order. For example, focus and label were achieved by using accessibility attributes on each component, such as the *'TouchableOpacity'* and *'AccessibilityLabel'*. These accessibility attributes are very useful while using screen readers, the user interface elements (e.g., buttons, icons, etc.) can be focusable by the *'TouchableOpacity'* and its label name (e.g., profile user) can be read out by the screen reader due to the use of *'AccessibilityLabel'*. Also, it added text to speech in all screens, as a voice assistance, to partially sighted users while opening the screens. This aimed to inform partially sighted users of the layout, the user interface elements, and the user actions available in the screen. The MSc student conducted the Unit Testing with Jest, a React Native's built-in JavaScript testing framework, to test most of the developed components after each integration. This allowed bugs checking earlier which made the integration phase easier.

5.3.3 Database and APIs

The author obtained the database used in the ActiveVI app from the Metro Blind Sport, a VI sport charity based in London. This charity offers VI sports and runs a website with many advertised sport activities and events across London. By the time of the prototyping phase, the offer of activities was sports only, such as VI tennis, archery, goalball, etc. The author decided to use this database to facilitate the addition of content (i.e., VI sports data) into the app and to allow the simulation of the user tasks in the evaluation phase. The Metro Blind Sport agreed to share the RSS feed to gather data and load them into the Cloud Firestore, a NoSQL database, which offered flexibility and no structure to use data saved in JSON format. Redux, an open-source application state management library, was used to store the user data, location and data from the database. Google Firebase was applied for authentication and data storing in the Cloud Firestore database, which allowed email and password, Google, and Facebook sign-in.

The information provided in the ActiveVI app was based entirely on the database and YouTube videos about VI sports. Also, the ActiveVI app allowed searching of public transport for the sports activities through the TransportAPI platform, which provided live public transport data in the UK. This enabled users to find public transport between their location and sport venue location. Additional information would have been added, such as the number of attendees in the sport events, as suggested by one participant in the user testing of the mid-fidelity prototype. However, as it was a suggestion from one participant and this information was not in the database, the author and MSc

student agreed to give priority to only use the data from the database to speed up the implementation.

5.4 Overview of the design of ActiveVI Mobile Application

The refined design requirements were used along with the WCAG 2.1 and Nielsen's Heuristics (Nielsen and Molich 1990; Kirkpatrick et al. 2018), and accessibility aspects based on previous studies, such as the use of user interface design patterns in mobile application (Ribeiro and Carvalhais 2012), use of background and foreground colour combination (Kulpa et al. 2013). The ActiveVI app had four main screens (e.g., home, find event, find coaching, and activities) and the screens for sign-in and sign-up user account. The user interface had bold text and large font size (e.g., minimum 18) on a colour contrast combination for more reading efficiency and for light sensitive users (Kulpa et al. 2013), such as white background and black foreground, dark blue background and white foreground, yellow background, and black foreground. The images of all screens of ActiveVI are in the Appendix D.

The ActiveVI app consisted of some additional elements to improve the usability and added functionality that were not present in the mid-fidelity prototype. For instance, VI young adults suggested to add a list of recommendations of physical activities and sports. This led to the addition of the 'home' screen and tab in the navigation bar to show this list. The navigation bar was set to be always visible with the four tabs (e.g., home, find event, find coaching, and activities) and its respective icons. The new buttons (e.g., user profile and chat) on the top header area were consistent in the main screens. A brief description of the screens and their functionalities are given below.

5.4.1 Home and user profile screen

This presented a list of recommending events (Figure 5.1) based on the user physical activity or sport preferences defined in the user profile. The user profile, the icon on the top header, is one of the first interactions when signing up in the ActiveVI app, in which the user needs to fill in name, email address and physical activity and sport preferences (Figure 5.2).

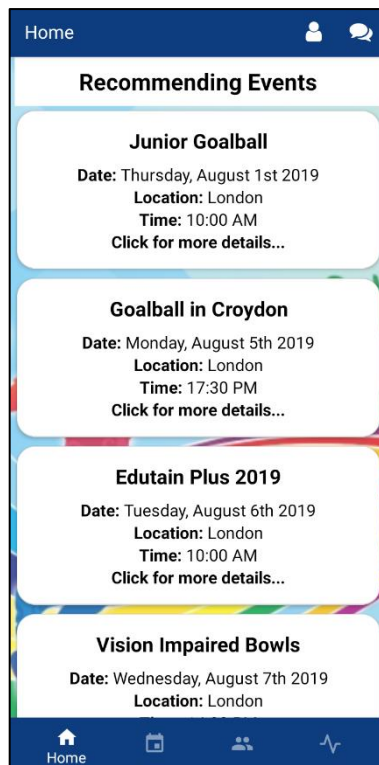


Figure 5.1 Screenshot of list of recommending events

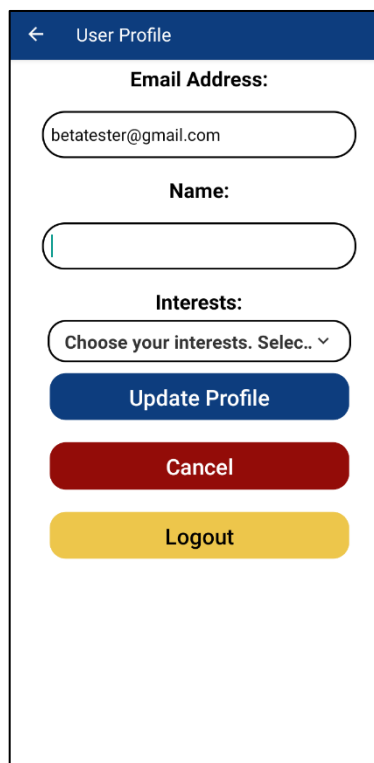


Figure 5.2 Screenshot of user profile

5.4.2 Find event screen

This filter task interface allowed the user to filter one physical activity or sport of interest at a time by location, activity, and month to select from modal filter picker components in React Native (Figure 5.3). From this main screen, the user was redirected to a list of the chosen sport activities available, the 'Event List' screen (Figure 5.4) for the selected month and location. This leads to a simple sequence of user tasks to provide more details about the chosen sport event (one-off activity) or session (regular activity). The term used in the ActiveVI app is 'event' for both categories.

For example, one selected item in the list redirected the user to the 'Event Details' screen (Figure 5.5), where it provides description, time, cost and the inbuilt functionalities to direct call and email the venue's organiser, add information to phone's calendar app, and find public transport (Figure 5.6). These are the immediate user actions to call, email, open and add information into calendar app and open the transport routes information from Google Maps, all direct from the screen. This can facilitate the user actions and avoid the effort to memorise or copy a phone number or email address and open the other applications (e.g., phone call and Gmail) to type or paste the content.

In the same 'Event Details' screen, the user can check who the coach is for that specific sport event by pressing the button 'Find coach for this event'. This opens the list of one or more coaches that run the sport event (Figure 5.7). For more details, the user can select one and it opens the coach profile (Figure 5.8) to direct send an email or initiate a chat with the coach (Figure 5.9). All the screens in this sequence have a back button to the previous screen and the navigation bottom bar, except the chat screen.

The screenshot shows a mobile application interface for finding events. At the top, there is a blue header bar with the text 'Find Event' and two icons: a person and a speech bubble. Below the header, the main content area has a white background. It starts with the instruction 'Choose the location, the activity and date of event that you would like to find below:'. This is followed by three input fields, each with a label above it: 'Location:' with 'London' entered, 'Activity:' with 'Goalball' entered, and 'Event Month:' with 'August' entered. Below these fields is a prominent yellow button with the text 'Find Event'. At the bottom of the screen is a dark blue navigation bar with four icons: a home icon, a calendar icon labeled 'Find Event', a group of people icon, and a pulse line icon.

Figure 5.3 Screenshot of the search for VI sport event

The screenshot shows a mobile application interface for a list of events. At the top, there is a blue header bar with a back arrow icon and the text 'Event List'. Below the header, the main content area has a white background. It displays a list of three events, each in a white card with a light blue border. The first event is 'Junior Goalball' with details: 'Date: Friday, July 21st 2023', 'Location: London', 'Time: 10:00', and a link 'Click for more details...'. The second event is 'Goalball in Croydon' with details: 'Date: Friday, July 21st 2023', 'Location: London', 'Time: 17:30', and a link 'Click for more details...'. The third event is 'Goalball' with details: 'Date: Friday, July 21st 2023', 'Location: London', 'Time: 18:00', and a link 'Click for more details...'. Below the list is a colorful abstract graphic with diagonal stripes in blue, yellow, green, and red. At the bottom of the screen is a dark blue navigation bar with four icons: a home icon, a calendar icon labeled 'Find Event', a group of people icon, and a pulse line icon.

Figure 5.4 Screenshot of a list of VI sport events

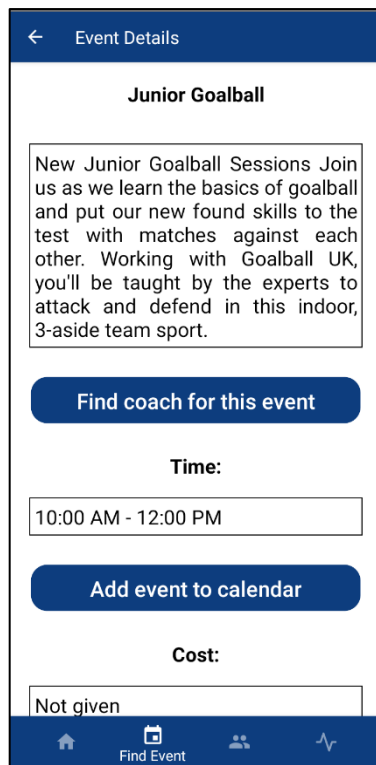


Figure 5.5 Screenshot of the event details of a VI sport

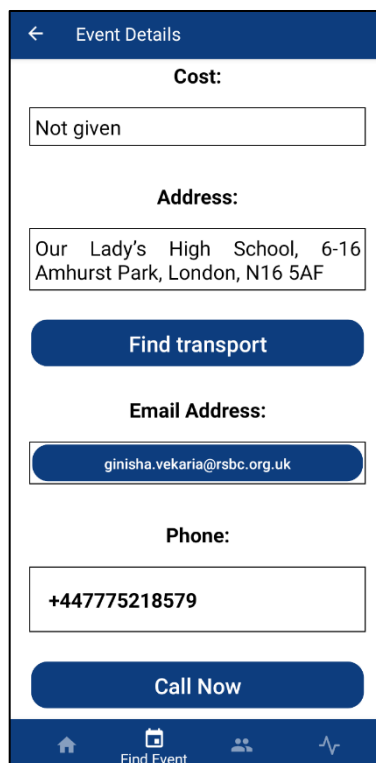


Figure 5.6 Screenshot of continuous view of the event details screen



Figure 5.7 Screenshot of a list of coaches

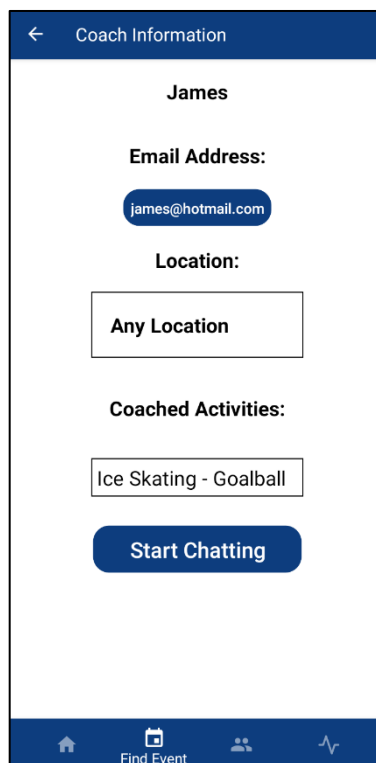


Figure 5.8 Screenshot of a coach's profile



Figure 5.9 Screenshot of a chat sent to a coach

5.4.3 Find coaching screen

The 'Find coach' screen (Figure 5.10) has similar consistent layout and user interface elements as the 'Find Event' described above. The difference is that it has only location and activity filters to find a professional coach. By filtering the result gives the coach profile in the Coach List screen (Figure 5.7).

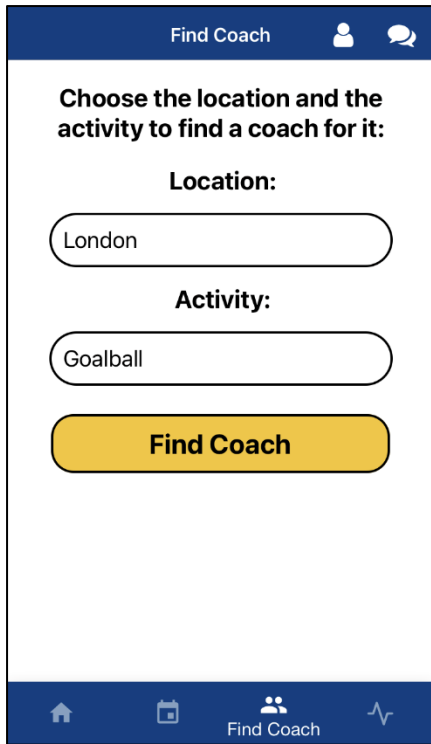


Figure 5.10 Screenshot of the search for a coach and VI physical activity

5.4.4 Activities screen

The 'activity list' (Figure 5.11) simply shows a list in alphabetic order of VI sports where the user can select the sport to know more about them. Each selected item opens the 'Activity Details' with the description of it and an explanation video button (Figure 5.12). This button opens the YouTube app with the respective link to the chosen VI sport video.

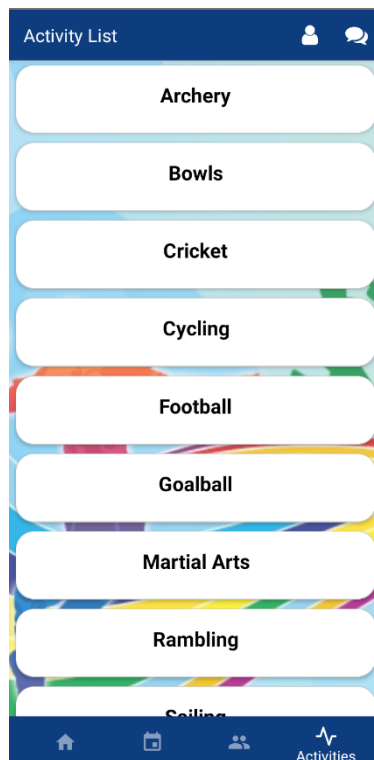


Figure 5.11 Screenshot of the list of VI sports

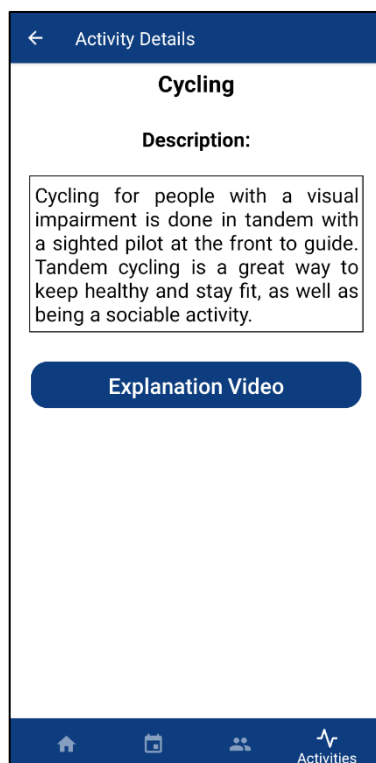


Figure 5.12 Screenshot of the description and button for a video of a VI sport

Due to lack of time, the implementation was followed by quick manual checking for accessibility of the beta version of the Android mobile application on both mobile phones available. It was not possible to create the beta application for iOS in the remaining scheduled timeline of the Master

dissertation project of the MSc student. The authentication and release of iOS beta version requires more time and effort to release it for testing and it was further addressed and discussed in the Chapter 6. After testing and evaluation of the implemented Android app, the MSc student did the compatibility testing to verify that the prototype was successfully tested and working on diverse devices and operating systems. All tests were successful and in some devices the layout appeared a little different which did not affect the overall layout.

5.5 Study 2 - Phase 2: User evaluation of the mobile app and interviews with VI young adults

The study 2 refers to the first round of user evaluation of the ActiveVI app in the phase 2 of the iterative design process of this research. More evaluations were conducted and discussed in the study 4 (Chapter 8) with VI young adults and a demonstration of the mobile app and evaluation from coaches of VI physical activity and sport (Chapter 10). The study 2 of this chapter aimed to interview, co-design and validate the design requirements with VI participants for further development.

5.5.1 Method

The study 2 followed the same method and ethics application as described in the study 1 (Chapter 4), such as the semi-structured interview and think-aloud user evaluation in August 2019.

5.5.1.1 Sampling and recruitment

The author reached out to several organisations, promoted the study advert on social media, and recontacted the local charity to invite participants from the previous Study 1 to take part in the user evaluation of the ActiveVI app. Due to time constraints related to the MSc student's dissertation schedule, there was limited opportunity for additional recruitment of VI participants. As previously noted, recruiting this population can be challenging, and only three participants volunteered for the study. Participants provided voluntary informed consent. Two had participated in study 1 (Chapter 4), while one new participant was recruited.

5.5.1.2 Procedure

The procedure in the study 1 was similar to that conducted in the study 2, and the user evaluation was followed by the semi-structured interview. Participants were asked to explore and think-aloud while navigating the app. They were asked to explore the app because VI users tend to learn new apps by first exploring the interface (Ghidini et al. 2016).

The interview guide had 19 questions about the demographics and the ActiveVI app. The two participants of the study 1 also evaluated the ActiveVI app together at the same local charity. The other participant took part in this study at the Winchester School of Art of the University of Southampton. All participants evaluated the ActiveVI app using the author and MSc student's Android mobile phones. Participants were informed of the study objectives, its procedure and that they had the right to withdraw from the study at any time. The sessions lasted up to 35 minutes and were audio recorded by both author and MSc student for data analysis.

5.5.1.3 Data analysis

The think-aloud evaluation and interview were transcribed by Otter.ai and revised by the author. Similar to previous study 1 (Chapter 4), the author conducted the deductive content analysis of the transcripts based on the same pre-defined categories (e.g., useful service, facilitators, barriers) based on the questions related to the design requirements of the design process (Robson 1993). It was necessary to take into account the context of the sentences which denoted usefulness (e.g., helpful, serve to some purpose) and were coded into the category 'useful service', while facilitators category related to text about facilitating (e.g., make easy, speed up, improvement, favourable) and barriers is a type of category regarded the difficulty, unfavourable, restrictions, and confusing context addressed in the participants' statements. Completed coding was followed by identification of patterns to help to answer the questions of the design requirements. For example, the category facilitators revealed new categories such as 'appreciated features and content' and 'suggested functionalities', described in the Category 3.

As a reminder, the choice of qualitative content analysis relies on how deep the researcher needs to analyse the participants' comments (Bengtsson 2016). Similarly, content analysis was applied in usability testing of an Android mobile application with four VI users (Ghidini et al. 2016), which helped the researchers to gather initial feedback from participants to identify key research issues.

Hence, as the aim of this study was to obtain the first impressions about the design requirements and general accessibility and usability problems, and the sample size was not enough to provide rich data for thematic analysis, then the content analysis again was the suitable method to apply in this study.

5.5.1.4 Results

Participant characteristics

Three participants, identifiable as PVI1, PVI2 and PVI3 (mean age = 24), self-reported as severely sight impaired (blind) (n=2), sight impaired (partially sighted) (n=1), physically active (n=2) and

inactive (n=1). Two participants were iOS users, and the other was an Android user. Although, the number of participants was very small this is typical in research studies with VI people (Shoaib et al. 2023).

Deductive Content Analysis

- **Category 1: Useful service for specific purposes**

In general, all participants found the ActiveVI app was useful to find information, sports, contact sport providers and recommend the app to others. The usefulness was also associated to the meaning of being helpful to young people who lost sight recently. Two participants, PVI1 and PVI2, expressed that those people struggle with the impairment and may want to be physically active. They explained that the app would serve as an aid to make them aware of the VI sport opportunities and cope with the visual impairment.

'When they lose their sight, they think...oh it's game over. That's it. And you show them the app, ah...use this, there's all these sports. And they: Wow, that's good. And then, they pick a sport and, actually, will help them cope with their sight loss as well.' (PVI1)

'If you were a young, I don't know...a teenager or 20, 30, 40 something, he was recently you know, recently with diagnose, been diagnosed the sight loss and you still wanted to be active.' (PVI2)

Two participants, PVI1 and PVI3, also perceived the app as more useful to young adults with VI who are physically inactive or those that a new to VI sports. The content in the activity list with descriptions and videos of VI sports was reported as helpful for newcomers to VI sports.

'But, for people aren't as active is more useful.' (PVI1, partially sighted, physically active, Android user)

'Yeah, that would be really helpful if you're like a newcomer or something.' (PVI3)

One participant (PVI1) expressed that the app would be useful for both physically active and inactive young adults with VI. This participant and another one (PVI2), both physically active, explained that would use the app to find new VI sports, if they wanted to try something specific to try out.

'If I wanna try new sport, I definitely will.' (PVI1)

*'I think I might, if I was looking for a specific thing and couldn't find it anywhere else. I wouldn't, necessarily, say oh, I would use it all the time. Because I know that my...my next sailing session is at *** on Monday. I know. That's an evening. So, I already know that. But if I wanted to find other things, and I might, I might consider using it.'* (PVI2)

PVI1 expressed that the ActiveVI app could be a way to bring awareness to the VI community as the VI sports seemed not be very well-known in the community and VI people would be interested to take part in VI sports.

'This is all first thing I've seen of it. I think it is brilliant, because we need even more of it. Because there's so many people out there, who wanna get involved with things that are visually impaired. They just don't know about it. [...] A lot of people probably don't think there's a sport for blind or certain sports, they won't do it, don't exist for the blind. They use the app, and they find it then, they'll start playing.' (PVI1)

- **Category 2: Easy to use features and content**

In this category, participants expressed that the Active VI app was, in general, simple, and easy to use, and they appreciated the features and content. Two participants (PVI1, PVI3) expressed that the app was simple and easy to use, it was easier for the partially sighted participant (PVI1) to sign up than the blind participants (PVI2, PVI3). This was due to the accessibility issue in the on-screen keyboard while using TalkBack. This issue is addressed in the category 4.

'Simple. It's pretty easy to use'. (PVI1)

'Once you figured out TalkBack mechanisms. It was really easy. [...] I think the app was pretty...was really simple. Like, you know, all together. Really'. (PVI3)

The partially sighted participant (PVI1) also liked the colour contrast of the dark blue background and white foreground as it allowed easy reading.

'I think it is really good. The colour code...the colour schemes sound very good. The dark blue worked very well. For me, it was quite easy being dark blue, it is easy to see and read.' (PVI1)

Regarding the features, PVI1 and PVI2 appreciated that there was a feature to directly contact the coach or sport provider from the sport event screen. They meant that it was easy to do a one-to-one chat with coach or direct call the sport provider from the app, which would be helpful to get advice and understanding before starting a VI sport. Moreover, by directly calling from the screen was perceived as easier compared to copy the number and move to another app to type in or paste the phone number.

'There you're able to talk to the coach one on one straightaway, and then just give you some advice and just have you understand as well. And then, so when you start going into the sport, you're more aware of it, more better.' (PVI1)

'If I wanted to contact the name of the coach for that sailing event next week, it's good that you can call them directly from the app. Otherwise...it's quite easy. Otherwise, you got to try and transfer the number from one part of the phone to the next.' (PVI2)

All participants liked the information content in the ActiveVI app because it was detailed with clear information for each sport event, such as description, time, location in one screen. In addition, the partially sighted participant (PVI1) appreciated the videos about VI sports in the sport description's screen and expressed that it could be an opportunity for users to understand the sport before taking part in.

'I like the event. I like the information. [...] that would be brilliant, see clearly like what sort of sections around, the time for it. Yeah. I think, definitely, give people a chance to kind of getting [the video] an understanding of something before they even take part.' (PVI1)

In addition, the PVI2 appreciated the content of 'activities list' because it could help the user to know more about VI sports and consider other activities that they might not heard about before.

'I would say, yes. Ah...and then the options to find the other activities that you might not thought of...' (PVI2)

The content in the transport feature was also appreciated by the blind participants (PVI2, PVI3), however, they explained that it would need more detailed information, for instance, step-by-step instructions.

'It was quite...it was quite good. Even though, I guessed I knew...I knew what sort of steps I have to take. And I would actually go a different...I would go about getting there a different way. I would go a different route entirely. But at least it gives you an idea, if you are not sure.' (PVI2)

'It was good that tells you...is like multiple routes, so...' (PVI3)

- **Category 3: Suggested functionalities**

Generally, all three participants provided some suggestions of changes in one of the current features for improvement of ActiveVI app, as well as some additions of new features and content to enhance the user experience. These suggestions were about transport information, search tool, peers' chat group, other types of physical activities, social network, and voice assistant.

The suggested changes were regarding the transport feature in the 'event details' screen, where the user can get information on how to arrive at the venue of the respective sport event. All participants expressed that this feature could be modified, for example, it could be linked to another navigational app, or it could provide more detailed step-by-step instructions to help the user to get public

transport, or it could offer other potential ideas of transport options, such as car sharing, taxi, and so on, especially something which runs locally.

'Maybe like, if it could be linked to an existing kind of blind GPS app...ah...so, you could like, programme the location into that directly from the app?' (PVI3)

'You know, even more detail than: walk from x, y, z get the number one bus, then walk. Literally, would have to be step by step.' (PVI2)

'If going alone, especially, they're not the most confident. Something like car share, taxi, bus, that sort of thing that makes it a little easier for them. So, things like more local to them, be quite a good idea. Definitely.' (PVI1)

All participants also suggested new features which were related to searching for physical activity, chatting with peers, finding running buddies, linking to existing social media group and voice assistant to search physical activity and sports. The addition of a search feature to find a physical activity or sport was suggested by one participant (PVI1). In this case, if the user had already been interested to know more about some sport or physical activity for VI people and needed to do a quick search, then the user could type in the name of the activity in a search tool. The reason was that some partially sighted people may need to avoid staring at a screen for too long.

'I think it is a really good app. I think one thing I'd add is like a search part, so you can type in a sport you're specifically looking for. If they already know about a sport, and think: 'Oh, it is that one for visually impaired'. So, they can click research, type it in, and they will see if they actually do it for visually impaired. [...] Then you go straight to the activities you're thinking you like. There's someone just saw they like tennis, they can then type in tennis, and it'll come up, it's blind tennis. [...] Cause some of them when they look at a screen too long harm their eyes, to the ones that can see a little bit. Something sort of slightly quicker to make it easier for them.' (PVI1)

The voice assistant was also another way to search for VI physical activity and sport which was agreed by two participants (PVI2, PVI3), however, as an optional feature for the user to choose. This is because they informed some issues with the voice recognition. This issue is addressed in the next category 4.

'...it's preference. I think maybe give people option. If you were to put it on there, maybe at the start of screen, would you like your...would you like this app to interact with you? Would you like it to talk to you? Maybe give them the choice?' (PVI2)

One participant (PVI3) showed interest to search for running coaches and buddies in the app. Another participant (PVI1) suggested to add a group chat to contact other users, which may help to build up friendship and the sense of being welcome in the sport sessions.

'I also think like, on this app, like a way to find like running coaches or maybe running buddies or something like that, that would be cool.' (PVI3)

'I like a kind of group chat, sort of thing on it. So, you can talk to other people. You might have friends on there, you're gonna make friends on there. And then, when you go into a club, you'll be more welcome.' (PVI1)

On the other hand, one participant (PVI2) expressed and PVI3 agreed that a social group was not seen as necessary due to the social media groups, for example, on Facebook which already provide some groups for VI people. PVI2 suggested that it would be enough to offer a link to those existing social media groups rather than creating another one.

'What about linking into existing social media groups for visually impaired people instead of creating, yes, another one? You could say there are great groups of British blind community on Facebook.' (PVI2)

Regarding the suggestion to add new contents, one participant (PVI3) wanted to find other type of physical activities, such as workouts, because the current app offered only VI sports. As this participant believes that starting a physical activity requires a lot of effort, she felt that there was a need to search for local gyms and workouts which could help users who are physically inactive to start from this type of category.

'...like aerobics, not necessarily competitive sports, but kind of like, you know, working out and stuff like that and stuff about gyms too. Because I think that's going to be a like a huge starting block for the visually impaired people to be active, because it's kind of like the basics most people should go to look. [...] I think to have that information to have like, you know, local gyms...to be able to like contact...ah...people and stuff like that, directly, from the app. I think that...that would really like get the user base. I probably use that if that was for...in the gym. You know, that was one of the categories that probably do that.' (PVI3)

- **Category 4: Accessibility issues**

Both screen reader users (PVI2, PVI3) agreed that the virtual keyboard did not work well while using the TalkBack. They noticed that the TalkBack did not read out the key characters when they typed in the edit text fields of the sign-up screen.

'It's because the keyboard doesn't work, and I can't tell you why it doesn't work. [...] There's no indication that it is typing in it...' (PVI2)

Another issue was related to the modal selector in the 'user profile' screen, in which the widget opened a partial screen with a list of VI sport to select from. The screen reader user (PVI2) expressed that she did not realise that she needed to open a list as the box 'interests' was not obvious. Then, she did not know how to go out of the activities list's screen. For this reason, she suggested another type of modal selector.

'Exactly, it was a pick activity, but I didn't know that it was another box, you had to open to get all the list of activities. So maybe that would...could be changed in some way, to say I don't know...Ah...picker or a combo box?' (PVI2)

Other accessibility issues were mentioned about the potential use of voice assistant in future version of the app, as it seemed to not work very well for both PVI2 and PVI3. They explained that it could not be accurate if the user is in a noisy environment or when it does not understand the user's English accent. However, PVI3 considered it in the case users might have severe motor impairment.

'I use Siri, and I have Alexa. But they're both, as an example, they don't always work [...] If you're in a noisy environment. You don't wanna be trying to talk to it. And then going...'I can't hear you. I don't know what you're saying'. It's infuriating.' (PVI2)

'No. And if you're like me, you have like, you know, some kind of like English and American drawl. Yeah, never understands me. [...] I don't think it's needed, unless, you have like severe motor disabilities, work hard to kind of pick up your phone or something.' (PVI3)

In addition, the four tabs of the navigation bar at the bottom of the screens were announced as selected by the screen reader, while the focus was moved through the tabs. This issue was reported by PVI2 and PVI3 while they used the TalkBack.

'One thing that I found a little confusing was when it says, 'Home' tab, one of four selected but it was also selected in. [...] That the other tabs are at the same time selected, but I knew they won't. Because you have to double tap on them to open them up.' (PVI2)

5.6 Discussion

The development of the ActiveVI app was a more realistic and accessible artifact for VI young adults be able to evaluate its feasibility, accessibility, and usability. This allowed use of assistive technologies, such as screen reader and magnification, to explore the design and test the navigation, flow and matching the design requirements and user models (Rudd et al. 1996). The system can be

explored, discussed, refined for an iterative revision (Rudd et al. 1996; Lim et al. 2008) and to learn from VI young adults about their accessibility needs and participation in physical activity and sport. Also, the design and process can inform designers and developers about devising an accessible and usable mobile application in the context of physical activity and sport for VI young adults. This helped to answer the SRQ 1 – ‘How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?’ by the designing, validation, and suggestions of improvements from VI young adults about the accessibility and proposed services for VI physical activity and sport.

The ActiveVI app was implemented in React Native by the MSc student who worked together with the author, who had no programming skills. The author guided the MSc student throughout the implementation phase in considering accessibility, usability, and modifications from the user feedback of the initial design of mid-fidelity prototype. In this process, the author provided detailed description of the refined design requirements to the MSc student. However, some of these requirements were not implemented, such as the addition of a feature of accessibility settings due to its complexity and the limited time left to the MSc student to complete the Master dissertation project. The author checked constantly the user interface of the mobile application during the implementation to make sure the design requirements and its details were well implemented. The intent was to design an accessible mobile application with simple interface with bold fonts, colour contrast, large buttons and one element displayed vertically line by line to easy navigation for screen reader users. The design followed four parts from refinement of design requirements into functional and non-functional requirements, review of previous studies on accessible mobile application for VI people, to learning and applying a cross-platform and database to build the mobile application. During this process it was difficult for both author and MSc student to understand and apply the accessibility guidelines, such as the WCAG 2.1, in a short period of time to learn the content, which is confusing and not focused on mobile application, as this issue has been recognised in the literature (Silva et al. 2019a; Paiva et al. 2021). Due to time restrictions, a brief manual checking for accessibility was conducted by the author when the MSc student completed the implementation and unit testing, therefore, it was not possible to conduct a heuristic evaluation. Thus, the accessibility checking was conducted by VI young adults. This was ideal because the usability testing is considered more accurate and effective than the heuristic evaluation (Law and Hvannberg 2002).

The React Native allowed to build both Android and iOS versions and to use its accessibility components associated to Android and iOS native code. Some participants missed some physical activities in the ActiveVI app, such as workouts, because the database was only focused on VI sports. This did not interfere with the interaction and understanding of the application. However, it might have influenced the participants’ opinion on how useful the app would be for them, as one

participant expressed no interest to use the app because there were no other types of physical activity rather than the VI sports. Generally, the mobile application and database provided participants with more realistic simulations of the potential functionalities and allowed them to ideate future actions to attend their needs.

The first evaluation sessions were conducted on the author and MSc student's Android mobile phones only, which represented a limitation to this study for two reasons. One refers to the screen reader users that were more familiar with VoiceOver and they did not use their own mobile phones with their preferred accessibility settings. In the literature, little agreement exists on evaluation techniques appropriate for mobile phones (Duh et al. 2006). Finally, more users were needed to further explore the design requirements and bring insights of potential features and improvements of the ActiveVI app.

5.7 Summary

The design phase of ActiveVI app provided the opportunity to learn and apply the refined design requirements and needs of VI young adults regarding the services for physical activity and sport, accessibility and usability, into the React Native implementation. The contribution of this study is to inform designers and developers about the importance of defining a plan to design an accessible mobile application for physical activity and sport by considering the accessibility and usability, and the coding platform and database; designers and developers need to learn and understand accessibility guidelines in order to apply appropriate accessible user interface components and visual layout; and consider more users to evaluate the minimum viable product to obtain more insights into the design of the application. The next chapter is about the technical updates of the mobile application and automatic accessibility testing which facilitated the next sessions of usability testing.

Chapter 6 App update and manual and automatic accessibility testing

6.1 Introduction

The last chapter described the first round of the user evaluations of the app and interviews with VI young adults. The results informed the design requirements with new insights, features, accessibility, and usability issues. Afterwards, the PhD was suspended for a period of 9 months due to author's maternity leave. In the meantime, the app had deprecated libraries, dependencies and other technical issues which needed to be updated by a new developer, as the MSc student who had help to build the app was not available anymore.

After the period of the PhD's suspension, the app's update was necessary to release the beta versions of Android and iOS for the next round of usability evaluations with VI young adults (Chapter 8) as more participants were needed to gather feedback on the app. Also, it was needed to conduct app demonstrations with coaches (Chapter 10). During the update, it provided an opportunity to make some adjustments of accessibility issues that were identified in the previous user evaluations and while checking for accessibility using the Accessibility Inspector in Xcode. Furthermore, the accessibility testing was conducted while the author undertook an internship at Microlink PC. This chapter presents the process for updating, fixing, and conducting manual and automatic accessibility testing.

6.2 App update

A second developer fixed some issues without documentation as this had not been created by the MSc student as originally this MSc student had agreed to stay available to update the app; This developer reported all the issues as sorted in the Gitlab but was not aware on how to release the beta versions and so the author searched for another developer with more expertise to do this. While searching for a new developer, the author investigated the release process and found it complex as although there are some instructions on the platforms' website about how to prepare the app for release, it does not say exactly where to start. The description of the tasks is very technical and does not have an alternative to help non-developers to understand the process for creating the distribution certificate and releasing the app.

A third developer was found who helped to fix the bugs, dependencies, and deprecation issues and released the app beta versions, the APK file for distribution of the Android app, and using the

University of Southampton's Apple Developer Account for the iOS app. Deprecation was the main problem, for instance, when searching a VI sport, the app was not finding any events in any month. Thus, any conditional queries to fetch events were removed or changed to allow the app to show any event available regardless of actual date. Another issue was related to the structure of the bottom (navigation) bar because the app was using an old version of the "react-navigation" dependency (version 3). The most up to date version was 6 at the time of updating. That is why the screen reader announced all tabs were selected. Although the "react-navigation" dependency can be upgraded, this would break the app as the existing code would depend on the old dependency. At the time, it would require further work and a large amount of time to be carried out before upgrading the dependency and once the app had been upgraded to version 6, then it would contain accessibility support for the bottom tab bar. However, it was not a priority given the time remaining available for completion of the PhD and the issue remained without seriously affecting the app's evaluation. The author had to explain these issues for participants during the user evaluation.

Moreover, the new developer implemented ModalSelector for sports' list in the 'find events' screen and fixed bugs as the modal selector was a better alternative to the picker component (see Chapter 5). Other issues solved were related to an internet error message not closing, a bug in activity selector, integration of Google Maps API for transport's information, location dependency, duplicated events, fixed location, bump Android version and so on. Also, some accessibility labels and lists were fixed.

6.3 Manual and automatic accessibility testing

The aim to check for accessibility of the app was to identify an approach to evaluate it by manual checking and automated tools, more details in Chapter 2. This testing was relevant to answer the SRQ3 - What is the guidance information that can assist designers and software developers when developing accessible and usable mobile applications for users with VI? to inform the design guidance about the accessibility testing process. During the internship, the WCAG-EM and its report tool was discussed as a framework to evaluate native mobile apps as well. This can apply a systematic approach to accessibility testing through the steps of report tool. The author decided to adapt it to support the accessibility testing of the app, similarly to the 9 phases' study of (Acosta-Vargas et al. 2020d), see Chapter 2.

6.3.1 Method

The author focused on the accessibility testing in iOS and Accessibility Inspector version 5 in Xcode version 12.5.1 (12E507), and an iPhone 7 and a Bluetooth external keyboard for manual checking

were available to use. The Android version could be tested using Robolectric or Espresso, testing frameworks to check accessibility at runtime during test cases (Silva et al. 2018), however, these resources require programming skills, instead the author manually checked the app using the Accessibility Scanner. The disadvantage of Accessibility Scanner in the development process is that it can only check limited accessibility properties and when the app is installed in an Android mobile device. This is not feasible for larger apps and short testing cycles because it is time consuming for developers who need to activate the tool on the device in order to obtain the results from each screen (Eler et al. 2018). Therefore, this section describes the method related to manual and automatic accessibility testing for iOS and Android.

The author attempted to do several times the accessibility testing filing in the WCAG-EM report tool (see Chapter 2); however, this tool was not practical because it does not allow the user to save the work automatically; the user must download the data in HTML or JSON to save the data on the computer. Sometimes it did not upload the data back to the tool, and it was not easy to use because of its structure, as there are many WCAG 2.1 success criteria to fill in the data, it is presented in a long list to scroll down and there is no quick access to previous criteria when the user is at the bottom of the page or whether to know the ones already completed or not. Additionally, there is no separate text field for automatic testing and manual testing.

This study followed the steps of WCAG-EM 1.0 and a similar approach used by (Acosta-Vargas et al. 2020b) as they used WAVE and an adaptation of the WCAG-EM 1.0 to record the results of the accessibility testing of a website in a spreadsheet. This current study used Microsoft Excel to create an individual spreadsheet for each Accessibility Inspector and manual check. In the first two steps from the WCAG-EM 1.0 (define scope and explore website), the accessibility support baseline (e.g., VoiceOver), additional evaluation requirements (e.g., Screen magnifier, Swift Control, Braille display), and the WCAG 2.1 level AA were described.

In the third step (Select Sample), screens were selected according to the screen type and different functionality. Little is known about methods of selection of screens' sample (Brajnik et al. 2007; Baazeem and Al-Khalifa 2015) and it depends on the website size, age, consistency (i.e., variety of page types, functionality, technologies, coding style), complexity (i.e., interactive, generated and implemented content), and development process adherence in terms of consistency in the coding and process, training for developers and for designers (Velleman and Abou-Zahra 2014). For example, the uniform random sampling method applies probability to select the sample, however it is not ideal for websites with few different templates. The selection criteria based on page template types is the most common approach in practice on accessibility evaluation of websites (Brajnik et al.

2007). Also, it is recommended to select representative pages based on different functionalities (Baazeem and Al-Khalifa 2015).

As the app is not large, one screen was selected from 3 groups of screen types and other 2 screens with different functionalities, the sign-up and chat screens. The author noticed the app had screens with similar layouts and UI elements which formed 3 groups with different functionalities between them. The author did not consider selecting a method related to a complete process as stated in the W3C's step 3c (include complete processes) because in this case, it would include a similar screen already selected from one of the similar groups (Velleman and Abou-Zahra 2014). Five out of 20 screens were selected: sign up, find coach, event details, activity list and chat.

In the fourth step (Audit Sample), the spreadsheet for the automated testing was divided into the sample screen's name, the built-in tools of Accessibility Inspector, the UI elements in the screen, and the type of automatic testing or researcher observation while using the tools. It had the three items (Result, WCAG 2.1 Success criteria and Comments) based on the WCAG-EM 1.0 of step 4 Audit the Selected Sample. All tables of the sample are in the Appendix E. The manual checking was later conducted to consider the remaining WCAG 2.1 success criteria and elements which were not addressed in the automated tool, such as sign up with social media, autocomplete function in forms. By using the app installed in author's iPhone and assistive technologies mentioned earlier. The spreadsheet used the same columns, except the column Accessibility Inspector, where 'testing' column were completed with VoiceOver or external keyboard.

The fifth step (report findings) consists of the summary and additional information relevant to add in the findings (Velleman and Abou-Zahra 2014). This identified that some tests are not possible to run on Accessibility Inspector, such as the text field's autocomplete function (1.3.5 Identity Input Purpose) and this was checked manually and the WCAG 2.1 success criteria included in the table to record this result. Moreover, the Invert colour, Dark Mode and Smart Invert are attributes specific of iOS settings which are not mentioned in the WCAG 2.1. A few success criteria related to perceivable, operable, and robust complied with WCAG 2.1, as expected according to the literature. In the spreadsheets, the 'alert' column was reported the outcomes of the testing, such as Failed, Caution and Passed, similar to the outcome input field of the WCAG-EM report tool, however, the author added the Caution for those results that partially failed, for example, by using the VoiceOver the focus order passed but failed when using the external keyboard.

Regarding the failures, Accessibility Inspector and Accessibility Scanner did not find all of them, similar issues were identified. However, some issues regarding the use of the Bluetooth external keyboard were slightly different between iOS and Android, especially in terms of focus order or not giving focus to some elements in the screen or keyboard trap. For example, in the 'Event details'

screen the Android failed when the user can select the options, but cannot go back to the screen, whereas the iOS allowed it. Most of the failures were about missing out traits, states, not allowed increasing colour contrast, icons' small size, date and time labels in the 'Chat' screen and, generally, the unnecessary information added within the label to be announced by the screen reader. This made the label to be repetitive if including the 'button' in the text label, the screen reader may speak for instance, 'Back button button'. The Accessibility Scanner does not report all the failures and there is no way to check if some elements passed to clear any doubts, as it can be done in Accessibility Inspector. Therefore, the spreadsheets related to the Android's accessibility testing reported only the failures in automatic and manual test, the manual test had several elements with similar issues identified in the iOS's manual testing, for this reason the Android's manual testing presents the outcomes which were different from the iOS' manual testing.

Another approach used was the Web2Access version 3. This is an accessibility testing website based on the WCAG 2.1 level A and AA and made by the University of Southampton for e-learning by students and academics. This allows users to test any websites through a step-by-step process with overview about the WCAG success criteria and techniques and its links to independent manual testing and it can also be used by novice developers (Wald et al. 2012; Draffan et al. 2020). This system was used to compare the process with the WCAG-EM 1.0. The Web2Access has 12 tests based on different functionalities, such as Login, Signup and Other Forms; Content Description and Text Alternatives; Link Target Definitions; Logical Page Structure and Order; Reading Order; Audio and Video Features; Appropriate use of Tables; Page Functionality with Keyboard and Touch Screen; Appropriate Feedback; Contrast and Colour Check; Page Integrity when Zooming, Resizing Text or using Device Motion; Language, Readability and Flashing elements. The author used the manual testing section to review the automated and manual testing to identify how the process works when testing the app.

In the review, the author followed the steps and selected the outcome that was approximate to the results observed in the manual and automatic testing. Each test offers 5 answers with ratings (0%, 33%, 67% and 100%) to select from that matches the findings. For instance, the 'Sign up' screen of the app was tested against the first test (Login, Signup and Other Forms) and the selected answer was at rate 100% which describes that no CAPTCHA was used, and forms were accessible and simple, etc., the other answers did not match. However, it was necessary to give more details in the summary to explain that some selected answers partially matched the actual findings or to inform failed components related to mobile app. In the case, the virtual keyboard failed to provide the '@' key while others in the screen passed, thus the rating was not helpful.

6.4 Discussion

The update process was challenging due to the difficulty to identify a new developer with expertise in mobile development and release of Android and iOS apps available to work in this study. It is important to undertake a project with a developer throughout the development lifecycle to avoid any delay and lack of support and keep any documentation for reference of the work done. According to the new developer, some components in React Native are not as customizable as the iOS native ones, then iOS might have more features than Android and React Native cannot accommodate both Operating systems. To achieve a fully accessible app, Swift for iOS or Kotlin for Android is preferred as they offer highly customisable UI components that can offer a more precise synchronization for accessible features.

Regarding the accessibility checking, the WCAG-EM applied in this study required a lot of time for checking each sample's screen against individual WCAG 2.1 success criteria. This became lengthy and complex due to the high number of criteria and structure of the tool which was not very helpful to input data. The failures, cautions and passed WCAG 2.1 success criteria were reported mainly about excessive text labels which provided redundancy information, small back button and icons' size, and issues while using the screen readers and the Bluetooth external keyboard. The reported issues led to recommendations or information of the expected outcomes of the user interface and assistive technologies.

On the other hand, the first positive impression about the Web2Access is that some WCAG 2.1 success criteria are grouped into the related functions mentioned above. This approach seemed to speed up the testing compared to the WCAG-EM as this gave one test for each success criteria of WCAG 2.1 for each selected screen. However, both methods do not support the record of single components or issues in a particular screen. This was also perceived by another study, which used spreadsheets to inform developers about ongoing problems (Elia et al. 2020). The spreadsheet in this current study was helpful for easy visualisation of completed data and was easy to copy and paste comments that were the same across the results. By recording the accessibility testing results during automated testing, the manual checking can be done for the remaining accessibility checks and for the element or function not supported and tested in the automated tool. This was a time-consuming process, especially due to the lack of experience of the author in accessibility testing with all WCAG 2.1 success criteria. The use of the WCAG-EM 1.0 may be more efficient at later iterations in the agile development process due to the time demanded and Web2Access throughout development for two reasons: firstly, because it provides an overview of the WCAG success criteria and extra resources and information of what to look for and use while doing the testing, this can be helpful for

newcomers in accessibility testing. Secondly it simplifies the testing by grouping criteria related to different functionalities.

Overall, this study suggests that the better option may be to do primarily the automated testing while implementing the app, using automated tools, such as Accessibility Inspector for iOS and Robolectric or Espresso for Android, and recording results in a spreadsheet for future reference and compliance, and after releasing the beta versions to do the manual testing using the screen readers, VoiceOver and TalkBack, and a Bluetooth external keyboard, if possible, by accessibility specialists (Acosta-Vargas et al. 2021a) or assisted by them if developers have been given training in accessibility testing of mobile apps.

6.5 Summary

This chapter described the challenging process for updating and releasing the beta versions for Android and iOS. The challenge was to find another developer available to fix the issues and release the app, especially the release of iOS app due to the extra effort and time to create keys and distribution certificates through TestFlight and await the Apple Store approval. The manual and automated testing reported an overview of the use of the approaches from WCAG-EM and Web2Access positive and negative comparison and the failures identified which were similar across the screens related to text label redundancy, issues impacting use of a Bluetooth external keyboard, and issues related to text reflow and size adjustment. The approached use in this study helped to report and suggest the expected outcome of the identified failures. The next chapter presents and discusses the interviews with VI young adults about their physical activity experiences.

Chapter 7 Study 3 - Phase 3: Interviews with VI young adults about physical activity experience

7.1 Introduction

The previous chapter, Design and development of high fidelity updated app (Chapter 6) summarised the adjustments done in the high-fidelity prototype app by a mobile developer. These adjustments were necessary for the online usability evaluations with VI young adults (Chapter 8) which was conducted after their participation in the online interview study about their experiences and views on physical activity and sport. This online interview study is the focus of this chapter.

In this chapter, the online interviews aimed to gather more in-depth knowledge and insights from VI young adults' experience in physical activity and sport in the UK. As reported in the literature review (Chapter 2) little is known about the physical activity and sport participation of VI young adults, thus this chapter aims to report their experiences, preferences, perspectives and needs to get active. The aim of this study is to explore the experiences, barriers, and facilitators to participate in physical activity among VI young adults. The findings could enhance our understanding of the experience, barriers, and facilitators to do physical activity and sport for VI young adults.

7.2 Method

The qualitative semi-structured interviews were conducted online due to the COVID-19 social restrictions between November 2021 and February 2022. Hence, it was not possible to undertake the face-to-face interviews. For this reason, accessible video conferencing calls overcame such a constraint successfully by allowing participants to easily access and take part in the interview study. It has ethical approval from the University of Southampton Research Ethics Committee, reference number ERGO/FEPS/53732.

7.2.1 Sampling and recruitment

A purposive sampling method was used to recruit participants who were eligible as young adults between 18 to 30 years old with visual impairment (partially sighted or blind) with no other type of impairment and no mental health problems. The criteria included participants regardless of being physically active or not. The author assessed whether interested participants met the criteria through the given answers in the self-report questionnaire. The sampling plan aimed to recruit up to 20 participants. This sample size was determined based on achieving the meaning saturation principle

which refers to fully understanding issues, for example the physical inactivity, which can be achieved with data from between 16 to 24 interviews (Hennink et al. 2017). To achieve this number, the author searched on the Web and made a list of 96 contacts of organisations, charities in disability and visual impairment, colleges, and universities to contact them by email as well as a list of visually impaired social media groups. The author undertook the procedure to recruit participants that is described in the ethics application (Appendix F).

Throughout the recruitment, organisations that did not reply after ten days of first contact received a follow-up email to check the author's email was received or a telephone call. Similarly with social media groups, the author reposted the study advert after ten days or asked social media administrator to do this. Due to the low number of recruited participants, the author made an accessible website on Wix, a video and an image inviting participants, which helped to get the study more participation. For example, participants contacted the author directly from the website's contact form. The website was made as accessible as possible with the features available in the Wix platform with information about the study, links to accessible participant information sheet, consent form on Word, demographic survey on iSurvey, authors' LinkedIn, Twitter, as well as the author's email address and a contact form. Before sharing the website, the author checked the website with Wave, web accessibility evaluation tool, screen readers Narrator, VoiceOver and TalkBack, and asked one partially sighted and one blind participant that took part early in the study to check the accessibility of the website and they confirmed it was accessible with one observation to make the text a bit bolder.

The author also made an accessible study advert post on a social media group by adding alternative text to the image and captions to the video. From this post, the author was able to share it. One visually impaired person checked the accessibility of the post. Thus, the author was able to copy the link of the study advert to send to organisations and asked them to share the link in their social media. In this case, organisations saved time in making an accessible post and the author could be sure the shared adverts were accessible throughout.

Another sampling method used in this study was snowball sampling. This method is commonly used to recruit hidden populations as the initial sample can provide invite other individuals similar to them to participate in the study (Faugier and Sargeant 1997). After each completed interview, the author asked participants to invite their friends or someone they know similar them to take part in the study to increase the number of participants.

7.2.2 Procedure

The interview protocol comprised the plan and data collection questions to undertake the semi-structured interview study (Appendix G). The plan was fully described in the ethics application (Appendix F). The interview questions were 18 in total divided into topics, such as experiences and behaviour, knowledge, and services. These served as a guide to understand and explore topics in the experience in physical activity and sport. All participants had access via email to the accessible participant information sheet and were asked to fill in the online and accessible demographics questionnaire created on iSurvey before the scheduled online interview and to provide consent to take part in this study by ticking a box on the first page of the survey. This allowed more time for the interview by providing the demographics survey beforehand, as the author did not have to ask the demographic questions at the beginning of the online session. The author conducted pre-tests of the interview study with two VI people invited by snowball sampling.

7.2.3 Pre-test

Two blind individuals took part in the pre-test of the interview study. Responses from one volunteer in the pre-test was included in the analysis as the other person was not eligible due to the age criteria.

The pre-test aimed to test the protocol and participants completed the online demographics survey on iSurvey and answer the questions of the interview. After completing the interview, these participants were asked about the accessibility and questions of the online survey and if the interview questions were clear and easy to understand. The pre-tests ran smoothly, and no observations or changes were needed.

7.2.4 Online interview with young adults with visual impairment

The author took the same procedure in the pre-test at the beginning of the session. Initially, the author provided more information about the interview or clarified any participants' questions. Such information was to reaffirm their participation was voluntary and anonymous. In addition, the author read a short definition of physical activity and sport to ensure the meaning of these terms were clear through the interview and avoid any misunderstandings.

The author was the only person to conduct individual online interviews sessions either on Microsoft Teams or Zoom and asked the questions in the protocol and probing questions throughout the interview. This helped to guide the interviewee to express more about their experiences, preferences, and views.

By the end of all online interviews, the author asked participants if they would still have time and interest to take part in the user evaluation of the ActiveVI app (Chapter 8). All recruited participants were interviewed, and the author used the recorded videos to transcribe the interviews for data analysis.

7.2.5 Data analysis

The transcriptions of video recordings were obtained from the automatic Microsoft Teams transcripts file, and manually transcribed on NVivo from Zoom video recording sessions. These transcripts were imported to NVivo (version 1.6.1) for coding and aiding the thematic analysis.

After listening to the video recordings and reviewing the transcripts on Word, the author anonymised participants data by creating an anonymisation system on a Microsoft Excel spreadsheet to include participants identification, which were VIP1, VIP2, and so on and code identification for places, etc. The author imported the transcriptions on Word document files to NVivo (version 1.6.1) and conducted an inductive approach of the thematic analysis; this had a complementary two-level coding system (“what/how”). The ‘what’ is a guiding question for researchers to ask themselves from the participant’s perspective - ‘what is the participant talking about at this point in the transcript?’ at the preliminary and descriptive level and this question is followed by the ‘how’ question at the interpretative level, which refers to ‘how is the participant understanding or constructing what they are talking about at this point in the transcript?’. This coding system is a simple and straightforward approach to help novice researchers to engage with the data consistently and confidentially. This can facilitate the coding process to understand of the issue discussed by the participant (Watts 2014).

The author was the only coder that produced the coding and themes. This was a way to get the coding consistent. One coder was enough due to the iterative process to understand the data, coding and recoding or combining codes until checking the agreement between extracts and codes (Elliott 2018). It aimed to reveal and understanding of the data from the participants’ views. The author invited input from her supervisors, for example the behavioural researcher, who met several times to discuss the codes, themes, findings, and interpretations and this was important for rigor and reflection of the study.

The author read the transcripts several times to become familiar with the data. The initial codes were assigned to the most important extracts of the transcripts which were addressing the questions of the design requirements. The author selected important extracts of transcripts and applied codes; such codes were short descriptions of what was said by participants. At this descriptive level, the author looked at what the subject-matter the participant was interested in and talked about at that moment in the transcript. Throughout this process the author continued coding and looked for

coding repetition. Then, the author coded at an interpretative level, by reading the extracts again and identifying how the participant understood the subject-matter. In this sense, the code assigned an interpretation from participant's viewpoint and the author asked the same question repeatedly through the transcript related to the descriptive codes.

At the end of this process, the author reviewed the codes and grouped those similar topics to create themes. The author created overarching themes and sub-themes, and this process was ended by a final review to verify the match between each theme and sub-themes with its extracts in the transcription. All coding review versions were saved for an audit trail to track how the themes were identified within the data.

7.3 Results

7.3.1 Participant characteristics

Eight participants took part: Four females and four males. Physically active participants (n=6) had participated in physical activity or sport on a frequency of mean = 2.125 times per week. They had been physically active for 3 months up to 10 years and more. Most participants were full-time employees (n=4) with a degree level or above (n=6), income between £20K to £40K (n=4), white (n=5), and living alone (n=3) or in another living arrangement (n=3). Whereas those full-time students at university and college (n=2) were Asian or Asian British and Latvian were living with parents with a household income between £20k to £40k and below £10k.

Most physically active participants were full-time employees and had a similar range of income and education at degree level or above. All participants, regardless of being physically active or not and visual impairment level, said they used computers and assistive devices on a daily basis.

7.3.2 Themes

The inductive thematic analysis of this study resulted in five themes and several sub-themes. A list of themes and sub-themes are in the codebook (Appendix H). The themes and sub-themes are described as follows:

7.3.2.1 Theme 1: Challenges with participation in physical activity and sport

This theme describes the challenges faced by VI young adults when taking part in physical activity and sport.

Sub-theme 1.1: Lack of knowledge and awareness of visual impairment and inclusive physical activity and sport

This sub-theme refers to the barriers faced by VI young adults related to information and awareness of visual impairment and inclusive physical activity and sport. Participants reported that there is a lack of information about physical activity and sport sessions for visually impaired people in their on the local area and how to get support to take part. In addition, participants reported that there is a need of more awareness about visual impairment and adapted physical activity and sport.

Regarding lack of information, participants reported that VI physical activity and sport sessions are not very well known, especially in the local area. For example, not knowing about running services offered from databases such as the 'Find a Guide', which is a website to find volunteer guide runners for VI people.

"...but, even when it does exist, my perception is that people don't seem to know about it [VI physical activity and sport] [...] and people ask me for help, as well. Now, they'll say because they like...someone will know that I'm a runner and they'll say 'oh, how do I get started with running?' So, so even when the provision is available even when things like Find a Guide are available, people don't know about it at all. There's a lot of people who don't know how to get into sports, I think." (VIP3)

"I wouldn't say there's a lot out there, maybe like through...I don't know. Maybe because I've not asked for it and I don't have any or involvement with these charities like, personally, anymore 'cause I'm very independent now. Uh, I don't like to use these services 'cause I don't feel the need to. But...in my line of work as well, I see you know a lot of visually impaired people and I don't hear of many events that are for visually impaired people as much. No." (VIP6)

Physically active and inactive participants, those who self-reported participating in regular physical activity, showed little awareness of VI physical activity and sport providers, as they mentioned few charities in the sector such as British Blind Sport, as a national body, and Metro Blind Sport, which run VI sports in London only and little knowledge about VI sport through social media.

"I don't know much, but I've heard they [British Blind Sport] do like goalball, cricket, they do kayak as well. Uh, that's all I know...I found like on social media, on Instagram." (VIP4)

Even when they know about these services, they may not use them, for example, VIP8 explained that she knew about some VI sport organisations, however, she preferred mainstream sport.

"Yeah, I do know of some organisations, but like I don't really use them myself. I don't use them personally...Because I prefer to do like mainstream sport." (VIP8)

The lack of information included also how to get financial support in the case there is a need to pay someone, for example, to support a VI person while doing exercise at the gym. VIP1 reported the need of more information around this matter, especially for a council run gym, and wondered how and where the money would come from, if the council would provide funding for a VI person to pay and get the support needed when the lack of a company may be a barrier.

“...and being able to get the support in which to do it. Because as I said it's more about the fact that people they have to pay for this support and there's not much information about how about, how...where this money is going to come from to pay someone. That's always the question, who do you pay?” (VIP1)

VIP3 and VIP8 also expressed that it would be useful to know how someone with visual impairment can start doing physical activity or sport, which implies getting enough information to get into the sessions by knowing where and who can join the sessions, what level of visual impairment is the activity suitable for, cost and so on.

“...how do you get into them [sports], you know...And then, you know like say help them [VI people] actually start doing them [sports].” (VIP3)

Participants also reported the need of more awareness about visual impairment and VI physical activity and sport everywhere. This includes their views that there is a lack of understanding of visual impairment among physically active members and staff of mainstream sport and gym venues. For example, VIP6 expressed the concerns if people around him would understand VI and his feeling of being under pressure to be “normal” in those environments and situations.

“I think it's partly down to...if I feel the need to slow down, I don't want to feel like the person at the back of the group, you know, if everyone...behind or I guess then, not being aware of my visual impairment. Maybe not having an understanding of how it works... I don't know just the pressure to be normal in that situation I guess, and though I feel like I come across quite normal when I'm when I'm running, but I think it's just more insecurities and anxiety that leads me not to do it.” (VIP6)

The lack of understanding of visual impairment among professionals of sport and physical activity was also mentioned as a barrier. VIP8 was concerned about this issue as she wanted that those professionals in mainstream sport and physical activity venues could understand her problems because she had to explain it every time she got into a new physical activity or sport.

“Oh if, like people probably understood my...like different...about like visual impairment stuff, so that I didn't have to explain it to people when I start something new...Because it's like a lot of people don't

understand or like they don't...they would then think that you're like less capable. Even though...yeah, they don't understand." (VIP8)

Regarding this issue, participants showed agreement towards the need of more training for those professionals to overcome the lack of understanding of visual impairment.

"Maybe just more training for people like personal trainers, you know, in in how to make their programs accessible." (VIP7)

"...and also, for more like...training like sport professionals and coaches to know about disabilities and to understand so you don't have to explain it." (VIP8)

Sub-theme 1.2: VI people feeling different

Generally, participants expressed the feeling of being different from others. Both physically active and inactive participants mentioned about this perception. Physically active participants perceived this feeling when they had to explain what visual impairment is to physical activity professionals, as they tend to treat VI people differently.

"...they don't understand. Uh, or like...yeah, they would treat you differently because of it...They might like to put you in like a different team because they think you're not as good or they might...yeah, just like have different expectations of you." (VIP8)

In addition, they reported some situations they perceived when disabled people are allocated all together in the same activities, which they expressed as bias and a concern because individuals have different needs.

"Oh, we tend to have situations where disabled people are just bunched together with other disabled people, and we just don't get to meet other people who aren't...ah...able-bodied let's just say. And kind...also it helps to lead to unconscious bias I mean that would be like saying that we should have only black sports, where is...that could be considered racist." (VIP1)

"they're like...mix you in with other disabilities as well. Uhm...So like everyone has very varying needs." (VIP8)

Moreover, VIP6 reported to feel the pressure to be normal due to his perception of lack of awareness of visual impairment among other members in mainstream running clubs. In this sense, he perceived it as intimidating and had never had the intention to join a running club.

“But no, I've never really thought of another way of getting support or going into like a running club. I find I find running clubs intimidating...I don't know. It's all very cliquey and I don't know if that's partly my anxiety as well of it.” (VIP6)

Also, VIP6 expressed the feel of not being part of VI community because he feels independent and had no need to search for VI activities.

“I don't feel part of like a visually impaired community. I feel very independent as such. I don't feel the need to find other people that have got visual impairments 'cause I've just grown up and got used to it, I guess. I've just dealt with it in my own way, uh, so I've never felt the need to find the visually impaired group, uh, which is quite contradicting to what I say when, you know, I don't wanna join groups, you know, where there's no one with visual impairment. I guess I'm just quite uh...you know, introverted when it comes to doing sport.” (VIP6)

Sub-theme 1.3: Concerns and insecurities to do physical activity and sport

Generally, participants expressed concerns on safety and accessibility of sessions, as well as insecurities towards taking part in physical activity and sport.

The safety concerns were around some specific issues reported by VIP2 (blind, physically inactive) that prevented her to get active. She had experienced sensory overload, and she struggled when she was at the gym. The loud environment was extreme for her to with stand while in the gym. This was an issue that prevented her from doing exercises at the gym.

“I would find it very loud because as I said, my other senses are heightened and that does include my hearing, so my hearing is amplified, and I hear things louder than they actually are. And obviously, sound isolation in large places isn't great either, so if you go in a big hall, you expect a lot of a reverb. Uh, when you, when, when, when you...when sounds are made. So, that all of that put together makes it very loud. It makes it unbearable for me to be in that environment, I find it very loud. It can give me a migraine. It can make me cry even yeah, 'cause physically I can't take it. It's too loud and I can't and which...and that...that's created an obstacle, and...uh, makes me reluctant to participate in activities like this, as well.” (VIP2)

VIP2 had concerns on risks of accident during an exercise. This is because she expressed that because of visual impairment she could not have a “sense of distance” due to not being able to know the environment clearly and it could lead to potential risks of accident as she would not know how far she would be from others or things.

“So, it's that inability of...knowing your environment, knowing your surroundings clearly and seeing what exactly is around you...Not knowing your sense of distance as well, for example, if

you're...uhm...doing something like stretching. Yeah, like if you're taking part in like stretches and stuff like that and you're standing between two walls, and you don't know how far apart the walls are and you stretch out and you could bump into both walls. You know? So, sense of distance, sense of environment. What is around you? What? What are my surroundings, what it, how large the area is like? Are there any obstacles around me? Is there anything I can bump into? Is there anyone that can bump into me? That kind of stuff.” (VIP2)

She also mentioned her concerns towards running, as she mentioned that she could not see if someone could run towards her or vice-versa.

“I could run into something or just, as easily, somebody could run into me and I wouldn't have a clue until I'm flat on the floor and screaming, yeah.” (VIP2)

Another reason of not doing physical activity or sport is because of muscle pain. VIP2 explained that it would not allow her to do daily activities due to the pain in her muscles after exercise or sport.

“And, obviously, muscle pain is another thing as well, you know, because when you either do something and then your muscles hurt and you think bloody hell, like I can't do normal things just because I took part in that physical activity, I can't do normal everyday stuff now 'cause I'm in pain all over me.” (VIP2)

Beyond these concerns on safety, other participants manifested concerns on accessibility of physical activities and sports sessions, whether these sessions would be VI focused.

“I think it's a lack of accessibility to certain sports. I feel like not every sport is visually impaired friendly” (VIP6)

“Yeah, the trickiness is always whether they're going to be accessible. Yeah, so that is always a concern. So yeah, I probably would broaden what I'm doing to different stuff if I if I could, and if it was going to be accessible to me.” (VIP7)

Furthermore, VIP6 reported feelings that may interfere with his participation in physical activity and sport, such as social anxiety.

“...because I don't like the idea of going to a social anxiety sort of situation, being in the gym surrounded by people.” (VIP6)

Whereas VIP2 mentioned about her lack of trust on a guide runner to begin running sessions.

“And even then, you know, even when running with a teacher, you know, even then the teacher doesn't look under your feet, yeah? You could still run over something; you know what I mean? Like,

for example, if there are cones on the floor, yeah, that you have to run around if they're in a tight squeeze. If they're in a small distance between each other. Just like that I'm gonna be...I'm gonna knock them down and fall over them as well.” (VIP2)

Also, she explained that although a guide runner role is to help VI people to bypass obstacles, this person would not be able to run and see potential hazard at the same time to alert her to avoid a collision with something.

“Well, what the guide runner is meant to do really is guide me around every obstacle there is. That...it doesn't seem to work very well because they obviously having to look while they're running and they're having to guide me around as well. And you know, running isn't walking where you have, you know, while you're walking, you have time to look and see and walk around stuff, but when you're running, you just running and all you're really thinking about is having to get to the finish line or get to...I don't know...get away from people before they catch you or whatever, you know, that's what you're mostly thinking about. You're not thinking exactly about how to run without running into anything, you know what I mean?... Even while having him as a guide runner, I could have other people running to me just as well.” (VIP2)

The same perception was described by another participant, VIP3 (physically active and blind), when he started running with guide runners. He reported that he was insecure whether to trust the guide runner to run with until he had experienced the sessions with two guide runners.

“Well, I mean it...I mean it was always...I mean you can argue that any run should feel hard to a certain extent because you want to push yourself. So, but...I mean the challenges were...I guess, initially, I wasn't sure whether I would trust the guides because, obviously, it's quite a big...it's quite a big thing to like..., you know, to go to sort of trust them for you to run with. But to be honest, after I'd had a couple of guides that sort of stopped.” (VIP3)

Sub-theme 1.4: Belief that physical activity and sport is difficult and not for everyone

Participants perceived that physical activity and sport are hard activities to do. Some participants exposed that they believed this when they were younger, when they had difficult experiences of physical education (PE) at school. Others believed that is very difficult to play mainstream sport, although had experienced some VI sports but reported it as not interesting.

“I feel it's difficult to play. That is not accessible. I know there's a few like games that are specific for people with visual impairment like Goalball. But I haven't...I've never tried it. I've tried to use a ball with bells in it. Uh...but I found was not really like...uh, I didn't find it very interesting.” (VIP4)

“So, when I was in uni few years ago, all of our sports weren't...they weren't adapted for VI, so even when I tried to play sports and do physical things. Like it was really difficult because you can't really play on the same kind of level that everyone else can 'cause you can't see the ball, or I can't see my teammates. Or you know something like that.” (VIP5)

A physically inactive participant (VIP2) explained that physical activity is hard for two reasons, although she recognised that she would be able to do some exercises. Firstly, she reported that she was not able to do physical activity due to weakness related to a blood condition, such as anaemia.

“I'm not a very physically active person, uh...there are various reasons for that. But in terms of what I am able to do, like I can...do...a walk like if I'm being guided or like I can use things like a treadmill or like an exercise bike or something like that. In terms of being physically active: a) I'm not able to do that because I'm very weak because of my blood condition.” (VIP2)

Secondly, she explained that physical activity or sport are very difficult because she experienced it as hard at her PE at school.

“b) I find it very difficult to...uhm...especially, when I'm taking part in like back ah you know, like you know, school's situation, when you take part in PE and things like that,” (VIP2)

She explained that running is very difficult because of visual impairment itself as she could not see the direction of where she would be running and described it as something compared to “blind driving”.

“Uh, not being able to, especially, if you are participating in something like running, which I used to do back when I was more stable than I am now. You know, I used to be able to like run. It's very difficult because you can't see where the hell you're going, yeah, it's like...it's like blind driving, yeah.” (VIP2)

In addition, she had the perception that running is something to do very fast.

“And you know, running isn't walking where you have, you know, while you're walking, you have time to look and see and walk around stuff, but when you're running, you just running and all you're really thinking about is having to get to the finish line or get to...I don't know...get away from people before they catch you or whatever, you know, that's what you're mostly thinking about. You're not thinking exactly about...uh...how to run without running into anything, you know what I mean?” (VIP2)

Based on that, she reported the experience she had with a PE teacher, who required her effort to run fast. This can be the evidence that her previous experience contributed to her view of running quickly and competition.

“Like for him [PE teacher], all mattered is that there is a competition, or there's a...uh...activity that we're doing, yeah, and that's it. That's all he's thinking about...He is gonna think about me running quickly and that's all, that's gonna matter to him.” (VIP2)

This perception of competition was also mentioned by VIP5 (physically active, partially sighted), who expressed that the competitive play in mainstream sport was a barrier for him and if it was for leisure, it would require adaptations.

“No, because the way, the way it worked is like it was competitive, right? So, they...it was too hard for me to play if I wanted to be competitive, and it was too hard for me to play if even if I wanted to play socially because it would just involve too much, I don't know...too much adaptation. I'd have to change the colour and the size of the balls. And like my teammates, would have to wear a bright colour so I can see them. So, it was just too much effort.” (VIP5)

Overall, VIP2 believed that physical activity and sport is not for everyone and gave an extreme example of impairment to justify that.

“I mean, if a person like doing it, if a person...if it makes them feel better, and if...it doesn't make them tired and doesn't run them out and everything and if it's something they like doing, feel free. But by no means...they, you know, by all means they should not try to get it on to other people doing it. You know, 'cause it's not for everyone. Physical activity, sports and all this stuff is not for everyone, and all that people say, 'movement is life'. That, whoever says that, makes me wanna hit them, seriously, like...you know, you know, I mean...movement is life...I mean, what sort of an expression is that? Like there are people who have never been able to move at all and can't move like and they live. You know that they're alive. They live, you know, so you can't say movement is life. It's not all about being physically moving and going here, there and everywhere doing this and that, and this and that. You know, it's not for everyone. Some people can. Some people can't.” (VIP2)

Sub-theme 1.5: External factors discourage physical activity and sport participation

Participants expressed several circumstances and resources they experienced from the service provision around physical activity and sport, which prevented their physical activity and sport participation. This ranged from limited or lack of VI physical activity and sport sessions near them, cost of the sessions, lack of support, relying on others to get active and not having enough guidance on online workouts.

Generally, participants said that VI physical activity and sport are very dispersed and some of them could not find sessions near to them. This is a barrier because of the distance they might have to travel to attend a session.

"Yeah, well, I know it's like something they [sport service providers] offer, but they're not like near my location." (VIP4)

"...it helps to be near the venues where sports are happening because, like I'm...again, I'm lucky that I'm in [PLACE8] and most things I can access within half an hour. But, if I was in a different city, like if I was back in [PLACE9], it would be like, I need to get two buses and a train to get to my sport venue, right? So, it's like I'm very unlikely to try it, if I can't access it easily, so I think being able to get there and back easily is pretty important, especially, if you've got, you know, disability." (VIP5)

Despite that, they reported the limited physical activity and sport opportunities for adults. They said there were more of these activities for VI children.

"I would say there's a lot out there for kids, 100%. But adults, I don't think there's that much. I've not seen a lot." (VIP6)

"I looked into football as well. I really love football. I love to watch football. I'd love to play football. And the only visually impaired football that happens around here is for kids. So, there's nothing, nothing really for adults as far as I've found out. So yeah, it's been tricky to find to find stuff going on around here." (VIP7)

Also, the difficult to find a variety of guide runners was reported due to the inability to find volunteer guide runners with commitment to run regularly, especially if a VI person would want to run more. Therefore, participants found that it was not fair to ask the same guide runner to do more runs during the week with them.

"You'd find some, like there are loads and loads of guide runners in my local area. But, what it's...when...when sometimes I find when people sign up to guide what they mean is like 'I'll do a park run with you' or if there's a race that you need a guide for 'I'll do that'. What a lot of them don't, I mean, some of them...some of them, fine. But they don't always want to commit to, you know, I will run twice a week with you, which is fine, you know, because everyone's got different things going on." (VIP3)

Participants expressed that online workouts did not provide enough guidance and were very fast paced. In this case, they needed to have someone to describe it for them to do the exercises.

"I think it depends on the video. Like some were very fast paced so I can't catch up. I think...at the beginning it's hard..." (VIP4)

"I couldn't use his [Joe Wicks] videos, because...of course, I couldn't see what he was doing, and I needed someone to describe what he was doing, and it just wouldn't work." (VIP1)

Other issues were mentioned regarding accessibility of some fitness applications. For example, VIP4 reported that she could not see, while using magnifier, the graph of her running track on Nike Run Club application. As neither VoiceOver could read the graph, she had to ask her family to tell her about the graph.

“...there’s running distance which gives...and it gives a graph, so it’s a bit hard to see that...So, I’ve tried using the magnifier on it and it doesn’t work for me. I don’t know why...sometimes I ask my family [to read], sometimes use VoiceOver, so...Yeah, it [VoiceOver] can’t.” (VIP4)

Another example was, some online workouts on Aaptiv app were not accessible, according to VIP7.

“Uh, actually some of the workouts I found weren’t that accessible and that was to do with the people doing them. You know, the people recording them”. (VIP7)

Furthermore, VIP5 expressed that the manual input of information about the exercise done on fitness apps was also something very difficult to do. Hence, he wished the app could input data for him.

“I was like it’s too difficult to write down like everything that I’m doing manually. So, if the app can do it for me, it’s yeah, it’s easier.” (VIP5)

7.3.2.2 Theme 2: Facilitators for doing physical activity or sport

This theme describes the experiences and perspectives of VI young adults about what helps their participation in physical activity and sport. Most participants expressed the importance of it for mental health, maintenance of the overall health and socialising. By seeing similar peers doing physical activity and sport was also considered to influence them to try to do it, as well as the openness and conversation about their needs with professionals in the sector.

Sub-theme 2.1: Support to get active from others

All participants shared the same opinion about social support as an aid to get active. This was reported as getting motivation from others, having more fun with a gym buddy, one to one support and so on.

This included the views that support from family members was important since they were younger and during the health concerns about COVID-19. In contrast, VIP2 expressed that despite of family members’ advice for her to get active, she was not interested to do it.

“My family are a pain in the brain when it comes to this...they in fact try to encourage me to be active and often I have mother instructing me on various exercises like sit-ups, walking and a bit of

stretching as well. I don't think my family members always realise how difficult it is for me to move at times...and they often say I make myself more ill by not participating in physical activities. Well, tough luck for them because I can't, and even if I could, I wouldn't want to.” (VIP2)

Participants expressed that knowing about other VI young adults taking part in physical activity and sport can be a motivation to do the same. For example, VIP5 (physically active, partially sighted) started to play cricket because he knew some peers from VI tennis that were also playing cricket with him.

“I knew people from tennis who were going to cricket. So, I thought I might as well join and see how it is.” (VIP5)

Sub-theme 2.2: Informational support

This sub-theme refers to the support necessary for VI young adults to know about relevant information about physical activity and sport sessions. Generally, most participants expressed the importance to obtain the knowledge of what and how to start physical activity and sport, get notifications to remind an exercise, learning from online content and being influenced by digital media.

Participants mentioned the need to know what physical activity and sport sessions are accessible and how and where to get started. They explained that the access to information about physical activity and sport in general happens through word of mouth and visual impairment network.

“...the only reason that I knew about the Find a Guide database was because someone just said it off hand to me in passing, you know, like there wasn't...and so, that could have easily not have happened. Then I just wouldn't have known where to get started. So, a lot of it is word of mouth... but, if you don't have that network, you know, that network of blind people that you can ask these questions to, like...well, what do you do, I mean you, probably, don't do anything.” (VIP3)

Whereas other participants showed that was enough searching on Google and Facebook groups for physical activities.

“Yeah, I'd say if I'm trying to find information about what sports are available, I would...I just use Google. I would just search like...VI Sport [PLACE8] and see what sites come up because there's...I mean that that's basically what I did right in 2019. And then I found [ORG1] ...I found [ORG1] from that. And then usually the RNIB, the Royal National Institute of Blind People. Their website has links to a lot of like sport, like pages and clubs. So, there's usually, yeah, can usually find something on there as well, about what's available.” (VIP5)

"So, I found a running group on Facebook. So, I joined that and that made me feel quite positive about it. So, I started it. I enjoyed it. So, carried it on." (VIP4)

From getting to know what opportunities are available, they reported the need to know the details of how to start into the physical activity and sport sessions.

"...like where you can do it, who can come. What like level you have to be. Uhm, how much is gonna cost, like commitment, time commitment." (VIP8)

Participants also said that they were able to find online workouts to do exercise at home through YouTube videos.

"I guess a lot through social media, like I feel like you're easily influenced by other people doing certain exercises, but maybe I can try that...but also YouTube videos, I feel like the best way to learn about certain exercises, certain sports. You get a lot of people given advice who are experts at that certain sport and for me, I'm a quite a visual learner. So, seeing it being done is my best way to learn how to do something." (VIP6)

However, one participant warned about the possibility to find wrong techniques.

"...because the thing you get a lot of stuff on the Internet, and you can do things in the wrong way on...if you always look at the stuff on the Internet you can end up learning how to do something but using the wrong techniques." (VIP1)

Sub-theme 2.3: More VI physical activity and sport opportunities and promotion

This refers to the need of more availability and promotion of physical activities and sports. This included their wish that organisations into VI physical activity and sport could have more choices of VI sports and other non-sporting activities and more promotion.

"I've only ever visited one or two of them and, you know, they've they seemed fine you know they did the job. Um I mean I mean yeah; I mean it's gonna it's gonna vary like...I mean my opinion is that they should be easier to find. Well so like yeah and if I say so like if...I've never done this before but if I google [PLACE6] sports for blind people in [PLACE6], which is where I live. Um okay, so we've got oh, actually, that's...okay. So, there is like there's the British Blind Sport activity finder, you know. So, I guess...I don't know, but there is...I think they could be...they need to be a bit easier to find and there needs to be a bit more promotion about them." (VIP3)

Moreover, VIP7 mentioned about online boot camps to get active at home, as she did during the pandemic. She had the opportunity to join an accessible and good session provided by a sight loss charity where she worked by the time of the interview. These online sessions were well described for

people who could not see the screen and to follow the instructions. On the other hand, she emphasised that it not always the case for online sessions because these are demonstrated instead without further detail verbal instructions.

"I've done a few sort of, you know, the online boot camps... that was quite good 'cause I know...they were explaining things on the basis that nobody could see what they were doing, so that was quite good and accessible. And sometimes online trainings like that, they don't tell you enough about if it's an exercise you haven't done before. They'll be showing you onscreen, but not necessarily telling you enough about what to do, so sometimes that's difficult for me not being able to see them demonstrating what to do on the screen." (VIP7)

Sub-theme 2.4: More inclusive physical activity and sport

This refers to participants' wishes to take part in inclusive physical activity and sport sessions for VI and sighted people and to get into inclusive gyms. VIP1 explained that the gyms tend to claim inclusiveness of their services, where he experienced it was not true due to lack of staff support. Despite that, he argued that there is a need to avoid the stereotype that VI people only get active with other VI people, and he expressed his interest to be involved in inclusive activities with both sighted and VI people. The same view was shared by VIP8 that would like to see more inclusive mainstream sports and "not so divided".

"...and the fact that I don't just want to do things specifically for blind and partially sighted people. I'd like to be able to do things with sighted people as well because we don't want to create a system where there's a stereotype that blind and partially sighted people can only do things with other blind and partially sighted people. Because we really ought to be trying to make it, so that we have a more inclusive society around disabled people, and in disability in general." (VIP1)

Another example of the benefit of inclusive activity was the interaction and support from sighted people to VI people. VIP1 mentioned, for example, that through an inclusive gym sighted people could meet and exercise with VI people, while sighted people could help VI people.

"...you can have sessions where you can actually talk to people, ah for example, you are on a treadmill you can talk to the person next to you, who is actually helping you, and it's a way of getting to know people as well. Because a lot of times when you just need support you only start with them, you're not able to speak with people in the gym who is on the next machine. It would be good to have situations where sighted people, sighted gym goers, that it's, help blind gym goers and so they do workouts together and get to know each other." (VIP1)

Sub-theme 2.5: Feeling independent and safe to get active

This sub-theme describes the factors that help VI young adults to feel independent and safe to do physical activity and sport. One of these factors was the provision of simple exercises at slow pace and more focused on how to do which can be done easily. This is because mainstream workouts can be difficult due to lots of information on it.

"I think it's a lot of like information on exercise. I didn't like workout for everyone. So...I think like something more like slow paced. Something that had more like tips in it and how to do 'cause some exercises are quite complicated so, and I feel like...it would be good if there's simple exercises to make someone feel more like independent." (VIP4)

Similarly, another participant (VIP6) expressed that users of fitness applications want to do exercise independently, as he liked to be on his own to get active and satisfied. However, he also mentioned that those applications seemed not effective, or he felt no motivation to do the exercises.

"...people want to do it independently and which I like the idea of it...I like being on my own and just doing my exercise and feeling satisfied with it. Like...but, sometimes I just don't feel like they're always that effective or you don't always have that motivation to use it." (VIP6)

While VIP2 expressed that if she had intention to start running, then she needed to be certain that she would not face any risk to run into something or other people and she would not take part in a running group.

"If I know that there's nothing on the floor. If I know that nothing's gonna happen to me. If I know that no one's gonna run into me and I'm not gonna run into anyone and I'm not gonna run into anything... But if I were to take part in a running activity or something like that, where there might be things on the floor that I might need to run around, yeah, or when there are other people running, then I'm definitely gonna say 'don't you dare drag me there'." (VIP2)

7.3.2.3 Theme 3: Motivations for doing physical activity or sport

Generally, participants perceived that to start doing physical activity or sport depends heavily on self-motivation and health consciousness. VIP4 said that what motivates her to do exercises was to remind herself of the importance of it for her health.

"...like reminding myself that like health is important because before I think I took it for granted." (VIP4)

On the other hand, VIP2 described that there should be a "valid reason" to do a physically activity, as she believed that there is no health benefit on doing it.

"There has to be a valid reason, which will make you get up and do it. So, you're not just doing it for the sake of getting up and running, but you actually have a reason. Be it to help someone or be it to get something for yourself. Something that you like, you know, get a treat for yourself or something like that. Or be it to see someone you love, someone you haven't seen for a long time, and you desperately want to see them and you're gonna run to go and see them, to meet them, you know?" (VIP2)

Sub-theme 3.1: Lack of belief regarding the benefits of doing physical activity and sport

This sub-theme describes poor motivation as VIP2 does not see the benefits, there is a lack of belief on any benefits of physical activity and sport. This is because VIP2 believed that, for example, health benefits could be achieved by other ways. Even though she was aware of the health benefits for the whole body.

"Well, people say that it helps to...helps your immune system, that it helps your mental health it is what people say as well, and people say that it...helps...to...with your uh...blood pressure and heart and stuff like that and makes your health better in general. Well, I mean...there are lots of other things that make your health better and things that are not tiring and are not risky and are not overwhelming in the end, you know." (VIP2)

Regarding mental health, she expressed that getting active could not be good for mental health due to the pressure felt by doing physical activity or sport, tiredness and time spent doing it.

"Well, I mean...I mean...I don't believe that...something that...is...gives you a lot of pressure, something that...makes your body tired, something that takes up a lot of your time...uh...is good for a mental health at all." (VIP2)

She reported her perception that physical activity or sport is useless because she perceived it as a waste of time and energy, instead of doing something more useful instead.

"...it's a waste of time. It's a waste of energy when you could be doing something more useful than that." (VIP2)

She reinforced that physical activity and sport leads to tiredness, accidental risks, injuries and make her feel overwhelmed.

"...even then, like before I had all my, uh...anaemia and all that stuff, you know, even before that, I would get tired very easily, but I obviously wasn't weak all the time. Yeah, I wasn't weak all the time. Yeah, like I was able to do these things, but even then, I would get tired very easily and what he [PE teacher] would do is tell me to go to class." (VIP2)

Also, she explained that sports can disrupt the community.

“Well, disrupting the community because you have, for instance, uh, I live right next to the cricket ground in the city centre. Yeah, it's when they do and stuff here, it's indescribably loud ...it's not gonna like to save anybody's life or it's not gonna, you know, it...it's not like they're raising awareness of something that the public needs to know, or it's not like they're trying to achieve something useful for the environment or anything like that. You know, in fact, the more they do it, the more they pollute the air. Yeah, so, uh, so yeah that's what I mean by disrupting the community” (VIP2)

7.4 Discussion

The results of this study helped to better understand the several social and practical barriers experienced by VI young adults when participating in physical activity. Although not all the identified barriers are directly related to technology, these findings give insights where the mobile app can be useful to tackle the challenges. It is important to ensure accessibility, but the mobile app can also help users to overcome the social and practical barriers. These aspects can help users have satisfactory user interaction of the mobile app, addressing their specific needs and enable users to take actions, make decisions based on the service provision and information, identify support, and so on. For instance, the mobile app can help bridge the gap by connecting users with inclusive activity groups or organising events that welcome both sighted and VI participants. The app could facilitate social interaction and community-building, making it easier for users to join inclusive activities. This could potentially increase their physical activity participation. The increase in the participation level was not meant to be assessed in this study, rather this study looked at the context and barriers of the active lifestyle which informed the user interaction needs to enhance the overall user experience. The outcomes of this study informed how to improve and adapt the app to the needs of VI young adults and could be used for further next iterations of the app.

Participants shared their views on the barriers for their physical activity and sport participation which correspond similarly to some previous findings from studies with VI adults, such as lack of opportunities, knowledge of physical activity on what and how to take part, and fear of injury (Haeghele and Porretta 2015; National Disability Sports 2015; Wrzesińska et al. 2018). There were also findings in this study that were not known before such as the need for more inclusive physical activity with sighted and VI peers, notifications to remind an exercise, learning from online content, not having detailed guidance on online workouts, difficult to find guide runners, lack of trust on guide runners to begin running sessions, feeling not being part of the VI community and feeling of being treated different.

Although little is known about the experience in physical activity and sport among VI young adults, Holbrook et al. (2013) argued that, in general, some exclusive aspects in the participation of VI people in physical activity and sport may negatively impact this experience, such as the progression of VI level and abilities in mobility and orientation. This study confirms that participants reported difficulties to get active, due to the deterioration of visual impairment, especially in the mainstream gym and sport venues. However, this was not the most relevant issue identified in this study, unless for one physically inactive participant (VIP2) as the visual impairment condition was one of the most important barriers, although it does not prevent an active life (Jaarsma et al. 2014; Sadowska and Krzepota 2015; Haegele et al. 2016; Haegele et al. 2018). Regarding mobility or orientation skills, physically active participants in this study emphasised the need of easy access to local and inclusive physical activity and sport venues, as it was hard to travel long distances to attend specialist sessions. However, costs for travelling and fees of these sessions were also important barriers; such issues had been discussed in previous studies (Jaarsma et al. 2014; Women in Sport et al. 2016; Haegele et al. 2017a; Haegele et al. 2018).

However, this is the first study to report the participants' perception that even when there might be local VI physical activity and sport and databases such as 'Find a Guide' available on the Web, VI people may not know about them. This might be due to lack of promotion, lack of interest of VI people to search for them, or the interest may appear when knowing about other VI people doing physical activity or sport, in which word of mouth and being involved in the VI community play a role for this awareness. In this study, both physically inactive participants were not part of the VI community and not aware of the opportunities in VI physical activity and sport.

Generally, little awareness of VI physical activity and sport providers and sessions seemed to be one of the relevant factors to understand the low participation of VI young adults. Alongside this is the lack of local VI physical activity and sport and few opportunities for VI young adults. The former issue is known in the literature (Haegele et al. 2017a; Jaarsma et al. 2019), whereas the latter had not been reported before. Other factors impacted negatively, e.g., lack of support from service providers, including inaccessible gyms and online workouts, difficult to identify several guide runners available for more frequent and weekly running. The lack of support was one of the most relevant challenges for participants. This made most physically active participants to feel treated differently, while physically inactive participants either felt pressure to be "normal" and insecurities to take part in physical activity and sport or were afraid of injuries.

Interestingly, the feeling of being different was felt in diverse situations whether by participants explaining about visual impairment and their needs every time starting a new sport, and pressure to be able to participate like others, or having specialist activities exclusively for disabled people,

whereas participants wanted to be involved in inclusive physical activities with both sighted and VI people. On the other hand, fear of injuries was only mentioned by one physically inactive participant (VIP2). This is because of lack of confidence and support from past experience at school, in which the safety concerns due to inability to see the environment and lack of trust on a guide runner were not addressed and misconceptions about physical activity might have become the barriers for this participant, such as running fast perception, competition focus and the belief that physical activity is not for everyone and does not provide health benefits was prevalent. For these reasons, participants claimed the need of more trained coaches in inclusive physical activity and sport.

Therefore, more availability and promotion of inclusive and accessible physical activity in local areas and via online workouts, in which both sighted and VI people can take part in whenever possible, are necessary. This offer whether locally and online could potentially overcome the lack of opportunities to get active, as well as transport and costs issues. Moreover, there is a need of personalised support for VI young adults to face fear of injuries and to address trust on VI coaches and misunderstanding of physical activity and sport, such as people must run fast and be competitive.

7.5 Summary

In this chapter the themes showed the need of more opportunities and promotion of inclusive and accessible physical activity and sport in both local areas and online, to consider either those VI young adults that may not be part of VI community and offer of more focused support on personal concerns and needs through professionals with inclusive training physical activity and sport. The study strengths were the two-level coding system which enhanced the thematic analysis as it helped to better explore the issues from the participants' viewpoints. On the other hand, the limitation refers to the low number of participants achieved in this study, due to the difficult to reach a hidden population, which may have impacted the findings in not providing a fully and rich understanding of the issues. The next chapter discusses the evaluation of prototype app.

Chapter 8 Study 4 - Phase 3: Think aloud user evaluation of the mobile app with VI young adults

8.1 Introduction

In the previous chapter, the online interview study was conducted with young adults with visual impairment about their experiences and views on physical activity and sport. This study was subsequently followed by the evaluation of the high-fidelity prototype app by the same group of research participants. The reason to conduct the studies in this sequence was to avoid any possible influence from the impressions about the app into the participants' responses about their experience in physical activity and sport. The aim of this chapter is to provide a detailed description of how the evaluation was conducted and present the analysis of the feedback from VI young adults. As stated briefly in the literature review (Chapter 2), a prototype has its function to examine and explore the proposed product, its potential improvements, and new ideas (Lim et al. 2008).

This study is one of few studies conducted with Android and iOS that have been reported. The majority of reported studies on usability testing have been conducted solely on Android mobile phones (Di Gregorio et al. 2022) for reasons concerning low cost and easy release of testing beta version on Android platform. The decision to address both operating systems was to make the evaluation available for both Android and iOS users, although most people living with visual impairment use iOS devices due to its enhanced assistive technologies (Di Gregorio et al. 2022).

The most common type of usability testing is done in laboratory settings by inviting participants to use a prototype in a pre-defined device and settings. However, this study was conducted online during the COVID-19 social restrictions. The initial plan was to invite participants to take part in face-to-face user evaluations. The think aloud evaluation and the following interviews provided insights for improvements of the features and functionalities through accessibility and usability and are discussed in this chapter.

8.2 Aim

The aim of this study was to evaluate the design guidelines of the prototype application. It aimed to identify accessibility and usability issues, user requirements, and evaluate the app usefulness and acceptance by research participants.

8.3 Method

This study followed the author's protocol to gather data on user evaluation. The user evaluation was conducted online due to the COVID-19 social restrictions between November 2021 and February 2022. It has ethical approval from the University of Southampton Research Ethics Committee, reference number ERGO/FEPS/53732 (Appendix F).

8.3.1 Sampling and recruitment

Participants' recruitment process was described in the previous Chapter 7. The inclusion criteria were young adults between 18 to 30 years old with visual impairment, regardless of being physically active or not.

8.3.2 Procedure

The initial step was to create a protocol (Appendix G) for the online and individual usability evaluation of the high-fidelity prototype app. The protocol described the online usability evaluation with seven tasks (e.g., creating a user profile, learning about VI tennis, searching for an event, adding information into calendar, finding a coach, sending message via chat or email), debrief interview questions, and online and accessible questionnaires created on iSurvey, such as the demographics and the System Usability Scale – SUS questionnaires. The SUS questionnaire is a survey scale used to assess usability of user interfaces quickly and easily (Bangor et al. 2008).

The author provided participants instructions for downloading the prototype and participant information sheet accessible Word document. Participants were informed about their volunteering, anonymous participation, use of their own mobile device and the online session's video recording via an accessible video conferencing software of participants' preference. They provided consent to participate by ticking a box on the accessible online demographics survey. The author conducted pre-tests of the usability evaluation and afterwards the usability evaluation sessions with VI young adults as they were the target audience.

8.3.3 Pre-test

The pre-test of user evaluation was necessary to be conducted online with volunteers that represented the target audience of the research. The author invited two blind individuals through snowball sampling to do the pre-test. Due to age selection criteria, only responses from one volunteer in the pre-test was included in the analysis.

The purpose was to test the protocol. By filming and video recording the participant's interaction with the app on their own mobile device, the author could identify any issues while running the entire protocol through an accessible video conferencing software, such as Microsoft Teams or Zoom. Both participants did not have someone to hold a second mobile device connected to the video conferencing software as per protocol. However, it was the opportunity to discuss with both volunteers the best way to do this.

As a result, one strategy was suggested by one participant such as to make a pile of books and position a second mobile phone on the top of the pile with the camera facing down. In the experiment, the pre-tester was able to place their hands under the second mobile phone with access to Microsoft Teams and the author was able to see their interaction with the app. This setting up worked well for observing in real time the pre-testers' actions on the interface and identifying potential issues that could have arisen, and the author could make notes and ask questions afterwards.

The pre-tests were useful for finding an alternative to film the interactions and testing the entire evaluation and interview protocol. It was an opportunity to identify a more appropriate way for VI participants to do it online. Participants' observations were about the poor quality of the audio output of the author's laptop, some unclear tasks, and questions. The author amended some tasks and questions and adopted the procedure to set up the video recording via a second mobile device. In the case of no extra device available, the author decided to conduct the recordings using think aloud.

8.3.4 Online think aloud usability evaluation

Prior to the online evaluation, the author initially informed participants about the number of tasks, objective of the evaluation, interview, and SUS accessible online questionnaire. The author was the only person responsible for giving the seven tasks, taking notes and asking participants to think aloud throughout the online evaluations via Microsoft Teams or Zoom.

Two out of seven participants had the extra devices to connect to the video call on Microsoft Teams where the author could see their interactions. One partially sighted participant (VIP5) had a flexible web camera stand to move easily and position it over his hands and the app's screens. Another partially sighted (VIP6) used a tablet placed on the top of a pile of books. He connected both the tablet and laptop to Microsoft Teams, then the author had two views, one from participants' face and other from his hands' interaction with the app.

Another partially sighted person (VIP4) accessed Microsoft Teams on her mobile device to make the video recording of her app's screen evaluation as she did not have a laptop at the scheduled session and was not able to reschedule it. Other participants had only one mobile phone and laptop. Therefore, all online evaluations were conducted with video call and built-in screen recordings for posterior data analysis. Participants saved the built-in screen recordings on their devices and sent them to the author's email address. The author did not receive two files because one participant lost it and the other did the evaluation via Microsoft Teams.

At the end of the tasks, the author asked participants to answer the questions (debrief interview data) about the usability of the app on the accessible online SUS via iSurvey or on Word format for those participants that would prefer it. The accessible SUS comprised eleven questions, including the question about the type of assistive technology used during the online evaluation.

Afterwards, the author asked some questions defined in the protocol and questions regarding participants' comments and observations made. The think aloud sessions lasted around 30 minutes each. All built-in screen and video recordings on Microsoft Teams or Zoom were used for transcriptions and data analysis.

8.3.5 Data analysis

The transcriptions of video recordings were obtained from the automatic Microsoft Teams transcripts file, as well as from the Zoom video recordings and the author listen all of them and made amends where necessary in Word documents. After reviewing the transcripts, only the author made the inductive thematic analysis (Braun and Clarke 2006). No other coder took part in this process to make the data analysis consistent. The use of inductive thematic analysis aimed to identify the needs and views of participants in the context of information seeking and provision of support to take part in visually impaired sports to help answer the question of design requirements, rather than using the content analysis as it is focused on identifying trends and patterns in documents (Stemler 2000). The approach was to adopt a more open think aloud protocol because the author was not interested at scores on how well participants did the tasks as the app was at the early stage of development.

The author read the transcripts several times to familiarise themselves with the data. The transcripts on Word document files were imported to NVivo 1.6.1 version. The codes were assigned to the most important extracts of the transcripts which addressed the questions of the design requirements. The inductive thematic analysis on NVivo included the transcriptions of both think aloud data and debrief interview data. Both were transcribed in the same document and analysed together. There were occasions that the think aloud transcripts were checked against the built-in screen recordings when the transcripts were not clear about certain issues or interface location. Also, one built-in screen

recording was difficult to analyse because of no synchronisation between the braille display focus and speech output. This may be because of lack of compatibility between the old app's code and the braille display.

The author reviewed and moved codes around and created themes that referred to similar ideas or concepts. By grouping the codes into themes, overarching themes and sub-themes were created. This process was ended by a final review of each theme and sub-theme and its extracts to check the matching allocation. Each version of the coding and review was saved for audit trail as a mean to track how the themes were generated.

While the thematic analysis can provide rich insights from the participants' viewpoints about the application, their feedback given on the accessible SUS questionnaire had its value to understand how useful and easy to use the high-fidelity prototype was. The data from the accessible SUS survey were analysed on SPSS for descriptive statistics results. The results of the inductive thematic analysis and descriptive statistics are described in the next section (Results 8.4)

8.4 Results

8.4.1 Participant characteristics

In this study, seven out of eight participants in the previous interview session (Chapter 7) took part in the online usability evaluation. The plan was to recruit nine participants as it is considered the sample size to identify 80% of usability issues (Hwang and Salvendy 2010). One participant did not take part due to not using a smartphone. She explained the smartphones are not accessible for her, as she said that she needs to feel the keys of a physical keyboard or keypad. Therefore, this participant was not able to evaluate the high-fidelity app.

This is a limitation in this study as it did not provide any other means to this participant to have access to the prototype. Alternatively, this research could have provided an accessible web application to be used in a desktop. It would be more suitable to this participant and any other individual with the same needs and interested to evaluate the prototype.

After the online interview session about participants' experience in physical activity and sport (Chapter 7), six out of seven participants directly took part in the evaluation after the interviews and one a few days later.

Participants were males (n=4) and females (n=3), severely sight impaired (blind) (n=4), sight impaired (partially sighted) (n=3), vision loss acquired after birth (n=2), and impairment existed from birth (n=5). Physically inactive (n=1) did not get active in winter as it is 'too cold for asthma', so instead

socialised with friends. Physically active participants (n=6) had done physical activity or sport with a mean frequency of 2.125 times per week for between 3 months to 10 years. Most participants were full-time employees (n=4) with a degree level or above (n=6), income between £20K to £40K (n=4), white (n=5), and living alone (n=3) or in another living arrangement (n=3). They were mostly iOS users (n=6) with an Android user (n=1).

8.4.2 System Usability Scale (SUS) results

During the evaluation, most of participants used VoiceOver (n=3), while others used iPhone's Zoom (n=1), Android's Magnifier (n=1), and one partially sighted participant did not use an assistive technology as the text was enlarged enough for reading. Although, one participant reported the use of VoiceOver and Magnification during the evaluation, the researcher observed the video recordings showed no use of them by this participant.

In the SUS questionnaire, the majority of respondents (n=4) had agreed while one had strongly agreed that they would use the ActiveVI app frequently. The overall SUS score is 79.64 out of 100. In accordance with the rule-of-thumb (Bangor et al. 2008), this score means the ActiveVI app is acceptable. However, Bangor et al. (2008) affirm it may not imply that it could be considered as high acceptability in the field.

8.4.3 Themes

The author conducted inductive thematic analysis which resulted in four themes and several sub-themes. These themes presented the positive and negative views about the app's features, suggestions for improvement and impressions. While this thesis aims to design guidance on developing mobile apps for VI users, the guidance must address not just the technical components of accessibility, but also the content and features that impact the user experience. The features revealed the content usefulness, offering one place with all necessary physical activity information and support. Also, the outcomes of this study showed some flaws on accessibility and usability such as unclear meaning of some components and lack of user's action feedback. These themes were helpful later in the creation of the design guidance and could have informed the updates of the design requirements for next design iterations. The themes and sub-themes are described as follows:

8.4.3.1 Theme 1: Positive comments

This theme describes the main positive views from participants about the app's aims and content. All participants expressed that the app was easy to use, concise and provided tailored contents, with useful functions while the interface was simple with bold and big font size and good contrast.

The app appealed to them as simple and one space to find all information they needed to get active, such as sport sessions, coaches, transport, etc. Such space was perceived as a 'cluster', where all necessary and enough amount of information was provided. This was especially noted about the 'find event' features, which they identified as useful to find sports sessions and its details, such as address, contacts of organisers or coaches.

Two participants highlighted that the app would help by bringing all information into one place, rather than the user having to search for different websites to know about inclusive physical activity or sport sessions. The VIP5 (partially sighted) expressed that the app could be an easy way to book sport and fitness session online. By comparing it to the gym's booking app that he uses regularly, he noticed the prototype app was less complicated and simpler.

'Because a lot of people who do VI sports are probably, they're probably gonna use or benefit from having an app where you can see all of the events, because at the moment I have to go on five different websites to see what the events are, right? So, this is like combining everything. So, I think in that sense this is like a really good app...I think this is the easiest way to book your sport sessions 'cause you can see everything...I think that because what people find difficult is knowing which websites to find the events. So, because it's all in one list, I think that's the most useful feature.' (VIP5).

'Because it means that you don't have to look at loads of different things to know. When something is on, you have it all in one place like it's more convenient and yeah, just makes it easier.' (VIP8).

Generally, participants appreciated the feature to add the sport event into their mobile phone's calendar. Four participants noticed it was easy by pressing one button to send the details to the calendar app, instead of doing it manually typing the details into it. In addition, another participant wanted to add the address along with other details in the calendar.

'Would it say what location is as well? 'Cause that would be handy if it did that for me...For me, I would have put that in my calendar anyway, so the fact that there's a button I can click that, does that, perfect. It saves me a job. So, it does it already for me. So, I think that's quite a useful thing.' (VIP6).

'I use my calendar a lot and I use my calendar to know what on Earth I'm doing all the time. I think when you put a... when you got a lot of stuff going on, it's good to be able to access that outside of the app just in your main calendar.' (VIP7).

Also, physically active participants perceived the data addition to calendar app as a mechanism of nudging. They expressed that if the sport event details were added into the calendar app, the user might be likely to attend that session.

'That's good, that was easy and that I think that's a good feature [to add event to calendar] to have [...] it's good to have it in your calendar some people get like some people live by their calendars. I don't use it that much, personally, I use it a lot at work. But I don't have a personal calendar, but I think sometimes if it's like if it's in your...if it's in your diary...if it's in your calendar, you're probably more likely to go to it, I would say.' (VIP3)

'For me, I would have put that in my calendar anyway, so the fact that there's a button I can click that, does that, perfect. It saves me a job. So, it does it already for me. So, I think that's quite a useful thing.' (VIP6)

Regarding nudging, three participants (two physically active and one inactive) liked the list of activities because it provides descriptions and videos of each inclusive sport, they perceived it as a trigger to discover and learn about new sports options.

'I know most of these sports already. That's something like rambling...I don't know what rambling is, so if just because it's here, it's useful for me to just like I can just find out more about it. Uhm...I think the videos are useful here because they give a bit more like context, because I'm assuming the videos are from like the official VI group.' (VIP5)

Another physically active participant expressed that the addition of push notifications of new sport sessions could be a nudge to someone who had a break from physical activities to restart doing them.

'It [push notifications] would nudge me to get...because I mean I suppose the problem is if I am not active at the moment, do I always think to open the app? Whereas, you know, so let's say that I have had a month or two where I have not been active, you know, for whatever reason, you know. I might have got out of the habit of opening the app. But if I get a notification all of a sudden that says there is going to be a new swimming event on, then that is just on my lock screen, then I think about, then I'll think about doing it.' (VIP3)

Three participants expressed they liked the chat with coaches, as it would be useful to contact them to know more about the sport event and obtain more support, for example, on how to arrive to the venue. Participants also appreciated the 'find transport' feature, where the app provided the public transport options on Google Maps or Apple Maps based on the user location. In contrast, some

physically active participants disliked the chat option as they would not use the chat to contact a coach.

'I think maybe if you wanted to know a bit more about the event, if you needed to know, say, like what your ability level needed to be up, or if you needed a bit more advice on how to get there. It's just always good to have the option to talk to the person who's doing the event, I think.' (VIP7)

8.4.3.2 Theme 2: Negative comments

This theme focusses on participants' views of flaws on accessibility and usability of the app. It presents two sub-themes: usability issues and accessibility issues.

Sub-theme 2.1: Usability issues

This sub-theme describes the observations made by all participants about components that were not very clear to them. They noticed some usability issues around meaning, content, wording, and purpose of functions.

In general, the meaning and purpose of three tabs and its icons (i.e., find a coach, find event, activities) on the bar navigation at the bottom of the screen were not clear to five participants (two blind and three partially sighted). These tabs were the main features (i.e., home, find a coach, find event, activities) and each one had an icon and a label.

One participant could not see and understand the meaning of the tabs, which made him to mention the lack of a tutorial to explain each tab functionality. For example, one partially sighted participant (VIP6) did not understand the meaning of the 'Find event' icon, as it looked like a calendar and not a search function. In addition, the icon did not have a permanent visible label, which in turn made it difficult for the new user to immediately understand the functionality of the tab.

'I found coach. But I don't know how I would find...the information about tennis in general. Or activity list, maybe? Tennis, tennis description VI tennis. [...] 'cause I did not know what they like what they mean. There was no like tutorial or anything.' (VIP8)

Not recognising or not being aware of the purpose of the four tabs at the navigation bar which led participants to get confused with other similar functions. Such functions were searches for a coach and activities to learn more about sports. One blind participant noticed that he could have made a mistake by searching for a coach. He would have tried to search on the 'Event details' screen by accessing the 'Find event' tab if he did not notice before the 'Find coach' function on the tab bar navigation.

'I'll do the find a coach thing on the bottom because I've seen that it's there, but it may be that if I didn't know it was there, I would try and find one through an event, as well.' (VIP3)

Similarly, the same participant would have made a mistake searching to know more about a sport activity. This participant would have clicked on 'Find event' tab, if he did have notice previously the 'Activities' tab. In fact, three participants did not accomplish the task of searching to know about VI tennis because they got confused with the 'find event' and 'activities' tabs. The reason for this misunderstanding was due to the wrong wording applied to these functions.

'I'm thinking about how to find the activity, so I'm going to look at the bottom. [coach tab selected activities] so I'm thinking soon as I want to find an activity instead of finding an event, I'll do activities but if I didn't notice that activities were there, I may have gone to find event.' (VIP3)

Similarly, two participants got confused with the meaning of the 'find a coach for this event' button at the 'Events details' screen. While one participant understood the term as a search for a type of transport, another one was unsure whether the search would tell the hosting coach or give more than one more option.

'...this button 'find coach', 'find coach for this event'. So, I click that because it said, 'find coach'...can't find transport options, the only option is 'find coach'. Coach name John Smith, location any, coached activities archery, bowls. Ah, when it said coach, I thought it said...I thought it was a transport option.' (VIP1)

Moreover, one blind participant wondered about the purpose of a confirm button after he selected items in the interests' list. By selecting the items in this list, he pressed the 'update profile' button and was expecting to update his profile immediately. However, he was surprised with another button to press and confirm the update, to finally get an updated profile confirmation message.

'...let's say that I select my interest, I do confirm. I might think that those have then been saved. But it looks like I have to do update profile for them to be saved. So, might be better if I didn't have to do the update profile button, you know, because to me when I see a button...like on that interest screen, when I chose to confirm, to me that means that, you know, things have been saved.' (VIP3)

Sub-theme 2.2: Accessibility issues

This sub-theme addresses the accessibility problems encountered by blind and partially sighted participants. In general, the identified problems ranged from low complexity, such as accessibility labels, to more structural issues, such as user's action feedback, which interfered with the participants' flow interaction.

Generally, blind participants faced more difficulties than partially sighted participants to sign-up to register themselves into ActiveVI app. For example, two blind participants (VIP3 and VIP7, iOS users) experienced an issue with VoiceOver focus and on-screen keyboard. After typing in the edit text field (name) and swiping right the focus moved to the last item in the screen (sign up button) behind the on-screen keyboard. While trying to move the focus to the next edit text field (email address), it was not announced by VoiceOver as it was done before. Furthermore, the screen did not scroll up and participants had to move focus into the on-screen keyboard and press the return key to get rid of the on-screen keyboard. The focus landed whether on back button or email address edit text field every time participants continued to fill in the edit text fields in this way. This is because while on-screen keyboard was enabled, the VoiceOver focus did not follow a logical order. One possible reason for this issue may be a lack of additional native iOS code, such as accessibilityElements array, which supports the retrieval and controls the order of swiping of grouped components.

'So, what's interesting is that the edit fields seem to be hidden when I've selected one. So, I tapped on...I tapped on name to enter my name and now I'm feeling around the screen I'm trying to find email and password which were there before but now they're not there or at least speech isn't seeing them. So, I'll try doing return and see if that...oh that works. So, the fix was to press return on the keyboard but that feels quite weird. I don't usually have to do that; the edit areas shouldn't disappear when I've tapped on one of them because there are multiple different ways, I could find that.' (VIP3).

Similarly, such issues affected the use of a braille display. A blind participant (VIP1, iOS user) had to press the enter key on his braille display to make it to announce the 'send' button in the coaches' chat. The author checked this issue in the built-in screen recording and noticed the 'send' button was visually hidden and appeared on the screen after the participation pressed enter on his braille display.

'I'm going to say hello John. Ops, now what I'm doing is I'm going to...there's no send button that I can see. So, I press enter, ah now I see it. Well, I went down once more and then I found it. It says hello John 1:24. Ah, it only pops up when you press the enter key. So, because I was using the Braille display actually allowed me to do that, press the enter key, and then it came up with the send option.' (VIP1)

Another blind participant (VIP7) mentioned and demonstrated that Google sign in page is not very accessible. This is because by loading a pre-saved email address in the edit text field, she could not scroll the cursor through to the end of the email address. Similar issues happened when the VoiceOver did not speak aloud the deleted characters in the edit text fields in the sign-up screen of the app, which would require extra code to make the on-screen keyboard more accessible.

'Like the keyboard works and it doesn't work to type in, but then let's say if I realized I made a mistake in the beginning part of my email address, I'd have to delete the whole thing and start again. You can't kind of scroll through what you've written, which on other in other situations you can, and you should be able to.' (VIP7)

Regarding the feedback of users' actions, blind participants asked whether they were in third party apps or wondered about expected feedback and confirmation of their actions. For example, two participants (VIP1, VIP3) did not notice the third-party apps, such as Google Maps and YouTube were open following their previous actions, until they were already into them. As they were not expecting this change in the interface, they asked the researcher whether they were navigating these apps. Because of that VoiceOver users had to explore the screen to understand it because they did not hear an announcement of the changes.

'It's asking if I want to use location. It says query loading...more options swap starts and destination driving now, navigation driving no navigation info available, button public transport, walking, no navigation in info, right...services are...So, we're using Google Maps?' (VIP1)

Similarly, VIP7 expected the announcement of a sent text to the chat's coach. She was only aware it was sent when she noticed it was no longer in the edit text field, and it was along with the time on the main screen view.

'It doesn't say sent, but it's...I can see my message is no longer in the, you know, in the editable bit.' (VIP7)

In addition, prior user profile updating, VIP3 expected to see a list of his chosen sports from the interests' list in the profile screen. He expressed that he would have to open the list of interests again to listen the selected sports because the app did not provide a summary list.

'I've updated my profile uh it's a bit annoying that it doesn't show my interest without having to go to the choose interest screen, but I mean that's a minor, that's a minor thing.' (VIP3)

Furthermore, blind participants disliked the brief built-in speech while VoiceOver spoke aloud at the same time. They were annoyed by the two speech systems as soon the screens opened.

'I think the only trouble with that is if you're already using VoiceOver you end up with the two kinds of chatting away to you at the same time.' (VIP7)

Most of them expressed, they needed short descriptions on labels of UI elements for fast navigation.

'Label additional details, below you can find additional detailed description of this activity, additional description, [...]. Right, you don't need to have that bit that says label additional description, you can

just have it say: additional description and then start the next line with "it is larger than a regular tennis ball and such and such"'. (VIP1)

On the other hand, partially sighted participants struggled the most with lack of proper text scaling which prevented participants to scroll the sign ups screens up and down. For example, VIP5 used magnifier with zoom and text size set to maximum. While he could not scroll the first sign up screen up and down, he could see the text on the top and partially saw the 'I am a new user' button. He was not able to navigate it, so he asked the researcher's permission to change the font size on his phone's settings. Although adjustments allowed him to proceed with the tasks, he expressed the displeasure to do it. Similarly, VIP8 experienced the top sign-up buttons did not fit on the screen and it did not scroll down.

'I can't scroll, so I think the scaling is like not letting me...I can't see everything on this. Can I change my font size?' (VIP5)

Regarding legibility, some partially sighted participants could not see the content. VIP4 could not see what she was typing in the edit text fields (i.e., name, email address) of the sign-up screen. This is because her mobile was set up for Dark Mode, which was not supported by the app when it was built in 2019. By June 2019, the Dark Mode was released as one of the features for developer preview on iOS 13. Therefore, after VIP4's evaluation this feature was quickly implemented in the app by a mobile developer to allow next Dark Mode users to undertake the sign-up task.

'But I think there's a problem, I can't see what I'm typing, or I can't scroll down either.' (VIP4)

Also, the iOS 'home bar' - a white bar at the bottom of the screen, which unlocks the screen and access the app switcher - crossed over some of the labels and icons on the main navigation tabs. Two partially sighted participants (VIP6, VIP8) had the latest iPhone's models, in which this feature crossed the tabs making it difficult to read the labels and see the icons. They also reported this issue in other apps as well.

'It just needs the design and the shape on the screen with that line at the bottom. For me that was the biggest off put 'cause that was really annoying. Trying...across those four different tabs. I couldn't read, 'find coach' or 'find event', I find that quite difficult.' (VIP6)

Furthermore, VIP8 found these tabs were small. Likewise, VIP6 expressed the back button was also small and he struggled to press it. In addition, the red bubble timing indicator of built-in screen recording was near the back button which made it more difficult to select it. On iOS, this feature cannot be moved around the screen, whereas it is possible on Android, however not while using

TalkBack. In contrast, on VIP5's mobile (Android 12) the red indicator was at the status bar at the top of the screen which did not interfere in the app's interface.

'I'm finding that button...I don't know if it's 'cause I'm screen recording, but that you know, to go back was quite there, that...so I was struggling to, you know, go back on the screen.' (VIP6)

Finally, VIP6 noticed the interface was "very text based" and needed more images. He expressed this concern towards other visually impaired people that may have learning difficulties and may rely on images to understand the content.

It's quite text heavy. There's not much images on there, I've...for me, fine. I'm just thinking of other visually impaired people who might rely more on images, or people that maybe who are visual impairments but have learning difficulties, and it benefit them as well, if there was more image based on there.

'It is quite text heavy. There's not much images on there, for me, fine. I'm just thinking of other visually impaired people who might rely more on images, or people that maybe who are visual impairments but have learning difficulties, and it benefit them as well, if there was more image based on there.' (VIP6)

8.4.3.3 Theme 3: Suggestions from young adults with visual impairment

This theme refers to the suggestions for new potential features and improvements of the existing ones to enhance the user experience of the app. In this theme, there are three sub-themes such as the 'Improvements on accessibility and usability', 'Improvements on information architecture' and 'New elements'.

Sub-theme 3.1: Improvements on accessibility and usability

This sub-theme refers to users' views on how the content and features could address their needs of easy, quick, and coherent elements. Generally, users made constructive comments about some components that could be added and improvements to the navigation (i.e., navigation to sport videos; search transport button; built-in speech; labels and headings; email address) and the techniques applied to them. Participants spotted specific aspects that seemed important to consider for making the app more accessible and usable.

Although participants accomplished the task (i.e., learn about a sport), by finding the description of a sport and the button to open the video explanation on how to play the sport, two blind and one partially sighted participant suggested that it would be easier to open the video inside the app rather opening YouTube app. They expressed two reasons for that. Firstly, it would avoid switching from

one environment, the ActiveVI app, to another one different, such as YouTube app to open the media.

'I only did [open the video] because I knew how to do that. I think, obviously, I know it's only a prototype, but I think in the final version, you'd want the video to play within the app because then you could then...because it opens up, you know, opens up YouTube, you know, the layout's obviously completely different.' (VIP3).

Secondly, with regards to screen reader users' ability to switch apps. VIP3, experienced VoiceOver user, showed concerns on how it might be difficult for newer VoiceOver users to return to ActiveVI app after opening the sport video on YouTube app. Therefore, participants expressed that opening the video on ActiveVI app would be easier to everyone, regardless of screen reader user's ability.

'I think in the final version, you would want the video to play within the app, because it opens up, you know, opens up YouTube, the layout is obviously completely different. If you're maybe a newer user to the iPhone, you perhaps you might not realize that it has opened up YouTube, I would say that you would do, but you know maybe some people would not. And then also like knowing how to get back, as well. So, I have done it before. So, it is one of those things where it is actually easy once you know. But if you don't know that it's hard.' (VIP3)

Participants also suggested to disable a button to search transport when an address of a sport event is to be confirmed. For example, VIP6 selected the button to search for transport to arrive to a sport activity. While it opened the Google Maps app, there were no routes as the address was still to be confirmed on ActiveVI app. Thus, he suggested to disable the button until the sport venue's address is defined.

'...maybe that button shouldn't be there or be blanked out, in Gray or something. Just to say, obviously, 'cause I maybe I don't know, someone else wouldn't read that. I know what TBC means, uh, so obviously, it can't find transport if there's no address there.' (VIP6)

Blind users expressed they needed to have the option to disable the built-in speech while the screen reader was speaking out at the same time. They did not appreciate it and suggested it as a turn on and off feature useful for partially sighted users to aid them to understand the content of the screen.

'So, it might be worth having a setting to enable it to say these things, [...] having an option to turn it off if you don't want it.' (VIP1)

Sub-theme 3.2: Improvements on information architecture

In this sub-theme, participants wished to have more information, alternative options for transport, to search sport activity by postcode and to reorganise some elements on screen. Blind participant (VIP3) missed the main tab bar navigation to be always available on all screens. He felt it was necessary while navigating the profile screen using the VoiceOver until reaching the back button to get into the previous screen to access the main navigation tabs.

'On the profile screen, I don't seem to be able to access the bottom tabs.' (VIP3)

Participants acknowledged the usefulness of the feature to search transport directly from the sport activity's screen. However, some participants preferred to have access to other options of accessible GPS navigation apps, beyond the Google Maps and Apple Maps accessed directly from ActiveVI app. Such suggested apps were GoodMaps Outdoors, Soundscape, Citymapper and to include Uber app also as one of the options to select from on the ActiveVI app. Participants mentioned the need to ask the user which options of accessible navigational apps to select from.

'I think maybe having the option of what app do you want to open this with. That would be a good option.' (VIP7)

'That one (Citymapper) is like a lot of visually impaired people use it because it tells you exactly what time the bus is gonna arrive or train so that, you know, which one to get on.' (VIP8)

One blind and one partially sighted participant agreed that Apple Maps app is a little more accessible than Google Maps app. The blind participant's view of Apple Maps advantage over Google Maps is to inform in advance what side of the road is the last direction before the user sets off. Similarly, the partially sighted participant shared positive views on Apple Maps app with regards to larger, clearer text and its integration with the mobile's settings. However, both Apple and Google apps are not enough to give precise directions and can be used along with other navigational apps, such as the Soundscape app.

'...and I tend to use it in conjunction with an app called Soundscape...So, if I'm following directions, I tend to have maps giving me the directions and then Soundscape going as well to tell me what I'm passing in...and that works quite well as a navigation. Yeah, I think maybe having the option of what app do you want to open this with. That would be a good option.' (VIP7)

Although, VIP7 liked the transport feature and when the author asked whether it would be useful to have more information such as the nearest train station or bus stop, she agreed it would be useful and suggested to add it very briefly in the description of the sport event. In addition, VIP6 wished the address of the sport event was added automatically along with other information on his mobile calendar app.

'You, obviously, would not want too much, but if even if it just says in the description of the event or just in the information very near X station. Yeah, that would be that would be ok.' (VIP7)

'Would that the address as well to do all that automatically? It's obviously it says visually impaired rugby and West London. Would it say what location is as well 'cause that would be handy, if it did that for me.' (VIP6)

Sub-theme 3.3: New elements

This sub-theme describes the users' wishes of additional elements to enhance navigation, to access extra information resources and more information about inclusive sport and fitness and its organisations, staff, and members; and to find and contact someone to get active together.

To aid navigation, participants said it would be easier to access the content by making changes of the UI elements through a custom setting button to be placed in the top right corner. They expressed the user could do the most common changes from a selection of colour contrasts, enable dark mode, and set text size.

'But you might also want some settings, a settings option. For example, you could choose colour contrast or text size and what do you want certain hints, such as, this is the screen for such, such...' (VIP1)

They wished to have access to more options of inclusive sport and fitness sessions to choose from, such as gym sessions, running, accessible home workouts videos, and so on.

'You're thinking about accessible sports for visually impaired people, but I think there are more than that. And again, I think running for me is a big one. I think that's something anybody can do with any sort of capability' (VIP6)

'I think it would be good maybe to have some accessible workouts on there that you could follow. That's I think that's something that's quite in demand these days as well. Kind of post pandemic. Lots of people doing home workouts where people are telling them what to do. I think having a resource base for that and very accessible ones would be quite good.' (VIP7)

Also, to be able to book and pay for the sessions quickly by pressing a button rather than making a call or typing an email or message to providers. For example, VIP3 noticed the potential to make a standard app for booking visually impaired sports every week.

'The only thing is would I be able to pay for my session? [...] Maybe it links to the website with the paying? So, the payment screen or something?' (VIP5)

Conflicting opinions on how important it is to know the number of sign-ups and age of participants in the sessions. While one partially sighted and physically active participant would like to know this information, one blind sighted said it was not important to know. In contrast, participants highlighted the wish to know more about the inclusive sport or fitness providers. It included the need of visual aids to understand the environment. They suggested to add pictures of the venue, photos and videos of past events, images of the coaches and team members, as well as coaches and members' profile picture.

'Maybe examples of the event in the past, pictures, videos, you know, this is something we've done like this before. A bit of an insight of what it is. That would be good. I think it would be good to see. So, I can envision 'cause I don't know what...if I just clicked on vision impaired rugby in West London, maybe a picture of the venues, so I know what it looks like. So, I know what to look out for when I'm trying to get there, a picture of the team or who was involved there.' (VIP6)

Moreover, they wanted to see the coaches' qualifications and their experience in inclusive physical activity and sport and users' reviews about the coach work. For example, VIP8 expressed that she could trust the coaches based on such provided information before sharing any personal details with coaches and contacting them.

'Yeah, but I would want to know like I wanna know more about the coaches before I shared it so I wouldn't share it like right at the beginning. I'd want to know that they were like trusted and like maybe reviews or like...yeah, links to their website or so that I knew that it was safe'. (VIP8)

Also, they expressed the need to access extra content. Accessible related fitness articles would be beneficial, they suggested to add a 'resource tab' where users could find accessible information, such as fitness and tracking apps in the market. This is because they mentioned about the need to have easy and reliable access to information on accessible technologies, instead of searching through many different sites. More information about sport or fitness providers also may be necessary. One participant pointed out that users may need more information about the organisation, such as what types of sports and services they offer to their members. Therefore, one participant suggested to add a link to the sport organisers' website.

'Like where they [coaches] work, their qualifications, like a bit of a bio about who they are and what they do.' (VIP8)

'It might be an idea to have an option for when...for some of these activities to have an option to navigate to navigate the organisers website.' (VIP1)

8.4.3.4 Theme 4: VI young adults' impressions

This theme addresses the viewpoints of all participants on the use and purpose of the app. Generally, to some extent they considered the app as a start point to get active, to do a quick search and book sessions, and to offer support to certain groups of VI people.

Sub-theme 4.1: Useful for quick search and support

Participants found the app was easy and fast to find sport sessions they were not aware of.

'I guess it depends on what the user wants it for. If they use it to find out about...I love the...I had no idea if there was...exist that there are events in London for people with visual impairments to do those sports. If I needed to know that I know I can go on that app and look, can find straight away when it's gonna happen, where it's gonna happen. And if I decided one day to take part, I could do that. So, I like that aspect of it.' (VIP6)

In addition, participants commented that the feature to search coaching could be beneficial for different purposes. This included the opportunity to find and identify the experienced coaches and check their understanding of visual impairment. This would help users build trust of professionals that are registered on the app.

'Maybe I would one to one tutoring on a certain sport, contacting the coach about that. You know, who works, who's visually impaired, where for me seeing coaches on the app shows that they've got, you know, acceptance, they've got understanding and knowledge of that people with visual impairments or experience working with them. I'd feel comfortable going to the coach about that on that app.' (VIP6)

Another view was that coaches could be able to find other coaches for replacements and offer whether one-to-one support is available to someone who needs help to play sport or support to organise a group activity.

'But then someone who needs help or something, they probably will want to find a coach. Or if they're trying to organize a session for a group of people, then they might want a coach. So, I think that's useful for them, but not for me [...] And may be useful for other coaches as well to see who's available if they can't make an event. So, if they're if they're unavailable for the next Friday session, they can find a replacement.' (VIP5)

Sub-theme 4.2: Potential users

This sub-theme refers to participants' views of who would be the most in need to use the app. Most participants agreed to some extent that the concept of the app had potential to benefit anyone living

with visual impairment. They also believed that some features would be more useful to address some specific needs of certain people.

Generally, participants perceived the app as useful for all those who need quick access to information about inclusive sports sessions and potentially other inclusive physical activities, as described in the previous section (sub-theme 4.1). Some participants also expressed that the app use would depend on how likely the person would need it and identify themselves as visually impaired people.

'If it was out there and stuff to be used, I definitely would consider it if I had that visually impaired identity and I wanted that, perfect. It's perfect for people like that.' (VIP6)

Participants (VIP1, blind, physically active and VIP6, partially sighted, physically inactive) referred to the app as a 'good starting point' to get active, which in turn might be useful for newcomers to physical activity and sport, and who wanted to talk to specialist coaches in the area for a one-to-one support.

'And if I wanted to contact a coach if I wasn't sure. Maybe I would one to one tutoring on a certain sport, contacting the coach about that. You know, who works, who's visually impaired, where for me seeing coaches on the app shows that they've got, you know, acceptance, they've got understanding and knowledge of that people with visual impairments or experience working with them. I'd feel comfortable going to the coach about that on that app'. (VIP6)

However, VIP6 argued that it might be difficult for those who are in their own groups and inside VI communities and may not want to try new activities. Then, such an app could be a start point for those people and those who identify themselves as visually impaired.

'Potentially, I'd keep it on my phone just in case, you know, you never know. Like, given my current situation, like I wouldn't use it now or with my current perspective of sport. I don't think I'd get involved that much. And again, I've not ever done it, so I don't know. It's good to know it's there. If it was out there and stuff to be used, I definitely would consider it if I had that visually impaired identity and I wanted that, perfect. It's perfect for people like that.' (VIP6)

In addition, VIP6 perceived the 'activities' feature (i.e., learning about sport) as an educational tool for younger users and not for adults who might have some knowledge about most of sports for VI people. He expressed no interest in the learning component. From his perspective, this feature could help children learn about inclusive physical activities. Another participant (VIP7) mentioned that the app could also be used by parents of VI children to know and understand what sports their child could take part in.

'I was less interested about what's tennis, what's swimming like...I'm 23 years old. I know what a lot of those sports are. If you're a younger and if that's aimed at children who, you know, want to try different sports out. Brilliant, I think that's a really useful thing to have. You know, gives them an insight to these different sports, but for the, you know, like adults and things who have knowledge of sports in general, I don't think it's that important for me personally.' (VIP6)

In contrast, VIP5 perceived the 'activities' feature as an aid to help to learn about a new sport that they may never heard about before.

'I know most of these sports already. That's something like rambling...I don't know what rambling is, so if just because it's here, it's useful for me to just like I can just find out more about it. Uhm...I think the videos are useful here because they give a bit more like context, because I'm assuming the videos are from like the official VI group.' (VIP5)

'...the reason why I would use it for a new sport would be because, you know, you've got the descriptions so it seems, you know, those descriptions were good like say...and then also again, you know, it's the one place, you know, I won't have to figure out you know, what...you know, like...maybe there's a dedicated website to blind people who do archery...I have no idea. But I wouldn't need to know because I'll just have that app and so I'd use it for that.' (VIP3)

On the other hand, some participants mentioned that if a VI person is physically active, then the app would not be to some extent useful to someone already integrated into sport: Especially, for those that would not be interested to use the feature to search coaching. This is because they would already know what the sessions are and the staff working in their sport or leisure centre or local area. Otherwise, they mentioned that users that may not know what is happening in their local area or have moved to a new area would get more benefit from the app.

'I guess it depends on how well I'm integrated into it. So, like if you had running, I probably wouldn't use it to find running events, but that's only because I'm part of my running club, you know, and so I'd get the events from there, but on the other hand, you know, I'm saying that as someone who's quite well integrated into that club, so I know what's happening.' (VIP3)

8.5 Discussion

In the literature, there is no indication of methods and techniques to evaluate digital interface for a specific target audience (Adam et al. 2020) and usability evaluation studies with VI people are scarce (Miao et al. 2016). Thus, there is little evidence on how to conduct and what to expect from a remote user testing study with VI people (Mankoff et al. 2005).

Nonetheless, this study reinforces the importance of merging data collection techniques with a focus on VI people to identify usability and accessibility problems (do Carmo Nogueira et al. 2019; Adam et al. 2020). This study applied remote usability evaluation, usability questionnaire (SUS) and interviews to register qualitative feedback, such as positive and negative comments. This study presented the main findings regarding to the participants' perceptions and interactions with the app and the researchers' experience in conducting the user evaluation experiment online. In this section, a summary of the main findings and its implications are discussed as well as the potential contributions to designers and developers.

Online user evaluation with visually impaired participants

Most participants did not have an extra device such as a second mobile device or a flexible stand web camera to use during the online evaluation. Despite that, those sessions were conducted with built-in screen and video call recordings without making observations at the time of user interaction.

Without additional participants' devices, the researcher had to adopt a strategy to understand their actions on the app. The researcher had both Android and iOS mobile phones to use according to the participants' device used during the session. Thus, the researcher could open the app and see the screen where participants were doing the tasks. This was an attempt to follow the user's actions on the screens while they were thinking aloud. This was an extra effort while making some notes of users' comments or issues to ask afterwards. It was a hard task to follow the steps the user took during the online user thinking aloud session, especially when the user was using VoiceOver.

It was a bit difficult to understand their actions while listening to the speech output and participants talking through the tasks at the same time. In this case, when it was not clear what the user was doing or they were not thinking aloud, the researcher had to ask them where they were on the screen or remind them to think aloud or ask for clarifications. For the author, it was difficult to track participants' interactions and ask them about their actions as it seemed to interfere a little the participants' interaction flow.

Blind participants could pause the speech of VoiceOver to talk aloud, as it requires cognitive effort, they tend to process information in small portions (Chandrashekar et al. 2006). Although they had to divide attention between screen reader output and talking aloud, they were not reluctant to comment whether they paused the screen reader output to express immediately their thinking or after completing the task or let the researcher know they would give more comments later. This is different from previous studies (Chandrashekar et al. 2006) where blind participants did not comment often during the think aloud study. This aligns with the proposed Synchronised Concurrent Think-Aloud method with VI users (Strain et al. 2007).

In this scenario, two partially sighted participants (VIP5 and VIP6) conducted a good experiment. One had a flexible stand web camera and the other had a tablet connected on the online video call to film their interaction with the app. This helped the researcher to observe their interaction in real time and was able to ask them about some observations after the evaluation and facilitated further data analysis.

Overall, the think aloud video recordings were very helpful for tracking the participants behaviour and feedback during the data analysis. Also, the built-in screen recordings were useful to help a close identification of the participant's actions that were not clear on the respective think aloud transcriptions, especially the evaluation done with braille display.

Simple and all-in-one place perspectives

All participants expressed positive feedback about the app and the majority perceived it as an all-in-one place system. They expressed the app attended most of the essential needs towards their participation on physical activity and sport.

The experiment confirmed the app's features attended to most of these needs, for example, the information seeking of inclusive sports. Previous studies mentioned the need to use a channel to promote VI physical activities (National Disability Sports 2015; Jaarsma et al. 2019). Participants expressed that the app provided an easy and simple way to identify the inclusive sports by selecting the type of sport and location through modal selector, which can reduce the time searching on the Web.

Regarding the modal selector, the researcher observed in the built-in screen recordings that screen reader users may need to avoid the navigation through all the options until moving to the bottom to cancel it, especially if there are lots of items. Potentially adding a cancel button on the top of the selector window, rather than on the bottom will reduce the navigation if the user wishes to cancel the modal selector once it is open.

Beyond the quick search, participants also liked that the app had the hyperlinks on email address, telephone number, address, as well as add-to-calendar details of a sport event, which immediately opened the respective apps to make a call, send an email, access the GPS with the user location and the sport's venue destination and the addition of information details into the calendar app. The add-to-calendar link was positively expressed to save time instead of manually adding information into calendar. It was also perceived as an aid to manage their time in the calendar, as well as a nudge feature as reminder from which people may be more likely to go to the sport event. Although contradictory opinions were given towards the list of activities for knowledge of sports, it could have

a nudging effect as it leads physically active people to be aware of inclusive sports they did not know before accessing the information available in the app.

Furthermore, the chat with coaches and guides appeared to suit better those physically inactive and newcomers to an active lifestyle, who are not sure of what to do and may need more help from a professional in a one-to-one support. Currently in the UK, promotion of physical activity and sports for VI people can be found on social media and organisations' websites. For example, currently the British Blind Sport's website offers an activity finder. This tool searches by activity, age group, sight level, region, postcode, and miles range. It provides essential information, such as activity's description, contact, telephone number, email address and a message form. The user has one easy access to communication by filling in the message form to submit to the activity's organiser. If the user wants to call or send an email, for example, they need to memorise or copy the telephone number or email address. Subsequently, they need to open the respective app to type in or paste the data. This can be an extra effort especially for less experienced screen reader users.

Considerations for accessibility and usability

Most of the accessibility and usability issues were considered minor by participants and the app perceived as simple and easy to do the tasks. However, the majority of accessibility barriers were found on the sign-up screen for both Android and iOS users. Therefore, consistency for accessibility and usability should be applied on all screens regarding to text scaling, avoid justified text and provide simple layout and content.

In terms of accessibility, it is important to consider recent trends, such as Dark Theme on Android or Dark Mode on iOS devices, also to apply responsive design to present and adapt all information to different size screens (do Carmo Nogueira et al. 2019) and to the "home bar" on the screen of latest iOS devices as reported in this study. Partially sighted participants appreciated and expressed that the app had a good contrast on buttons and font sizing. Nonetheless, they pointed out the need of a custom settings in the app for colour contrast of the screen to select from colour combinations. While blind and screen reader users emphasised the importance of short label description of UI design elements to be announced before the role (i.e., button) to allow fast navigation, it is important to provide well-defined properties to UI design elements and focus order to better aid screen readers users' navigation and feedback of users' actions. Developers need also to be aware that some UI design elements may require additional iOS and Android native code implemented on React Native codebase whenever is possible and necessary. By default, VoiceOver does not recognise accessibility elements on a group of elements, therefore extra code is needed to support the retrieval of elements grouped into a container view and control the order of focus. The built-in voice was meant to run when the screen reader was not enabled to give a brief overview of the interface

for partially sighted participants. However, the function did not work and proved to be a burden to screen reader users. Although they suggested it as feature to turn on and off for partially sighted users, it seemed not relevant to be implemented in the app. Regarding usability, consistency should also be applied to tabs bar navigation. It means to make icons and labels always visible and accessible on all screens for easy and fast access to home and other main tabs without navigating back to previous screens to access them.

Overall, the researcher and developer did not have enough knowledge and experience during the development of the app and accessibility testing to identify the potential problems. In addition, the existing documentation on React Native and other resources around accessibility guidelines are diverse, complex and does not offer a simple and clear language to aid fast development of mobile apps. The developer had limited time during the Master dissertation project to learn, test and implement all the necessary code on React Native and to make the app as more accessible as possible. Training in accessibility for mobile app development would have helped to better design and develop the app.

Improvements and potential use perspectives

Although participants wished to have more inclusive options beyond sports for visually impaired people, such as fitness, running and mainstream gyms with inclusive approach such options were not provided in the app as the database source was originally based on VI sports data only. This evidenced their needs to express what their preferences and views are, which includes to be part of inclusive mainstream activities.

More information is needed regarding the number of sign ups and age of people attending a session. This would allow users to know about other young people that will attend the sport session and to meet someone similar. Similarly, the need for information about coaches' qualifications, experience, provided inclusive activities and reviews from others can ensure the coaches are trusted and users could feel safe to share their personal information and contact them. In addition, images and videos of venues and past events, as well as pictures of coaches and members were suggested as an aid to have a "visual memory" when partially sighted users are at the venue. It means knowing what the venue looks like and if they are in the right area, be able to see familiar faces, such as knowing how the coach looks like before getting to the venue. It confirms that VI people perceive a visual item with a purpose, as they are focused on functions (Correia et al. 2019). This was also observed on the welcome screen where the screen reader announced the overview of the app's logo. By providing accessible images of the venue and members, it could help to create familiarity and boost confidence to get into the venue by making them aware of the environment and people who they would be in contact with.

Moreover, the app could allow users to find others available to do physical activity and play sport together, and to make easy session bookings and payment. There were also concerns for less experienced screen reader users on navigation between screens. In this case, developers may need to consider and allow resources to open inside the app, whenever possible, such as videos of workouts and sports, sport organisers' websites, and articles about accessible fitness and tracking apps. Adding the sport videos in the app could make it easier for severely impaired users (blind), screen reader users, to have access to the videos without opening it on YouTube app and going back to the ActiveVI app. This is especially true for users with low skills on VoiceOver and TalkBack. However, this addition could make the app heavier with lots of videos and it would require the ownership of the videos.

8.6 Summary

This chapter presented the main findings about participants needs and views around the service provision of sport activities and other types of physical activity with an inclusive approach. Also, the experiment helped to identify the accessibility and usability issues and improvements to information seeking and other supporting features. The contribution of this chapter is twofold. First, a research perspective is presented within the usability evaluation method, in which an overview of the online experiment with visually impaired young adults provided relevant insights of negative and positive outcomes. Second, for designers and developers, the concept of the app provides some useful insights within personalisation of the service and support needed to get active and the accessibility and usability considerations to develop a mobile app for inclusive physical activity and sport for VI young adults. The next chapter describes the work experience and perspectives of professionals and volunteers in physical activity and sport for VI people in the UK.

Chapter 9 Study 5 - Phase 3: Interviews with coaches on work experience of physical activity for visually impaired people

9.1 Introduction

In the previous Chapter 8, VI young adults expressed their opinions about the design of the ActiveVI app. In this chapter, coaches individually took part in online interviews. They provided their views about VI young adults' experiences in physical activity and sport, and it was an opportunity to understand how coaches provide their service for VI people, especially young adults.

The literature is scarce about the coaches' work experience and their perspectives about VI young adults' participation in physical activity and sport (Chapter 7). Therefore, this study' findings can inform the physical activity and sport experience among VI young adults and identifies potential improvements related to the service provision. The following sections explains the data collection and analysis process and discusses the findings. To identify the coaches' perspectives about their service and experiences of VI young adults in physical activity and sport.

9.2 Method

This interview study applied a similar method, qualitative semi-structured interviews, as described in the Chapter 7. This study received the ethical approval along with other studies (Chapter 7, Chapter 8, and Chapter 10), reference number ERGO/FEPS/53732 (Appendix F).

9.2.1 Sampling and recruitment

Purposive sampling method was used to recruit participants who were coaches with one year of experience in physical activity and sport for VI people. This study aimed to recruit up to 20 participants. The author contacted via email around 42 disability, visual impairment and VI sport charities, and administrators of social media groups with VI members. The recruitment plan is described in the ethics application (Appendix F).

The recruitment management was similar to that applied in the Chapter 7. Due to low interest to take part in the interviews, the author decided to create an accessible image with a message to invite coaches to the study. This was added to the study adverts and the accessible study's website on Wix. The author also used snowball sampling method to recruit more participants.

9.2.2 Procedure

The protocol had a semi-structured interview study plan (Appendix I). This had 17 questions split into 3 topics, such as demographics, work experience in VI physical activity and sport, and opinion. This aimed to guide the focus of the interview within each topic. Prior to conducting the study, the author interviewed one coach to test the protocol and obtained their feedback about the questions and procedure.

9.2.3 Pre-test

The author conducted the pre-test with one coach and afterwards asked for feedback on the interview process and questions. This helped to check these were clear and to do with other participants. Since this ran satisfactorily conforming to the protocol and the participant provided interesting responses, the author decided to keep the data for further analysis.

Online interview with coaches of VI physical activity and sport

This online interview study followed the protocol, and the author had to prompt participants to check what age group they were talking about. In this sense, the author attempted to keep the interviewee focused on the subject matter.

9.2.4 Data analysis

This data analysis applied a similar method, inductive thematic analysis and produced codebook (Appendix J), as described in the Chapter 7. In the anonymisation system on Microsoft Excel spreadsheet, the code identification for coaches were CG1, CG2, etc., and other codes for organisations, staff and members' name mentioned by participants.

9.3 Results

9.3.1 Participant characteristics

This study recruited 7 participants. It was judged that data saturation was achieved as the latest interviews were not adding more new information, thus it was not necessary to extend the 3 months' recruitment. The mean years of coaches' experience was 11.33, during which they have worked as coach (n=4), volunteer (n=2) and guide (n=1) in sports such as VI tennis (n=2), running (n=3), goalball (n=1), triathlon (n=1), Pilates (n=2), and cricket (n=1), mainly with visually impaired people of all ages. Some participants were partially sighted (n=2) and blind (n=2). Table X summarises the information.

Table 9.1 Coaches' demographics

Participant ID	VI level	Role	Physical activities	Years of experience	Range of impairments
CG1	No	Coach	VI Tennis	30	Wide
CG2	Blind	Volunteer	Goalball	5	VI
CG3	No	Coach	Running and Pilates	8	VI
CG4	Partially sighted	Guide runner	Running	6	VI
CG5	Blind	Coach	Cricket	10	VI
CG6	Partially sighted	Coach	VI Tennis	4	VI
CG7	No	Volunteer	Triathlon, Running and Pilates	5	VI

9.3.2 Themes

The themes revealed the coaches' perspectives on VI young adults' physical activity participation and how it could feed into the app's content to improve the user experience of VI users. These themes helped to understand VI people and coaches' needs in the physical activity service. Also, the findings showed the challenges faced by VI people and coaches, what facilitators and improvements are significant. These aspects can reveal the features of the technology that can help to overcome the barriers or facilitate and impact the user actions. The author used these themes to aid the creation of the design guidance and could also have informed the updates of the design requirements for next design iterations. The inductive thematic analysis resulted in three themes and sub-themes which are described as follows.

9.3.2.1 Theme 1: Challenges for VI young adults to participate in physical activity or sport

This theme is regarding the coaches' perspectives of the challenges faced by VI young adults when taking part in physical activity or sport.

Sub-theme 1.1: Lack of knowledge about opportunities and how to take part

In general, coaches expressed that VI people do not know about some specialist sport and exercises and how to get involved. This is because of little advertisement.

“But actually, when you start to socialize that you hear, you know, I didn't even know about visually impaired tennis or visually impaired sport until my mum actually went to an event that a girl who plays visually impaired tennis was at. And just happened to have a discussion with her and that's how

I found out; you know. It wasn't advertised anywhere, [...] it's not done on a wider scale, which I think is, you know, important.” (CG6)

“So, like people just aren't aware. Maybe they don't really know about certain sports that they could get involved in...” (CG7)

In addition, coaches had heard some VI young adults wondering about how they could participate in sport activities and how to play them. This evidenced the lack of awareness on how to start getting active.

“They [VI young adults]’ve taken the first step by thinking about it in the first place and then actually wanting to reach out, and ‘How can I do this?’, ‘How do I do it?’. That's what we hear all the time is ‘How can I do it?’, ‘How does it work?’ It works, we know it works, and we can do this.” (CG4)

Sub-theme 1.2: Limited opportunities of inclusive physical activity and sport sessions

This sub-theme brings the coaches’ perspective that there is a lack of inclusive and local physical activity and sport sessions.

“I think just having more stuff on generally. I think that there's sort of limited opportunities and for all types of sports, [...] That's the main thing is just having things in the local area that they can access, and which are accommodating, basically, for people with visual impairment.” (CG7)

They also mentioned that existing charities’ opportunities are often focused on children and elderly people. Furthermore, some physical activities and sports do not seem to appeal to VI female adults, thus there are few opportunities to them.

“I mean my personal experience. I was 29 when I eventually came out of hospital and everything...and the things you are sign posted to, you know, aren't really...I wasn't particularly interested, you know, and I think like I said, when you're young, sort of under 18, you know, there are charities that are very focused on, you know, young people...have like their families and that kind of there's a lot of support around that age group.” (CG6)

“There are also, I think, less sort of things that are female friendly. Maybe so, whereas the young doing things like football and then once you get to a certain age as a female, I think that your options become may be more limited.” (CG3)

Sub-theme 1.3: Perceived VI people's fears and concerns to get active

Coaches considered that fear of a new experience is what keep some VI people physically inactive, especially for those who have congenital sight loss and have little or no experience in sport or exercise.

"I just get visually impaired people to say, 'I can't do this', 'I want to do this'. This isn't something to be afraid of. It's the fear of the unknown. The fear of something new. [...] What is it that holds people back? I think it's just fear. And how do you bridge that fear? Can't find the answer and I keep trying. [...] That's great if you know what tennis is. But if you not never have vision. You only got a concept, but you never hailed the tennis racket, you've never been on the court. And now, you got a ball flying towards you with bells in it. And it's like learning and that can be fear. [...] So, if you're going to go running, you know, there are lamp posts or people, there are long leads, the street. But there's so many things and there's fear of that." (CG4)

CG2 and CG4 highlighted the excessive fear among VI people starting to get active, when there is lack of confidence due to a new activity and poor support.

"...because if you're new to any situation it can be scary to join, but if you're visually impaired or blind as well, it can make it even more scary, potentially, if you're not very confident." (CG2)

"When I first started running, I thought 'I'm going to die because I can't see where I'm going'. [...] my guide didn't know anything about visual impairment or guiding, 'I'm going to run into every obstacle and I'm going to die'. That's obviously what I thought. And I think a lot of people still think the same thing." (CG4)

Also, people born with visual impairment or who lost their sight very young might be intimidated in getting into the sports hall and start to play.

"Because somebody used to sight loss from birth or from very young might not have had the chance to actually see or see somebody like physically run or move, you know, in a kind of agile way, and if you've never done that before to then go to a sports club or a session and be surrounded by people who are doing that activity is really, really intimidating I would imagine, and just a barrier straight away I think." (CG6)

Coaches also perceived that some VI young adults may find it difficult to be the youngest in a physical activity or sport session with older adults.

"I think people... certainly at the younger end, as well. So, like the 18-year-old..., especially if they're going to like an adult session. So, they can be the younger and then I think that's quite difficult." (CG3)

CG4 explained that families of VI young people ask how the activity works and what the risks are.

"...but you still hear family saying, but 'How you gonna do this?', 'How you gonna do that?', 'How's that gonna happen?', 'What's the risk?'. That's the biggest problem. [...] We sometimes when we've got sighted people there supporting, I'll get to do a video of their sight impaired person and when the family is turned up and say 'look, look what they did, wow'. And then the blankets go back on 'oh please, stop doing it!' It's all they know. It's like, it's instinctive, you know. So, it's hard, it's really hard." (CG4)

CG6 also showed concerns that VI young adults rely on others to take them to sports sessions. This can result in low attendance as the support for mobility may not be available every session.

"a lot of the kind of opportunities that are there within sport and physical activity, you know, [...] they do rely on people being independent and, you know, getting places themselves. Or for example, if a parent or a family member or whoever that might be the support network can only get [...] somebody somewhere, I don't know on a Sunday, twice a month, and the sessions are every week, twice a week, you know, automatically, there's a, you know, there's a barrier there straight away." (CG6)

Sub-theme 1.4: Accessibility barriers in VI physical activity and sport

Coaches mentioned about some accessibility issues reported by VI young adults, as well as their perceptions about some attitudes of VI young adults towards the use of social media. CG1 explained that VI tennis coaches run tournaments in an online system, where VI players would need assistance to access it. Thus, it prevents the independence of VI players, and it means more workload for coaches to create and offer an accessible alternative.

"...what we find in visually impaired tennis is we're often running a parallel system because the technology is not accessible. So, we ran a tournament a few weeks ago and we ran it on WhatsApp and on Excel sheets because the players can't access the online entry portal. So, either someone has to do it for them, which takes away their independence, or we do it another way, but that then creates more work for us." (CG1)

A similar issue was also described by CG4 about complains from some VI people towards the social media posts as not accessible.

"I hear people, visually impaired people, say: 'oh, I can't access social media' or 'it's not accessible,' 'oh, it's no good for me'. They don't try...No, no matter what you do, you know, we whenever we post an image, we put a caption to it explaining what's in the image and they still complain." (CG4)

CG4 emphasised that he saw this resistant behaviour in all age groups towards social media as they believed the content was not accessible. Thus, they promptly argued its inaccessibility before even trying to access what the coach had posted.

"It happens in every age group. It's this attitude... (both hands on his lateral front head) It's 'blinkless'. It's... 'no. I don't like that', 'no, no, I'm not going to try that.' It gives... it's people saying, 'I can't do it', 'I won't do it'... because they don't want to do it, because it gives me an excuse to complain that it's not inclusive. But it's not inclusive because you haven't tried it. If you don't try it, how can it be inclusive?" (CG4)

However, this behaviour can vary from person to person as coaches said that the majority of VI people can communicate via digital platforms, whereas others prefer verbal communication.

Sub-theme 1.5: Lack of social support

This describes the difficulties faced by some VI young adults when doing physical activity and sport because of little support, either from difficult to find professionals or company to get active together.

"...or may not have anyone to go out exercising within a family and so then that can lead to a real lack of sporting opportunity for some people, not everybody, but for some people." (CG2)

This can become harder for those people that are already physically active and want to improve their level or become an athlete, then they need to identify who could support them at that required level of training.

"...one of the things is which is kind of most difficult, is actually finding the right guide for someone because, especially, if someone gets faster and better and wants to do more training, as a kind of performance athlete, and it's hard to find someone, who's like able to do that level of training but also, it's kind of willing to. [...] so, for triathlon especially, you can't really do races as an individual, and as a guide all in one season because it's a lot. So, I think it's about trying to find someone who is the right kind of personality and also ability to guide at that level." (CG7)

Generally, CG1 expressed that part of the poor experiences that disabled people face in physical activity and sport is related to the interaction with coaches and other staff of a sport or leisure venue.

"So, or they've been turned away, they've been told they can't do it so..." (CG1)

Thus, previous lack of support can have an impact in the relationship between VI young adults and coaches. For example, CG1 said that some VI people are not open to discuss their impairment and needs, then CG1 often hear the conversation between VI people about the VI impact in their lives.

"It varies, varies. Some people are very upfront. Some don't and then what you find is you...one thing I do a lot is listening to them talking to each other. And then...you hear them talking about their condition and how it impacts..." (CG1)

9.3.2.2 Theme 2: Challenges for coaches' work that impact the service in VI physical activity and sport

This theme concerns the challenges that coaches face to be appropriate to accommodate the needs of VI people, which range from accessible digital systems, relevant information about visual impairment level and requirements of VI participants, to coaches' apprehensions and fears.

Sub-theme 2.1: Coaches' views on what knowledge is needed

This refers to the participants' opinions about the lack of knowledge of visual impairment levels and eye conditions among coaches. This is not understanding the visual feedback of partially sighted while they are playing a sport, not knowing about other types of impairments that VI players might have because they do not reveal this to coaches. This information is important to be used by coaches to prepare their sessions for VI participants.

"So, it's learning what an individual can do, cannot practically do, and what you can bridge between the two. It's almost like a triangle. This is what you can do now. This is what you want to do, but you cannot do or think you cannot do. How do we find a way to make those two come together, so you can do?" (CG4)

One challenge is to be aware of multiple impairments because some people are not straightforward, or they had poor interaction with other coaches not understanding their impairments or they had been told they cannot take part in the activity.

"So, one of the players I work with is also deaf. Yeah, more in one ear than the other, so that's [...] you can't see that. And that, she didn't tell me to start with. It just as the trust builds up, she said: '(CG1's name), I'm also deaf'. So, I'm like OK, you know? Right, so that means we've got to look at things slightly differently." (CG1)

Moreover, the process of learning is continuous and not simple throughout the development of the sessions. For example, some eye conditions require awareness of the environment impact on the players' ability.

"In terms of the impairment itself and so our sessions are at evenings as well, so there's some [inaudible] visual impairment...it doesn't make any difference if it's dark, but you know, if you can't see whether it's light or dark. But there's certain conditions, like Retinitis pigmentosa, I think when it's

dark, it becomes even more disorientated. And so, I think just an awareness of how things change according to like time of day, what you are coaching, that sort of thing.” (CG3)

Knowledge is essential for all coaches to become inclusive, as CG4 expressed that VI people usually prefer to be guided or coached by a VI coach because they may believe these coaches have better understanding of sight loss, instead of a sighted guide.

“I think that when it comes to visually impaired, they like to work with me because I'm visually impaired. I think they believe I've got the understanding of sight loss. I've got little bit of vision left and if it's bright light, no light, no vision at all, but I've got the understanding of sight loss, whereas a sighted guide, you train a sighted guide, but you can't really understand what it's like to be without vision all the time. [...] And they've only got perhaps idea of different eye specs and things like that, so like the visual impairment plays a major part in it all from the coach.” (CG4)

This reinforces what CG1 expressed about not understanding the visual feedback that partially sighted perceive while playing VI tennis.

“... 'cause I don't know how much feedback they [partially sighted] get. Yeah, totally blind I know they get no feedback. Yeah, so I can give that feedback. With the partially sighted players, everyone sight loss is different. So, I actually don't know what feedback they've received visually” (CG1)

Sub-theme 2.2: Coaches' apprehensions and fears

This sub-theme refers to the coaches' feelings of apprehension and fear when they do not have knowledge and qualification on inclusive physical activity and sport to work with VI people. CG1 explained that this issue happens across all types of impairment in sports.

“I think across disability we would like coaches to do more, but I think...wheelchair tennis, learning disability tennis, deaf tennis, which is essentially the same, coaches currently feel more comfortable.” (CG1)

According to CG1, the fears are due to their inability to approach VI people.

“Yes, how to guide, how to say, yeah, what to say, what not to say. So, I think there's...when I speak to coaches, there's apprehensions around... ‘well, I've never done this before on court’, but also there's... ‘I've never met a visually impaired person before’. ‘I don't really know...’, ‘how to guide them?’, ‘what to say?’. Yeah, “how to run the session” ...So, therefore, I end up doing it, which is not really my intention. My intention is to train others to do it. But we haven't got there yet.” (CG1)

Sub-theme 2.3: Administration difficulties

This regards coaches' difficulties in managing some administrative tasks to run physical activity and sport sessions. This is because of an inaccessible system to register players or not obtaining a confirmation of attendees. In general, the need to streamline the administration would mean to allow more time for coaches to dedicate themselves on the practical tasks and other work involved in their sessions.

"I think for a lot of coaches, I think it would be a similar answer is to streamline the administration. So, that you can spend more time doing stuff." (CG1)

In this sense, CG1 reported the need to improve all the administration related to sports sessions. For example, the self-registration of players needs to be accessible.

"I think registering players, getting information or... so, all the administration around running sessions, so that and some of it is there already, but it's also making it visually impaired friendly, which is all that is not." (CG1)

In addition, CG6 and CG7 reported two reasons that they find it difficult when they do not have a list of participants' attendance. Firstly, it seems difficult to know the number of participants in the sessions and coaches need to be prepared to receive the attendees.

"And I do I ask people to tell me if they're attending. So, obviously, I collate that information just to know, sort of how many people to expect and things like that, but not a great deal." (CG6)

Secondly, by organising a physical activity or sport session may require hiring venues and other things necessary to run the sessions. Due to financial resources applied into the sessions, it requires coaches to know the number of attendees to evaluate its feasibility. If not knowing this, then coaches must rely on a certain number attending the sessions.

"I think one of the hardest things for me, so I'm trying to put on walking group as well, at the moment, and also have sort of like a ball skill session which I'm doing with someone and another organisation. But the problems with that is the fact that you've got...people...there's a bit of an unknown, you know, if you're hiring out venues and stuff, and then you've got the cost of that and now, so you have to then rely on enough people coming for it to be kind of viable, and so really sort the cost of venues without the kind of confirmation that you could get participants." (CG7)

Sub-theme 2.4: Getting VI people in physical activity

Coaches reported that it is difficult to get VI young adults involved in physical activity and sport. The reasons for this issue may vary from lack of interest among VI young adults in getting active to female gap.

"...so, we've got, I think 6 guide runners and so have 6 visually impaired people and, but we just don't have enough interest. [...] And because we're all set up to go, it's just we need the people and trying to find visually impaired people that are interested in taking part is the big challenge really. [...] So, obviously we've got a lot more scope for having more people, and but yeah, we just can't find them".
(CG3)

CG3 and CG6 also explained that they noticed an age gap and also women.

"There's loads of people that are taking part in the age of 16, and then that tends to be quite a lot of stuff towards 30 upwards, but that little group in the middle they, especially women, tend to just disappear, I think." (CG3)

"So, I think that age that you're talking about 18 to kind of 30. I think there's a bit of a gap there, you know, but it's not an easy sort of...you don't automatically transition to something that's particularly suitable for that age. [...] So, it's quite tough for, especially, for that that age group. I mean, that's the age group we're actually trying to focus on" (CG6)

Regarding to get VI young adults involved in physical activity and sport, CG6 explained that the issue is not with the communication itself, rather it is harder to engage them and have them committed to the sessions.

"But that age group with regards to visually impaired people, I think are quite hard to...not communicate with, but actually engage with at that next level. [...] I think a lot can be done, you know, through social media and over email and phone and all that. But to get them to actually commit to something or to take it to that next stage I think it's quite difficult for that age group."
(CG6)

Also, CG6 emphasised that VI charities and other organisations had failed to engage this age group, as their engagement depends on themselves.

"It's hard because a lot of groups and things and charities and all that are trying to achieve the same thing and grasp, you know, grasp, hold of these people that in that category that just don't seem to be engaging. But again, it's down to, you know, it's down to the person." (CG6)

CG3 and CG6 reported they wanted to reach more VI participants and promote their accessible sport. However, CG3 expressed that she does not want to spend a lot of time to get VI participants in their sessions.

“...you know, we could do more to promote it as being like an accessible sport [...] so, we spend a lot of time trying to get people in. [...] so I need more reach, but I don't wanna spend time doing that, if that makes sense.” (CG3)

9.3.2.3 Theme 3: Facilitators to engage VI young adults

Sub-theme 3.1: Coaches need to know about VI players

Coaches emphasised that is necessary to understand everyone with visual impairment, as the impairment varies from levels and its impact on people's lives. The process to know a VI person starts before the first physical activity and sport session, in which the coach needs to discover about visual impairment level, physical activity level, requirements, expectations of a VI participant and how this person can arrive at the venue and so on.

“I think as well dealing with everybody as an individual is key because a lot of sight loss is very different depending on who you are coaching, you know, we've all got different eye conditions, [...] just to get things like information about their sight and what their level of vision is. [...] any medical conditions or concerns I would need to know about. [...] what their sight level was. [...] I would need to know where they were coming from, how they were getting there, if they had, again depending on what their sight level was, if they had any help. If somebody would be coming with them, you know, that kind of thing. More to do for the safety of them as well.” (CG6)

Coaches need all this and other information to prepare themselves and adapt the sessions for VI participants. CG6 explained that communication is important, and it depends on being able to adapt how coaches communicate and run the physical activity or sport sessions.

“I think been good at communication, obviously, verbal communication is key. [...] ...we've all got different eye conditions, different experiences, different backgrounds, so I think being able to adapt the way you, you know, you communicate or the way you teach the sport or whatever is really important as well. [...] But I think communication overall is the biggest one for being a coach in VI Sport.” (CG6)

Furthermore, CG1 expressed that by asking questions to understand the needs of a VI person can help to build the trust in the relationship between coach and VI people.

“So, you have to ask questions to...explore and build a real sense of trust between you and the player which you do with any player” (CG1)

Sub-theme 3.2: Improvements to accessibility and usability

Coaches expressed that some accessibility and usability factors provide better service in physical activity and sport for VI people. Accessibility considerations are accessible digital registration system, physical environment and sessions of physical activity and sport. Regarding digital systems, the impact of COVID-19 was that everyone started to communicate and book sessions online.

"I think it was easier before COVID, obviously, on a face-to-face level. But digitally, I think it's actually better since COVID because everybody had to kind of communicate maybe in a bit of a different way. [...] Well, obviously, you know...using everything on social media and digitally and, you know, things like...like booking sessions and things, it's all online now." (CG6)

In addition, from a usability perspective, they believed that there is a need of making their service more efficient by automating some processes, for example, by providing accessible and online registration and booking of sessions. CG1 explained that efficiency of an accessible registration systems could benefit VI players and coaches, where VI players would be able to register themselves and coaches would easy check in the attendees and would not have to do extra work over two systems, i.e., one for sighted and another for VI people.

"...just then making things efficient. So, and a lot of the techs already...So, when I coach on a Saturday morning, I just have an app with the registers on my phone. So, when the kids come in, it's just bum, bum, bum, bum. Yeah, they're in and that could work with my visually impaired players, but they can't easily register themselves. Then if you don't have, we end up having two systems." (CG1)

As an example of building awareness about sight loss, CG1 created videos about sports which were audio described to promote VI sports to the general and VI communities. He also emphasised the quality of audio description of sports during the sessions.

"How that works? How do you explain to people, you know, you say audio description has to be really good. But everything has to be described. So, and just coming up with ideas of what the game looks like, 'cause it's getting better." (CG1)

Sub-theme 3.3: Inclusive coaching

This refers to the need of an inclusive approach for coaching. The inclusive approach for coaching can make VI people feel more comfortable and welcome. Participants argued that more coaches need to become more inclusive. CG1 considered that training about inclusiveness for coaches is important to build coaches' confidence in working with VI people. As a result, it would form a bigger workforce of inclusive coaches that could work more locally, and opportunities of inclusive physical activity and sport would be more available for VI people.

"I want other coaches to become inclusive, [...] and the big part we talk about this is training coaches. Yep. So that we have a bigger workforce. All coaches who are confident to work with visually impaired players. And...so that players don't have to travel so far to go to sessions, they can get to a local club, play with sighted players. [...] they can go to a local club and play with sighted family and friends using that ball. Yeah. So, I think that's part of the education piece as well." (CG1)

Moreover, the inclusive coaching approach was also applied online during the COVID-19. As coaches needed to keep some skills sessions, for example, in VI tennis coaches perceived that online sessions brought lots of creativity from attendees at home that were joined by their families or people that were in their social bubble.

"...we learned a lot over the pandemic. And we were coaching blind tennis online, so I was where I am now. Coaching blind tennis... [...] So, by the end of the lockdown, so in January this year we were running a multi-sport and an inclusive Tennis Club online and we had wheelchair user, got a deaf player, partially sighted, totally blind, non-disabled, all joining in together. On Saturday morning doing skills and the players were coming up with their own solutions, so they'd have beach balls, or they put the ball in a tight. So, if it ran away, they could put it back in. They have a balloon and with what, so we did a lot with balloons with [inaudible]. So, that you can hear it and then they would tie string to the balloon so. If they're tapping it with a racket and it goes somewhere they pull it back in and so lots of creativity. [...] that taking those ideas into coaching and yeah and also, I think help us reach young, you know, reach people and families." (CG1)

He believed that this was the opportunity to start playing VI tennis at home which may help to engage VI young adults.

"...if you want to start playing tennis you can start at home, and this is how you can do it. And you don't need to travel then. So, hopefully that will help engage more young people." (CG1)

Sub-theme 3.4: Promoting sessions

Important aspects to consider when promoting VI physical activity and sport sessions involved the recommendations to find better way to promote VI sessions at local level with an inclusive focus, clear target audience and quick information. Coaches expressed their wish to promote their sessions more effectively to reach VI people, and it would save them time to do other work.

"So, one thing I'd like to see sort of non-pandemic is to have a better way of promoting that. [...] So, I suppose, yeah, things I'd like to do less advertising, and I'd like to make it more effective." (CG3)

CG3 also explained that they have advertised and made notifications of sessions on online group of VI members in social media as one place to keep them updated of notifications about the sessions.

"...so, I mainly do things on Facebook and Twitter at the moment. Just because that tends to be where my people are, so I did quite a lot of advertising on Facebook and we linked up with local visually impaired charities and things via that sort of group, and so we try and do the majority of like advertising and like saying what sessions are on. So, not necessarily advertising it as advertised, but just saying 'OK, we're going to meet today at 6:30' or that sort of thing. Yes, so everybody in theory then just has one place that they need to look, so they can just be kept updated reports." (CG3)

CG7 explained that coaches need to put extra effort to advertise their sessions, thus by making this to be advertised also widely into radio and social media may help to reach more people.

"...but also, when there are opportunities, they...it seems to be sort of a problem for communicating them. [...] I've seen people do a lot of things, which are really kind of well-advertised. [...] there just needs to be even more effort than normal, and I think kind of because it's easier for things to get missed like a flyer. Obviously, you know, someone has got sight loss like I say they might not see it. And I think so maybe having kind of more things like under radio and more things on social media, but just really kind of amplified the kind of existing level of advertising and communication that there is." (CG7)

Even though, there are existing social media groups with VI members where coaches can advertise and make links with VI charities, coaches perceived that adverts may not be appealing to the VI young adults. Therefore, CG6 believed that advertisement needs to be attractive for this group, however CG2 argued that it is not easy to make attractive adverts.

"You've got to be in the right place at the right time, you've got to advertise it in such a way in which it's attractive to everybody. That isn't always easy though." (CG2)

"I just don't think it's appealing to the younger, like younger adult, if you like." (CG6)

This is because there are some aspects of their lives that are priorities and visual impairment itself is something that can be perceived as scary.

"Well, the reason it's not always easy is because like sometimes people are maybe nervous to get involved if it's something new for them. Visual impairment can be a scary thing if you've not experienced it before. [...] also maybe time, giving up your time doing something, regular commitments can be stressful if you've got a family or if you've got a busy job and that can work for both sides, actually a visually impaired person or any volunteers or coaches that you may get involved." (CG2)

In addition, CG3 said that advertisement should be appropriate to the target audience. For example, making advertisement in certain groups, especially in the VI charities, may not be effective because there might be more VI older people than younger ones.

"Yeah, mainly social media, but also via like the local service providers. They can find in RNIB, ... I mean I don't know if part of the issue is that maybe comes mainly older people that use their services, perhaps. So, if there were sort of like, I don't know, like a lot of the service users tend to be older for the visually impaired charities, so I don't know whether it's specific sort of thing aimed at younger people that wasn't, you know, saying about getting you out for walks and stuff aimed at like the over 70s? Maybe that would make things a bit easier." (CG3)

Sub-theme 3.5: Support for VI young adults to engage in physical activity or sport

This sub-theme regards the needed support to aid VI people to get active. This can range from different levels of support to education, network and communication, such support could make VI people feel more comfortable and welcome. Therefore, coaches explained that family members need to change to a right attitude, instead of holding back VI young adults because it takes away their independence and physical activity or sport participation.

"...and I think sometimes if the family needs to have the right attitude as well. They need to, obviously, know what opportunities are out there. See how many people are taking part in it, you know, that don't rely on, you know, a lot of people and things. I think that needs to be improved as well. You know, rather than just 'Oh my God, this...my child got this...that and the other so therefore they can't do that'. It needs to be a different attitude from 'right, how can I get my child or person or husband or whatever involved in this to make things better for them?'" (CG6)

CG6 emphasised that those dependent on others are the most in need of support to do physical activity or play sport.

"...somebody who has massively relied on somebody or people for everything up until that point. It's crucial for them, I think. [...], there's all these kind of elements for that support network that you've got that could change when you become an adult and it's a massive shock to the system. So, I would say that the least independent of those people, it's the biggest gain for them." (CG6)

These considerations on target audience require the adequate support to help VI young adults to overcome their barriers to get active. In this sense, different levels of support need to be put into practice, such as one to one support for beginners or for those already physically active that need more input to their physical activity level, or for those that just want to play, and support for those who live with multiple impairments.

"Yeah, but they didn't know how to be involved, how to be...how to take part because they thought like it's not for people like with visual impairment. Because it was that kind of barrier that they were facing. But then when I started talking to them, like kind of giving them one to one support and like supervising them and like talking to them and everything then, and then they started getting OK and understanding and everything." (CG5)

"We've got people coming for all sorts of different reasons, and some of the visually impaired players that I coach come and they are all...they want to do is come and play some tennis. They don't want any input from me, really. They just want to play. [...] And then there are others that want more input." (CG1)

"And people that have multiple different needs. As I said about the guy that we've got that is both blind and deaf. And so, the level of support he needs is obviously different, he doesn't necessarily need more for all facing mechanisms in place and stuff, but he needs a different sort of level of support, I think." (CG3)

In addition, CG7 commented that everything should be accessible from the first time receiving the VI person at the door of the venue to guiding that person through the facilities.

"...also just making sure that the little things are accessible like just adjustments like someone will be at the door, if you want to be sort of shown where the room is for certain activities or just offering kind of guiding support where it's needed and making sure that's consistent as well." (CG7)

All the service provision needs to have a support network to make it efficient. According to coaches, they suggested there must be more links and collaboration between organisations, professionals, volunteers, and peers which can make an impact to the physical activity and sport experience for VI young adults. Furthermore, more links are needed between recreational providers and sight loss charities, as CG6 said that there is no point of connection between these entities. This could be essential as sight loss charities are the first point of contact for people that acquired or have congenital sight loss.

"...there needs to be a bigger link between the people who provide the activities. So, if it's leisure centres or local walking groups or whatever it might be, there needs to be better links between them and sight loss charities. Because at the end of the day, when you lose your sight or a member of the family loses their sight or whatever, you are always linked to a sight loss charity, you know. It's the first thing that happens and I think there needs to be that network between different activities that people can do now. [...] I think, you know, the leisure providers or whoever it may be needs to have that link with the sightless charity, that needs to be a signpost because if...they're two separate

entities, which a lot of them are at the moment, with...like I said, I'm trying to achieve that with work at the moment. One doesn't hear about the other, you know, it's just a separate thing..." (CG6)

Moreover, CG4 and CG7 argued that organisations could collaborate more because the collaboration seems to be fragmented.

"We have a national, assorted national body, if you like, in [PLACE2], the [ORG14]. And in theory, we should all collaborate through that. In practice, it's very fragmented. So, I have to say no, not really in a practical manner. Theoretically, yes, practically no. OK, very much each coach doing their own thing." (CG4)

"No, not that I can think. I've really not...It's not a...It tends to be quite a niche sort of thing today." (CG7)

This collaboration could be established between coaches as well. This would mean sharing learnings and swapping VI people over to the right coach. Coaches said it has happened to some extent as where there are less inclusive coaches there is less collaboration, as it is in VI tennis.

"It would be really good to have more professional collaboration because amongst the coaches that are doing it, to share learnings and then also spread those learnings out, as I mentioned earlier, to those other coaches who are doing some or doing none, but we need to influence them. But, yeah, there could be a lot more and across disability tennis, a whole. I think there could be more collaboration between the coaches, to share ideas and practices. And learn from each other 'cause vision impaired tennis is very, very young. And there are probably six or seven coaches in the country that are doing most of it. So, it would be useful for those of us to get together and so...how do you do this? How? And it has happened a bit." (CG1)

Whereas in running, the collaboration exists between guide runners within the same running club and not externally to them, which CG3 considered a shame.

"So, specifically with running how it tends to work is like if you're in a club then you tend not to refer outside of your club, so you don't really collaborate between clubs, which is a bit of a shame and so our other local running club tend to be sort of like the elite runners, whereas we're quite sort of recreational, so we're not too worried about times and things like that. We're just [inaudible] actually doing something. And I think there could be more collaboration between clubs. So that, like if I had someone that wanted to like be an elite runner, for example, I could refer them to ORG9. And similarly, you know, if they had something that was a bit more just wanting to get out and just have fun, then they could refer to us. So, I think there could be more of that sort of thing." (CG3)

On the other hand, there is a different opinion on this matter.

"We do have a good network of coaches, both mainstream and through like disability or impairment tennis in my experience. We have a lot of mainstream coaches around the country who actually, you know, coach the visually impaired sessions as well. So, it all comes under disability tennis. But as a whole there is a lot of professional collaboration, and we have a lot to do with the national governing body, which is the [ORG18], and so you know, they're very supportive and there is a big, you know, there is a big focus on inclusion and things like that at the moment." (CG6)

CG3 also emphasised that more networks are needed because it seems there is a lack of awareness of what organisations and coaches are doing in physical activity for disabled groups.

"...there are few people that will know that we do visually impaired stuff, but not everybody knows that, and I think there could be more sort of links, so that it's more visible, but who does what? I'm not...I think that's with the whole of like disability sport as well. And so, like we know there are people out there that do this. We just don't know how to find them. So, like more networks I suppose would be useful." (CG3)

Generally, coaches expressed that this awareness could reach widely everyone in and out of the VI community.

"...and people hear about it about sport and physical activity just by chance, by knowing somebody who's involved in it, I think." (CG6)

"Better understanding that visually impaired people can, and that understanding is societal, as well as familial. Because families have to understand, society has to understand the visually impaired people can, if you let them in, if you encourage them, instead of putting barriers up and saying 'cause you can't see, so you can't do. Just say, 'ok, so you see things differently', you know." (CG4)

According to CG4, inclusive awareness relates to educate VI people about the support available and that they can do physical activity and sport and exclude any misleading conceptions they might have about it.

"So, it's education, I suppose. Educating people that you can do it. It's not what you think it is. You got support. We put everything in place in trying to get people to understand that. So, suppose our strategic approach is 'look, we've got it all. We just need you, and you find a goal'." (CG4)

By encouraging young adults with VI to believe in themselves, coaches said that it can help them to face fears, for example, to establish a mindset through showing examples of others and friends with VI, at similar age, having good time getting active.

“Younger people are more willing to do it and have a go, especially to hear from somebody else of a similar age who's done it or is doing it. [...] I think it's peers, it because their peers do it. They like ‘why can't I do it?’” (CG4)

In addition, CG6 believed that by showing similar peers to young adults with VI would potentially create more participation, rather than showing athletes as it usually happens in the current advertisement.

“So, somebody who's brand new coming into the sport or like physical activity, it's like the first thing they see, you know, like really sort of high achievers. Whereas I think if there was more focus on like I said, more publicity around the fun element and the recreation element and the social, 'cause that's what got me involved, and that's the biggest bonus I think of becoming involved in sports and team, things and everything. If there's more focus on the social and the confidence and people's positive experiences rather than, you know, the highflyers or the ones that have achieved the most. I do think people would feel less apprehensive going into the sport, especially, if they're not very physically active at the moment. And I think if, you know, if they just saw examples, who people have attended there, maybe not that great at it, but they had a really good time, and they've met new friends and new skills and things. I think if it was focused a lot more on that, I think we'd have a lot more participation, if I'm honest.” (CG6)

Coaches perceived that young adults with VI may need to feel being part of a group, a group of similar people whether visual impairment and sighted people at the same age. This may create a sense of belonging among them.

“...people want a sense of belonging. They want to belong to something [...] Young person probably wants to belong to something that includes other young people. And some of that might be they want to be around other young people with vision impairment. Some of that might be that they want to be around their friends who may not have a visual impairment.” (CG1)

From the coaches' perspectives more support from peers and volunteers are needed to aid VI people in taking part in physical activity and sport. As peers could help newcomers to be involved in the sessions and make them feel welcome, especially the younger people as they could feel more welcome by others.

“I think what's nice about [ORG1], so there's a lot of peer support. So, when the younger players come in or younger or new players come in, there's good support from...everyone make you feel very welcome. And that helps, you know, we try to be part of that process, but it helps when players are made to feel very welcome not just by the coach, but by the group.” (CG1)

Volunteers can either make the sessions easy and fun by having a role such as a buddy coach to give more information and being careful with attendees, and at the same time help set up the session for coaches.

“...we have sighted volunteers and one of the things that I've learned over the last few years is to really work with the volunteers as well to give them the skills to join in, play and give feedback. And so, they're not just there to pick up the balls and help, they become almost buddy coaches. [...] which we've worked with the volunteers to give no coaching feedback, but information 'Sorry. Where did that ball bounce?' So, it's not just about...It's not just in or out, it's like it was out to the left by 50 centimetres or it's the network was halfway down the net, or it was in the bottom of the net or hit the tape, so just working with volunteers to give more feedback so that the players can...Yeah, that feedback so that they can learn themselves.” (CG1)

“But, again, I think, you know, having more people involved, like more volunteers and things like that, would take the edge off doing some of the sort of, you know, tasks that take time and everything like that. You know as a coach you spend a lot of time sort of setting up the session. You know, like I said with equipment, and you know the tactile lines and things have to be applied to the floor and everything. It does take a long time to actually set up a session and so having more hands-on deck, if you like, would be better if you do more sort of volunteers and helpers involved, definitely.” (CG6)

Coaches emphasised that more volunteers are necessary across the country as not all organisations have funding to employ more staff to work in the sport venues.

“Well, I think that things like there's like various volunteering things you can do through British Blind Sport. I believe to maybe become a guide or a coach in sport or a volunteer support in sports and I think they need to be made more inclusive and extended out more across the country.” (CG2)

“I personally or whoever's in like a coach or whatever, you tend to do, like a lot of it all yourself, you know. And a lot of it is kind of voluntary, because there aren't that many clubs and places like that where, you know, there's enough funding, or there's enough participation to warrant, you know, being paid as a coach and staff.” (CG6)

9.4 Discussion

Although there are common challenges for VI people of all age groups, for VI young adults there might be specific ones which can impact their participation in physical activity and sport in the UK. Generally, the common challenges among VI people are limited local opportunities and lack of knowledge on physical activity and sport opportunities due to poor advertisement, as it often occurs through word of mouth. In addition, lack of social support through not having a company, difficulties

to find a professional for VI person's required physical activity level, poor experience from the sport and leisure centres and staff, which may lead to VI people not trusting coaches. On the other hand, coaches may also lack confidence and knowledge to work with VI people. Therefore, coaches need continuous professional development on inclusive physical activity and sport and collaboration between them to provide inclusive sessions. The trust needs to develop from the start of the relationship between coach and VI people to avoid missing any relevant information to the development of the sport sessions.

VI young adults may need their families to be positive and know more about the inclusive physical activities. Also, they need more offers of appealing physical activities and sports, especially for female. More support is required for those born blind and who lost sight very young that are scared to start to get active, where one to one support may be more necessary as well as the need to be involved with similar peers which brings a sense of belonging. This could be achieved by either face-to-face or online sessions, where online sessions and systems must be accessible for registration and sessions should be well audio described. VI young adults may access the Web than others VI age groups, although coaches reported resistance to use social media in all age groups due to inaccessible posts. In this sense, accessibility is important when promoting sessions because it needs to have a clear target audience, quick information, with inclusive and attractive adverts. This is because current adverts seem not be appealing to young adults due to their lack of interest, time, beliefs in themselves or opportunities focused on VI children and older people.

Overall, coaches expressed that a wider encouragement is necessary to encourage both VI young adults and the VI sport community and collaboration between coaches and organisations to be involved and sports to become more local and inclusive.

9.5 Summary

Coaches expressed their experiences and needs that impact on the service for physical activity and sport for VI people, as well as the needs and views about the experience of VI young adults. This showed that families need a positive attitude towards participation of young adults with VI and VI young adults need to be aware of the provided support, overcome fear and know how to get active. Also, more effort is required to tackle limited and not appealing physical activity for them. The next chapter reports on the design and development of the accessible online survey.

Chapter 10 Study 7 - Phase 3: Coaches' feedback on the mobile app

10.1 Introduction

In the last chapter, coaches were individually interviewed online and shared their opinions about VI young adults' participation in physical activity and sport, as well as their work experience with VI people and other disabled groups. After these interviews, all participants were invited to give their comments and views about the high-fidelity prototype app, called ActiveVI, on the suitability for VI young adults. Such perspectives were essential to enhance understanding of the needs of VI young adults and of the whole service provided for physical activity and sport in the UK for VI people. Coaches were able to look at the mobile app after the interviews (Chapter 9) for the same reason described in the study with VI young adults (Chapter 8). In this way, it was possible to prevent potential deviation of focus from their views about the physical activity and sport participation of VI young adults by their impressions about the app.

This chapter aims to address the coaches' opinions about the app on the suitability for VI young adults and their insights for potential use by professionals in the sector. Firstly, it describes the procedure adopted to allow coaches to examine the app. Secondly, it provides the themes regarding their feedback about the potential use of the app by VI young adults and coaches. This study presents a unique opportunity to report the viewpoints of coaches about a technology aimed to help VI young adults to overcome some of the barriers in the service of physical activity and sport. In the literature, a few studies with professionals in physical activity and sport for VI people (Jaarsma et al. 2019). Therefore, this chapter offers the findings which can help to identify to considerations when designing digital interventions about the service provided in physical activity and sport for VI young adults.

10.2 Aim

This study aimed to obtain the views of coaches about the mobile app. The focus was to identify how the app can be useful to VI young adults to take part in sport and physical activity from the perspectives of professionals and also to understand the potential use by these professionals in the physical activity and sport services.

10.3 Method

This study received ethical approval along with the protocol in the study with VI young adults (Chapter 7). The approach was to use the usability tasks (Appendix I) to demonstrate the app and not to evaluate the accessibility and usability with coaches in this study. This study happened online due to the COVID-19 social restrictions between November 2021 and February 2022.

10.3.1 Sampling and recruitment

Recruitment process of coaches is mentioned in the previous Chapter 9, in which a convenience sampling was applied to invited coaches with at least one year of work experience in the physical activity and sport for VI people.

10.3.2 Procedure

As previously mentioned, the think-aloud protocol was used as a guide for the researcher to demonstrate the functions of the app through the usability tasks to participants in this study. The description of this protocol is in the ethics application. Prior to the online demonstration sessions with coaches, the author conducted one pre-test with one coach with consent for the author use their data in case it was relevant to the study and if the session occurred smoothly without major adjustments needed for the next demonstrations.

10.3.3 Pre-test

In the pre-test, the online session was conducted with one coach and the researcher aimed to test the protocol by asking the coach to do the usability tasks to demonstrate the app's main functionalities. This participant was recruited by snowball sampling. Firstly, the author gave instructions about the session and asked the participant if the app was installed and ready in his mobile phone to start the demonstration. Video recording was made on Microsoft Teams and there was no need to use another device to film the participants' interaction. This was not the aim of this study as coaches were not the target public. The author asked the participant to sign in the app by giving a pre-defined email and password.

Based on the usability tasks, the participant in the pre-test had the opportunity to follow the steps that a VI young adult would take using the app by listening to the author reading the tasks and explaining what the features do for the users. Then, the participant could provide comments during the session and afterwards when the author asked some questions in the protocol to obtain his opinions about the app. This session lasted around 30 minutes and ran smoothly. Once the session

was completed the author asked the participant to delete the app from his mobile device. By checking his answers and comments, the author made little amendments in the questions for future participants. Therefore, his responses were relevant, and the author decided to keep them for the data analysis.

10.3.4 Demonstration of ActiveVI app

Once participants signed and sent back the consent to the author, the online sessions were arranged and conducted on Microsoft Teams. Participants were not asked to think aloud and enable the built-in screen recording in this study as it was not meant to obtain the usability and accessibility aspects of the app from coaches' feedback.

At the beginning of each individual session, the researcher informed participants about the session and clarified any questions. The researcher asked participants to look at the app from a VI young adult perspective as well as from their perspectives as service providers.

In this study, the author was the only person to conduct the entire session. The author asked participants to do the tasks while the author was reading and explaining what the task was and what a user could do with the functions in the given task. In this way, the author could demonstrate how the app worked, and participants could understand the features and purpose of the app.

By the end of the sessions, the author asked participants their opinions about the app, what impressions they had or any concerns, and how useful it would be for VI young adults. Also, the author asked about any potential use for coaches to be part of the service provided in the app. The author used automatic transcriptions from the video recordings on Microsoft Teams to export to Microsoft Word to read and review the transcription to do the data analysis.

10.3.5 Data analysis

The main themes and sub-themes obtained from the inductive thematic analysis and descriptive statistics summary are reported in the following section (Results 10.4). The data analysis was regarding qualitative data analysis through thematic analysis of transcripts. Regarding the qualitative data, the author was the only researcher to conduct the thematic analysis of this study to make the data analysis consistent throughout the process. While this was an iterative process done by one coder, the author of this study, by developing understanding of the data, codes, recoding or combining codes until later checking the agreement between extracts and codes (Elliott 2018). It was enough to create consistency as the aim was to generate meaningful understanding of the data,

rather than highly consistent codes expected from other approaches, such as coding reliability thematic analysis (Byrne 2022).

In this study, the thematic analysis and the author followed the approach suggested by (Braun and Clarke 2006). This sits between the coding reliability and reflexive thematic analysis approaches (Byrne 2022), in which the researcher seeks to create themes as topics from common comments expressed by participants. In this sense, the themes were produced early in the analytic process and according to the participants viewpoints, as the study approach was more applied-focused, rather than a more interpretative approach used in the reflexive thematic analysis, in which the researcher brings subjectivity and meaning to the themes (Braun and Clarke 2023).

The main purpose of the thematic analysis was to gather the viewpoints of coaches about the ActiveVI app aimed to assist the needs of VI young adults in physical activity and sport. The author identified codes in the transcripts that emerged from the data and also looked at two initial topics that were related to some of the data collection questions: (1) to obtain feedback about the app and its usefulness for VI young adults; (2) to discover what coaches might think about the potential use of the app for their work in physical activity and sport. The decision to not conduct a deductive approach exclusively was due to its disadvantage, as the coder can miss some findings that do not match with pre-defined codes, which can be either based on prior studies or on expected findings from this study (Elliott 2018). Therefore, the deductive approach is not recommended for data analysis when there is a lack of previous studies in the studied subject (Mozelius and Humble 2022). In this sense, the author had some initial ideas of what to expect from participants' responses and was open to identify shared viewpoints about the app.

In this study, the data analysis process started from the familiarisation by reading the transcripts several times until identification of topics or issues relevant to the questions of design requirements. The author created an anonymisation system on a Microsoft Excel spreadsheet to ensure participants details were anonymised in the transcriptions. After reviewing the codes and extracts, a codebook was generated to refine the themes. Also, writing up the results was a final stage of analysis and selection of data extracts, where the author reviewed and refined the findings.

Moreover, the demographic data were analysed on IBM SPSS (version 28.1.1.0) and summarised to obtain an overview of the average of work experience and characteristics of participants.

10.4 Results

10.4.1 Participant characteristics

This study was conducted with six participants who were either a coach or guide that had experience in a range of different physical activities and sport for VI people. All participants in the previous interview study about coaches' work experience with VI people (Chapter 9) took part in this study, except one participant. This participant (CG5) was not able to use the app due to a lack of accessibility compatibility with his mobile phone, SmartVision 2. Thus, the data from this participant was not considered in this study. This is a limitation of this study due to not providing accessibility compatibility to the participant's device and the author did not provide an alternative format.

Table 10.1 Coaches' demographics

Participant ID	Visual impairment level	Role	Physical activities	Years of experience	Range of impairments
CG1	No	Coach	VI Tennis	30	Wide
CG2	Blind	Volunteer	Goalball	5	Visual impairment
CG3	No	Coach	Running and Pilates	8	Visual impairment
CG4	Partially sighted	Guide	Running	6	Visual impairment
CG6	Partially sighted	Coach	VI Tennis	4	Visual impairment
CG7	No	Volunteer	Triathlon, Running and Pilates	5	Visual impairment

The mean of years of coaches' experiences was 9.67, in which they have worked as coach (n=3), volunteer (n=2) and guide (n=1) in sports such as VI tennis (n=2), running (n=3), goalball (n=1), triathlon (n=1), Pilates (n=2), mainly with VI people at all ages. Some of them were partially sighted (n=2) and blind (n=1).

The blind volunteer, a Goalball player, had helped a main coach to set and assist with warm-ups and played with attendees. The sighted volunteer had been a triathlon coach for VI people in the past and was volunteering for a VI Pilates group by helping members to get prepared for the session and volunteering as a guide runner with visually impaired people. Other participants had been working as coaches for sport centres and charities.

All participants had enough experience with VI young adults and knowledge of the physical activity and sport service provision in the UK that were relevant to examine the app's usefulness. Three out

of seven participants were visually impaired. One was blind (CG2) and two partially sighted (CG4, CG6). However, one blind coach (CG5) interviewed in the previous interview study (Chapter 9) could not take part in the current study because he was not able to sign into the app to start the demonstration. This is because of an accessibility compatibility issue that prevented this. This participant had a mobile phone devised for VI users, SmartVision 2 by Kapsys. It is an Android smartphone with three types of interfaces such as a physical keypad, touchscreen and voice command and has its text-to-speech output, Kapsys Voice. Although his assistant had an Android mobile phone, he was unable to use it because he did not know how to use TalkBack.

On the other hand, partially sighted participants did not express any issue as the text was large enough. The blind participant (CG2) who used a Bluetooth keyboard connected to his iPhone complained about difficulties to sign in and being confused to hear both the built-in screen and screen reader speech. This participant suggested the built-in speech may be useful for partially sighted users.

10.4.2 Themes

The themes present the coaches' feedback on the design concept, its usefulness for VI users, and suggestions for features to enhance the physical activity information and services for both VI users and coaches. They addressed social aspects, app functionalities, accessibility considerations, and the need to optimise coaches' work and services, all of which could be incorporated into the app to improve the VI user experience. These insights informed the development of design guidance and could have refined the design requirements for future iterations.

10.4.2.1 Theme 1: Coaches' opinions on app usefulness for visually impaired users

All coaches expressed positive feedback towards the concept as a simple app, easy to use with access to a variety of sports and specific functions in one screen. Some of them mentioned that it was a brilliant idea and if it was live, they would recommend it to their organisations and the community in general. Their positive feedback brought sub-themes regarding to the range of services provided in the app and interesting implemented features which would be beneficial to VI young adults. On the other hand, the negative aspects observed by participants about the app referred to some UI design elements and less meaningful features from the perspective of VI young adults.

Sub-theme 1.1: Views on the purpose of the app

This sub-theme refers to the coaches' perspectives that the app had a multi-use purpose such as a tool to build users confidence in seeking information. CG6 expressed that apps are very commonly used nowadays, and it serves a "bridge" to help those that are not confident to seek information. In

accordance, CG1's perspective was that the app would be helpful because it provides quick information needed for VI users. Therefore, most of participants agreed the app presented all essential features which made it appeal as specific and easy to navigate with all information in one screen, i.e., information on event details screen, in which contains details about the sport session, such as a brief description of the sport, time, address, price, and links to open coach's information screen, to add details to calendar, to find transport, to send email and call. For example, CG6 reported that the app seemed a "one-stop shop" to know everything about a sport session, especially beneficial at a local service provision as it is perceived by the participant as a poor point of information.

"I would say really positive and like a one stop shop for everything that you need to know. Which is ideal. Because there's nothing worse than finding out, finding out about a sport, then having to go and find where the nearest activity is. Then once you found out where the nearest activity is, who's running that? You know there's not...there's not much out there, unless it is run by a big organization, but when you're talking about local things, you know, to find an actual point of contact is really difficult." (CG6)

In addition, another coach (CG4) perceived the app as an aid to overcome the barriers, i.e., find sport sessions, transport, etc., discussed in the previous chapter (Chapter 9), except the resistance of family members of VI young adults. However, this participant implied that all the information provided in the app could help VI young adults to show their family members all the necessary details to be able to attend the sport session.

"Everything is there. Absolutely everything, all the barriers that I could possibly think of, other than family, are all deal with, and hope deal with family normally is down to the individual. But here you can go to your family and say found coach, know how to get there, know when it is, there's all the details. Where's your argument? This is terrific. This is absolutely terrific." (CG4)

Moreover, participants (CG4, CG7) saw that the app could help users to broaden their views by offering a variety of sports. It could act as a prompt of ideas to consider when interested to get active.

"...you can broaden your horizons by, let's say...Well, I've never...I've never thought it going...swimming. How do you go swimming when you can't see? Oh, I'll give it a try. And the fact you've got a coach means they can tell, show you how it works, and you broaden your eyes, and you may find something new." (CG4)

"...also makes people think about ideas that they might not have actually considered before as well. 'Cause as shows all the kind of options." (CG7)

Sub-theme 1.2: Perspectives of the app

All participants expressed that they liked some of the features such as the chat feature, the sports' videos, the 'find a coach' feature, and the transport feature. Some participants perceived that some of the features were more important than others, while CG2 and CG7 said all features were important, appealed useful and its functions worked well together.

One of the most relevant features reported was the 'find an event' feature. This feature was perceived as most useful by CG3 because even though most VI people would know about the VI sports, they overlook them. Such a feature would be helpful to identify these events near the user. Another coach (CG7) expressed that the chat is unique to the app and useful as it could facilitate and speed the communication between users and coaches.

"I think that actually having the chat function is a good idea because that's quite unique to the app and also it kind of takes the pressure out of having to...just...I don't know...call someone or something. They can just ask us so quick question if they're worried about anything, and they just get and get an answer in it. It'll be a bit less, uhm, unknown." (CG7)

On the other hand, CG3 referred to some features as less important such as the activity descriptions as people would already know roughly what a sport is.

"...by the time they're thinking about something they probably already know roughly what sort of thing know, they've already looked and gone..." (CG3)

Also, CG3 expressed that the user may not need to find a specific coach if they are searching for a sport activity users might be interested to do. In this case, the 'find a coach' feature in the main bar navigation may not be necessary.

"So, if you're looking to do, I'm not sure you necessarily want to find a specific coach." (CG3)

While other participant (CG6) saw that the link to Google Maps would be only necessary when the user is near the sport venue. Alternatively, it could be substituted by basic information about the local public transport.

"To be honest, it's all...it's all really useful information, but like I said to you, I don't think there'll be as much need for you to have like a Google Maps or something on there. If I'm quite honest because the Google Maps thing will be sort of the last port of call when you are literally like 10 minutes away from the venue. Do you know what I mean? Whereas I think just a basic bit of information about the venue, where it's situated, maybe under the address with like I said, the local public transport things just actually on that page would be just as good." (CG6)

In general, some negative comments regarding to UI design elements were about missing a menu to customise the interface, for example, to magnify the screen.

"...can't see menu on it though. Ah, something to make it bigger...Yeah, 'cause that's that seems to be certainly with my visually impaired people. They tend to magnify..." (CG3)

Also, the icon of the activities tab was confusing and CG1 showed concerned towards visually impaired users if they would understand the meaning of that tab. This is because the 'activities' tab had a symbol such as a thin zig zag line which did not represented the concept of activities features. Moreover, the built-in speech was also found to be confusing by the blind participant (CG2). CG1 wondered whether the app could make someone who never played sport before to be excited to start exercise.

"And again, it might be slot, but if someone's never played it before or just...Does it excite them to do it?" (CG1)

10.4.2.2 Theme 2: Suggestions from coaches to improve the app

In this theme, the participants' insights were about additional functions to the app to aid better user experience for both coaches and VI young adults. Participants expressed ideas of extra elements in the app, such as from visual elements to customisation, whereas they also expressed ideas to improve their work and service. One participant expressed that the app could have the potential to be used everywhere from schools to sport clubs.

Sub-theme 2.1: Ideas for improving VI young adults' user experience

Participants provided insights for what could be ideal to include in the app to aid the experience of VI young adults related to seeking information, notifications, images, and interface customisation.

CG3 and CG4 expressed the same opinion regarding safeguarding users. They suggested the app could provide information about the coaches' background checks and licenses to show the coach's affiliation or inform that a specific organisation approved the coach. It could include criminal background checks, appropriate licenses and qualifications from which families and users could clear any concerns on coaches' reputation.

"I don't know whether like you could say, say this coach works with the RNIB and British blind Sport type of thing. OK, almost like there's an affiliate. So, British Blind Sport approved this coach." (CG3)

"...would expect as somebody who's very involved in safeguarding that the coaches would be licensed and qualified and have the appropriate licenses, which means involve automatically, criminal background checks and the like. So, I would expect that coaches would have the necessary

background checks and licenses. But that is something that could be clarified anyway. That's easy to clarify. But if anybody was asking me, I've got my license card and I can just produce it and my...what we call in [PLACE2], a [PLACE2] check, which is your criminal background check. I can produce those, and any legitimate coach could do that in an instant anyway, so, that I think the families would have...that would be their concern that the coach is legitimate.” (CG4)

In addition, CG3 pointed out that it would be also necessary to add the link to sport or leisure organisations' websites, in which users could have background information about the organisation. In terms of seeking information components, CG3 and CG7 suggested to include more filters in the search of sport sessions. Such filters could be by recurring or one-off session and by age group.

“And maybe being able to tell if it's like the event for it's like something happened every week. 'Cause I know you've got them featuring every week. It would be quite...So, if I was looking for like a long-term running clubs to join, then I'd want to know they meet every Tuesday at 6:30, you know or whatever, or there is like a one-off event that's at this specific time there, maybe knowing if it's like a recurring event or just the one off.” (CG3)

CG7 showed concerns about the young adults that may be interested to know the age group of the sport sessions; thus, it would be ideal to provide a filter to help users to identify sessions that are targeted to them.

“Sometimes people are a bit concerned about whether there's gonna be people like them there. And...to be honest, it's actually probably more in the older age groups, but I think again, sort of with young adults, they could maybe be worried that it was like a kind of kids group, and that they'd be a bit out of place that sort of thing.” (CG7)

In addition, CG2 wondered whether users would receive notifications once coaches replied to their chat as he did not notice any mechanisms to turn on notifications, which would be necessary for users.

“So, what I would be interested to know is if, say, I sent a message in the chat to John Smith, the coach who does everything, would I get...because he might not reply straight away yeah so are there notifications, tell you maybe an hour later John Smith has replied, open the app? Or will you get notifications to say that someone has replied because there wasn't anything about turning on notifications.” (CG2)

Also, he suggested to add league tables for sports teams. He expressed it could inform where members of a certain sport are ranked, which in turn could help people to be involved into a bit of competition and help them to get more active, as they might see it as fun to play.

"...another thing I thought of...is imagine there's like lots of different football teams, VI football teams, across the country or across London, because you have like league tables, could you have like a league table of the different football teams? So, like people can see where they are and it'll get people to be more active and more part of it, for example, gives people a little bit of competition...So, a league table is like...on Saturday we had a mixture of like teams playing each other from across London...uh London Rangers beat London Southwark by two goals to one. They are now top of the table, something like that, just to get people involved...That might make people feel like, 'oh this looks fun to play for'." (CG2)

Sub-theme 2.2: Ideas for improving coaches' user experience

Generally, coaches expressed that the app would be helpful for their work by using it as a tool to reach out to participants, provide content and contact other users, both coaches and VI people. The app was perceived as a good mechanism for coaches to advertise the sport or physical activity sessions. In terms of enhancing the adverts and information about coaches and sessions, CG7 was also interested to make a short video to introduce herself and to explain what it would be expected in the session.

"Maybe just even have my own sort of little video, one minute video, just introducing myself to people, also, knew kind of what to expect when they got there and just sort of an introduction of the coach." (CG7)

In addition, she suggested the app could provide a FAQ from most common questions that users would send to coaches. From the coach's perspective, she mentioned it would be interesting to know what users want to know about and it would help coaches make clear adverts.

"I suppose it depends how popular it is, because if you are really sort of overwhelmed with messages. But then again, if you are getting overwhelmed with messages and they're all the same questions, then actually then you just need to put that into, I don't know, maybe a list of sort of FAQ into your description or something, so I think it's probably also actually a good thing to know what people want to know as well, as a coach. So, that you can just make that information really clear, like everyone's asking you the same thing, you just need to make your advert slightly clearer." (CG7)

Moreover, CG4 and CG6 expressed that they needed to know in advance the information about the registered participants into the sport session. Such information, as a booking list would include the number of attendees, what their needs and visual impairment level are. This could help coaches to prepare themselves to support their needs and requirements. This includes to know, for example, if a VI person would arrive at the venue with a guide dog, as well as to review the expectations that VI

people may have about the session. In this case, these coaches mentioned that a face-to-face conversation about the expectations is also needed before the session.

“So, you can't just rock up and expect to just take that. You know, everybody is different. To be a coach, to be a good coach, you have to understand the individual. So yeah, and then this instance, you need to understand. What your support needs are. What I need to do for you? I mean, if somebody walks up with a guide dog, what I'm gonna do with the dog? You know, if I got 10 people turn up with dogs, I could have got a chaos. So, you need to know in advance what to expect of that person and what they require. Expectations are reviewed 'cause it may well be that there's too high, you know. We're all different levels of coaching as well as ability. So maybe the line coaching is not good enough for you. It's like [PLAYER2], I coached him at the outset, but now he's moved up to professional coaching because he's coming very international standard. That's way beyond. He needs another level. Like we need to have a conversation in advance.” (CG4)

“I think to be able to chat about those things would be really good, if they could do it beforehand as well.” (CG6)

As expressed by CG4 it is difficult when the coach does not know whether people would come to the session or not, and not have discussed about their needs and expectations prior the sport session. This participant expressed concerned towards potential behaviour of users in the app, such as they would get the details of the session and turn up to the venue with the expectation that all is prepared and ready for them, while the coach would not know what the expectations and needs are.

“If I know that person is coming, and they've got the visual impairment. As a coach, I need to know what their level of sight loss is. What they expect, what they feel they need when they arrive. And how I'm going to support them? So, if it's realistically a case, I would hope, I would hope that the person using the app would make contact in advance. So, that we could discuss those issues. But there's a risk that they wouldn't. And they would just say, well, that's the time and date and that's me, I'm in and the expectation that you could turn up and everything to be there ready and waiting for them. But practically, that wouldn't work with, you know, especially if you need somebody to support you or guide you or whatever. If you've got a group or multiple groups. It's really hard. You need to know people are coming and you need to have that conversation in advance. So, from the coaches' point of view, I'd like to know that somebody's expressed an interest.” (CG4)

Therefore, CG4 and CG6 mentioned that it is important to have a conversation with people interested to take part in the sport before confirming their attendance.

“Yes, before we confirm your attendance, we need to have a conversation.” (CG4)

"I think to be able to chat about those things would be really good, if they could do it beforehand as well." (CG6)

As CG4 explained that people are different, and coaches need to understand everyone.

"That's what I think. Yes, yeah, as a coach that to me is vitally important. Whenever I coach new people, I take time to get to know that person. What the what the expectations are, what their existing level is. And how we support you. And as I said before, what your goal is. What do you want to get from this? Where you're going to and then agree what the journey is likely to be." (CG4)

Once coaches would have a booking list, they suggested that would be in some cases necessary to add a note to inform registered users about the changes in the session, for example, in the venue location, time, cancelled session and any other immediate information.

"It would be just a really good place to advertise and, especially, if more and more people use it...And you can also if there was a way that if you were the coach, you could just go in and update it straight away. So, for example, if your venue changed or something, if there was a way where you could then just say, put a note 'this week it's not on at this location' or 'this week, the times changed' and just in case there is any sort of emergency that means something needs to be sort of cancelled or changed." (CG7)

Furthermore, coaches expressed that they would like to contact other coaches and VI young adults as well. The reason for contacting other coaches through the app would be the opportunity to share knowledge about how to improve the sessions and son on, as expressed by CG6 there is little guidance available for coaches in their field.

"I think it'd be really good if you could contact other coaches. Is that going to be a feature or not? Because, for example, they could share...You know ideas and you know if there's two coaches in a local area, or they're both trying to achieve the same thing. I know again from experience, it's really good to be able to talk to others, because at the moment there's not a massive amount out there for coaches to access to make them better at whatever they're trying to achieve. So, it'll be really interesting if, you know, I could get in touch with a coach from Metro Blind Sport and say, oh I'm thinking about putting on a recreational competition, how would you recommend? You know, just like a bit of a function like that maybe." (CG6)

Another coach (CG2) wondered if the app could provide more knowledge about visual impairment and the experiences of VI people, as well as information about coaching qualification and training courses in inclusive physical activity and sport.

"...could you maybe put links into different like, if people wanted to different stories of different experiences of different visual impairments from the young people, different videos about eye conditions? Could you put like different links to different courses or qualifications in which that coach could learn a bit more about sight loss? Could you go with some of the local sight lost charities and get them involved with like training courses and that kind of thing, potentially?" (CG2)

Similarly, it would be useful for coaches to contact VI young adults. Another coach (CG3) wondered if they could contact a VI user that viewed their profile, since the user had provided consent to be contacted. CG3 expressed that it would be a way to contact that VI user who seemed interested in the coach's profile and the coach could persuade them by promoting activities and events that people might be interested of.

"So, if they've looked at my coach profile, then they're potentially interested in what I'm up to, so if I could then proactively like, obviously, with their consent, etc., if I could then push things their way, that might be interesting to them. That would be...maybe an easy way to...uhm...promote stuff. As well as like listing events and things, if I can specifically promote things, people that have shown an interest, then that would be useful, I think." (CG3)

Sub-theme 2.3: Comfortable and trust feeling built via users' profile

In this sub-theme, coaches mentioned about the opportunity to access the users' profile as useful aspect to be added in the app. They mentioned that it would be beneficial for both coaches and VI young adults.

From CG6's viewpoint, the most important aspect of the app would be for users to view other user profiles. He suggested that the app could allow coaches to provide information about their experience in VI sport or physical activity, then it might help some VI users to feel more comfortable once to know more about the coaches, for example, where they worked before and so on.

"I think it would be really good, if the coach could put their experience, you know, with visually impaired sports or what experience they've got. 'Cause again that would make somebody feel a bit more comfortable as well." (CG6)

On the other hand, CG6 also mentioned that by having access to the user profiles of VI young adults would help to disclose the information they needed to know about users. According to the coaches' view, it would be helpful for both coaches and VI young adults. Firstly, he expressed that coaches would appreciate to know the visual impairment level, physical activity level and other aspects which could be answered by the VI young adult and available in their profile.

“You know, but it is trying to engage them and get them to go or something. I think this would be a great example of, you know, disclosing things like the level of sight, if they have played a sport, whatever questions you want them to be able to answer in their profile...I think just having as many sort of things to talk about in your...when you are creating your own profile, you know, it's a good thing. Like you said that they have to answer them, or you can eradicate those questions on a 1 to one face to face basis the better really. Or at least it prepares them for what the discussion might be when they attend.” (CG6)

Such knowledge could enhance the first face-to-face conversation between coaches and VI young adults. He explained that coaches could be able to elaborate questions based on their user profile's answers. As a result, he expressed that it could take the pressure off for the face-to-face meeting for both users.

“I think it would just take that pressure off for, you know, for the initial sort of face-to-face encounter they are going to have together. I think to be able to chat about those things would be really good, if they could do it beforehand as well.” (CG6)

It would avoid asking difficult questions, as he emphasised the importance of having a conversation before the first physical activity or sport session.

“It also creates a discussion point, you know, for when they do meet them face to face. So, instead of a coach asking what might seem as a lot of awkward questions, I would already know the answers to those questions. But I could just then, obviously, elaborate on them, if you like, you know, rather than striking that conversation up first. I think it is a bit of a really weird comparison, but it is a bit like kind of the online dating era, is not it? You get all that initial stuff out the way, yeah, yeah. And then you can just elaborate on that on those topics. When you finally meet face to face, if that ever happens. Yeah, I think it's a great idea, especially like you say for that age group. Everything is doing on an app these days, is not it?” (CG6)

10.4.2.3 Theme 3: Suggested improvements to the existing features of the app

This theme refers to the coaches' suggestions to improve the existing features in the app for VI young adults. They perceived that some aspects of the app needed more specific and personalised information to aid VI young adults when seeking information of sports, transport, and coaches.

Sub-theme 4.1: Searching by categories and preferences

By searching for specific activities, coaches said that it would be better to add the level of ability associated to the sport or physical activity sessions provided in the app. In addition, CG2 pointed out that it would be relevant to search the sessions based on what the aims of the user are. These

mentioned aims referred to whether starting to get active or trying to find a new sport, rather than showing all sessions about a chosen sport resulted from the search feature. Other types of activities such as running, and athletics were suggested as well as to be included in the app.

To improve the search, CG2 suggested to add a query about the level of physical activity or sport, such as beginner, intermediate or all levels. In this case, users would be able to refine the search to their aims based on their level and interests.

“So, there is going to be people that are: Ok, I play football at this level. I want to find all of the football stuff it is near me and then you can have people that I want to get more active, but I do not really know what to do and I do not really know what all the sports are. So, maybe then suggest me some outdoor stuff, so I could go and try.” (CG3)

In the case of looking for a new sport, CG3 wondered if users would search for activities based on preferences, as they would need to be given a way to filter the options. For example, the filters would be by categorisation such as individual or team sports, outdoors or indoors, light activities to meet others or more towards intense activities.

“I wonder whether, uh, so if I were looking for a new sport. Then maybe what I want to do is to say, OK, I am interested in like a team-based thing or an individual, or I am interested in outdoor versus indoor. They maybe have something so they can like drill down on. So, you can find what activity like it points them in the direction of activities, maybe? I think like the way the activity works is fine. But whether there is a sort of way of. Make it more about so these activities are about meeting people or these activities are about endurance maybe as opposed to. 'Cause I would have thought that the people that are going to do. Uh, you know people are going to be running. I'm going to be very different to the people that are going to do archery, for example. They're having some sort of. Categorization maybe?” (CG3)

On the other hand, CG3 also mentioned that by giving suggestions of other types of sports or physical activities it may help users to start to think about activities they have never thought about. Another way to help users in getting into new a sport or physical activity is to provide, for example, a list of events by coaches. According to CG3, although people stick on a certain activity and like the coach, they tend to try the other activities run by that same coach. Therefore, CG3 suggested to include the upcoming activities that each coach run to foster this interest.

“From a coach perspective, so they've already found me and I'm running...doing running sessions, for example, and then if they can come and look at what else I'm doing, people tend to say once they found a sport they like, they stick with it. But also, when they find a coach they like, they like to see what else that coach offers and go and try some stuff out. So, like I get people that are doing running

that will come and do Pilates, for example. Just this, just to see what it is 'cause they think, you know, I'm OK. So, I wonder whether there could be more links between what that coach is offering.” (CG3)

Sub-theme 4.2: Closest activities and transport options

In this sub-theme, the importance of showing local and nearest sport or physical activities sessions is highlighted by participants. CG6 mentioned that the upcoming events’ screen could be improved by showing activities locally, based on users’ location. As CG6 commented that generally people want to identify sport or physical activity sessions near to them, especially newcomers. Whereas physically active people tend to attend sessions either close or far from them.

“I think maybe if you...with regards to the home screen with the upcoming events, I think if that could be linked to location that would be really handy. Just because you're more likely to attend an event that's closer to you than you are...that's to do with your like...your interests are important as well, but if you're brand new to something, I would go somewhere closer rather than something that you know. If I used to play football before and the nearest football session was 60 miles away, but there's a...there's a local tennis that's only 20 and I was new to sport and physical activity. I'd go for the tennis.” (CG6)

This is because CG6 perceived the importance of providing information of closest sport or physical activity sessions to the user due to the barriers around transport. However, CG6 explained that it also depends on the stage of engagement with the physical activity or sport. Therefore, the suggestion was to improve the search for sessions by user location and distance.

“...with regards to the barriers that people face with regards to transport and everything like that. I would say 90% of people would go for the closest one...Just from a personal experience with people, but definitely the distance is a massive factor. I think it depends where you are in the stage of being physically active and already know the experience. If you are brand new, yeah, I would say location. But for somebody, for example, taken from a tennis point of view, once somebody gets involved in tennis, they will literally travel anywhere to do it. I mean we bloody travel miles, it's ridiculous. But once you so, I think it depends on where you are in your journey if you like.” (CG6)

Regarding transport, two participants mentioned that it would be ideal to add the nearest train station or the nearest bus stop.

“...for from a personal point of view, I think it would be really good. Hum...if on that information page with the address and everything, if it just had a...hum...like the nearest train station or the nearest bus stop, somebody would actually just use their own app to then find that from where they got to. If, you know, what I mean, so you might not necessarily need to add Google Maps into that, just some of the

really important information for the nearest public transport and then judging from the people are known, once they got to at the bus stop or the train station or whatever, they would then just use whatever app they had installed to find it from there. But the public transport information would be really cool to have on there, you know, just two lines like nearest, you know, nearest train station or nearest bus stop or whatever. That would be really handy to have on.” (CG6)

As well as let the user know that someone from the venue would be able to meet them at the destination and take them to the venue, this would help those for the first time to attend a session.

“...and just things like...just making someone available to go meet them at the bus stop if it's their first time or something and then just walk with them to the venue, if they're not sure and just making that option available”. (CG7)

Therefore, this information could be a requirement for organisers when adding details of the activities in the app.

“Almost just trying to make the actual organizers just advertise things as well, and maybe putting that as a requirement for anyone who wants to advertise is just what are the nearest bus stops. Any sort of near nearby landmark features where people are kind of...they know of those and could maybe kind of get themselves to that place and then someone meet them there or something like that.” (CG7)

10.5 Discussion

In this chapter, participants who are coaches of VI sports or physical activities had the opportunity to share their opinions about the high-fidelity app aimed to help VI young adults to find support and information about sports. Their feedback and contributions enhanced the understanding of the potential needs of VI young adults around the service provided from organisations and coaches, as well as the needs of coaches as information and service provider.

This is the first study to report the coaches' opinions about a high-fidelity prototype app for VI young adults to take part in physical activity and sport. Coaches' feedback was based on their experience in the sport services and working with VI people. Moreover, this is also the first study to provide evidence to improve coaches work or volunteering, as well as it highlights the need of more offer of training courses in inclusive sport and physical activity and visual impairment.

The online demonstration and interviews resulted in many comments either positive and negative, concerns and suggestions to improve the features of the app and to add new ones. The main findings and its implications are discussed about coaches' perspectives of potential use of the app and its

impact for both coaches and VI young adults. Such discussion may inform designers and developers what the aspects are necessary to consider when designing physical activity and sport mobile applications to VI young adults and coaches.

Strengths and weaknesses about ActiveVI app

In general, participants described the app as multi-use, simple and easy to use which may aid VI young adults to find sports and support. The views were generally positive but there were some negative ones too that were considered. As such the app was reported as a place to help those users with lack of confidence to search information and potentially to broaden their views with diverse sport options, as it seems to be ignored even when they know about existing VI sport activities. However, one participant questioned whether the app would make the user excited to get active, while others saw the app could open opportunities for both VI young adults and coaches.

These opportunities referred to quick access to all essential details about a sport session available for VI young adults and chat with coaches, which may help to overcome their barriers and may be useful to help build knowledge and confidence for both user and their family members about the sport service and support, as well as the opportunity to provide personalisation of features to newcomers and physically active users. Coaches appreciated that VI young adults could be able to contact them via chat, as a unique and useful feature which would facilitate and speed communication and take the pressure out to call the sport organiser for more information or booking.

Improvements to sport and physical activity service

Participants also exposed their needs to provide better service and improvements by the addition of features to make the app more useful for both VI young adults and coaches. They viewed a potential range of services they could be able to use in the app, such as to improve advertising, make coaches' profile and introduction video, obtain booking lists and details about attendees, communicate with other coaches and VI young adults.

By promoting sport sessions, their views were to include opportunities to provide more information and introduction video about the coaches, which may potentially help users to gain confidence and trust the coaches they would be in contact with. Similarly, the use of images of coaches and venues would make VI young adults, especially those new to sport or physical activity, feel more welcome as they would know in advance how the environment and members of the sport venue look like. Also, it would be necessary to provide more specific details about the sessions to show more personalised results, such as sessions filtered by age group, indoor or outdoor, recurring, or one-off, and user location, as users tend to search for local and near venues to them.

In terms of potential benefits to coaches' work, the most relevant benefit would be able to prepare themselves by obtaining a list of booking and to know about the physical activity and visual impairment levels, needs, and expectations of VI young adults. Such knowledge would help coaches to prepare the conversation before the session when coaches need to know more about the person. In addition, coaches would have the chance to send updates and reminders to users about the sessions, any changes, or cancelations. Although this would be useful, there is a need to provide more qualifications and training about visual impairment and inclusive sport and physical activity practices for coaches. Therefore, the app was seen as a mechanism to offer links to existing training courses and stories of VI people experiences in sport and physical activity.

Overall, the app could have potential use for all age groups of VI people, especially those interested to start to get active and the young adults living with parents. It was also noted as a tool to allow coaches to provide better service, which needs to be more personalised and centred to the needs of VI users.

10.6 Summary

The main findings of this chapter reported the positive views of participants towards the potential benefits of the app for both VI young adults and coaches. This chapter emphasised the need to build a service towards to make the support and search of activities more personal, visual, and informative. The contribution of this chapter addresses the design questions in providing the positive feedback of coaches about the app as a tool to help VI young adults to overcome the barriers of information and support in physical activity and sport. Also, it contributed to a better understanding of the needs of coaches when providing such services, as it is not well known in the literature. It also pointed out the need of more training to coaches to become more inclusive. Overall, these findings presented the participants' agreement about the app and potential suggestions for improvements which inform designers and developers about useful features to be designed for both VI young adults and coaches. The next chapter discusses the design of the accessible online survey.

Chapter 11 Accessible Online Survey design

11.1 Introduction

The last Chapter 10 reported on the feedback provided by coaches about the functionalities of the mobile app. This involved the description of the study and findings from participants' viewpoints about the application developed in the phase 3 of this PhD study. This current chapter presents the decisions and development of an accessible online survey. This survey was the first study developed, and it was conducted concurrently and independently from the other studies. The accessible online survey aimed to collect data from VI young adults about physical activity levels, demographics, and behaviour answers. This aimed to obtain a profile of the physical activity levels and preferences, barriers, and facilitators of physical activity participation among VI young adults. This chapter addresses the details of design, accessibility, content, and testing of the survey which contributes to inform future studies in this matter. The other phases of this study such as administration, distribution, data analysis and results are discussed in the next Chapter 12. The following section in the present chapter describes the survey design, development and testing and provides discussion about the results of the final version of the accessible online survey.

11.2 Method

11.2.1 Survey design

This study received ethics approval from the University of Southampton Ethics Committee, reference number 51707. This study used a survey design that aimed to obtain quantitative and qualitative data from respondents. The development of the survey comprised the selection of online software for survey distribution and collection of data responses, choice of questionnaires and types of questions and answers. The accessible online survey was developed on iSurvey and its accessible version in Word format. The iSurvey is an online survey generation and research tool maintained by the University of Southampton (<https://isurvey.soton.ac.uk/>). The survey was divided into sections to inform the topic and type of questionnaire: physical activity levels, demographics, preferences and barriers for physical activity or sport.

In iSurvey, the design of the accessible online survey aimed to provide easy and simple layout to follow from one question at a time and per screen. These questions were both closed, checkbox questions and open questions. Open (free text) questions have a qualitative approach and aimed to explore and gather information about the physical activity and sport experiences of VI young adults.

For example, by adding a free-text question and box after a list of response options, respondents can write other answers that are not in the list.

11.2.2 Survey decisions

In the survey design, the author made decisions regarding the accessibility of the survey, its content, and sections. The first decision was to provide the survey in two accessible formats: Word document and online survey via iSurvey. The aim was to offer more than one option to fill in the survey, as some VI people may prefer to use an accessible Word document instead of a website. The second decision was regarding the content of the survey, the type and format of questions and answers.

Accessibility of survey

Regarding the accessibility of the survey, the author decided to use iSurvey because it is free for members of the University of Southampton, and it is accessible, and it provides an accessibility toolbar available in all pages while participants complete a survey.

This also provided flexibility in designing the survey, as it was possible to define different sections and types of questions and answers and make one question per page. Also, it allowed creating a welcome statement to be presented in the landing page with a survey consent tick box and text to obtain the participants' consent to the study. Since the tick box could indicate the consent in participating in this study, the author did not provide the standard consent form used by the Ethics Committee to respondents to complete and sign it. The use of the tick box was useful as it would allow VI respondents to easily consent their participation by placing a tick in the box rather than downloading the consent document in Word to provide a 'x' as a signature and to the consent statements.

On the other hand, the consent document was the option for those that would prefer to complete the Word version of the survey. Then, they would need to download both Word documents to consent their participation and complete the survey to send them to the author's email address. The consent form in Word requires a signature and there is no tick box to confirm consent. Implementing two versions of the survey, participant information, and consent statement, allowed the author to prepare the all the materials of the survey study with accessibility and usability considerations for VI respondents.

Content and questionnaires

The content was decided based on the initial aim to understand what the level of physical activity was among VI young adults, and to gather data about the barriers to participate in physical activity

and sport. Since this study was planned at the beginning of this PhD research, the survey was also an opportunity to get participants interested in taking part in the next studies. Because of that, the author decided to include a question at the end of the survey to ask respondents if they were interested to take part in future studies. Then, they could reply to the authors' email address to inform their interest. The author received some emails from respondents and saved their contact details to invite them during posterior study's recruitment process.

Other decisions were to select the type of questions and identify the options of existing and validated questionnaires in physical activity levels and related to barriers to physical activity. To measure the physical activity, the International Physical Activity Questionnaire – IPAQ was chosen because it has been used in previous studies measuring level of physical activity among VI people (Saebu and Sørensen 2011; Marmeleira et al. 2013; Sadowska and Krzepota 2015). It is also a validated self-reported questionnaire (Marmeleira et al. 2013). It assesses walking, moderate-intensity, and vigorous intensity activities. The author decided to use the IPAQ short form because of its short length, seven-day recall. The calculation of continuous indicators can be reported as median minutes/week or median MET minutes/week i.e., METs are 'multiples of the resting metabolic rate'. To obtain MET-minute is necessary to multiply the MET score of an activity by the minutes done (Hagströmer et al. 2006). The author made some adaptations in the IPAQ by adding more information to the given instruction on last seven-days recall. The author added in the original instruction to fill in the questionnaire the following: 'typical seven days if you were unable to do physical activity in the last seven days'. This extra information was an attempt to clarify the questions as the original statement, 'last seven days', seemed to be a time restriction, for instance, if during that period the respondent did not have a typical week due to not being able to take part in physical activity, being injured, etc. Thus, this time frame would probably leave the respondent to provide limited or no data.

This first version was reviewed together with the authors' supervisors, and they discussed the advantages and if it was clear to understand the questionnaire. After reviewing and agreement, the IPAQ was not considered to progress in this study because it is not recommended to change validated questionnaire and the original IPAQ asks respondents to answer the questions based on the 'last seven days', which requires recall of one day and likely be into adverse circumstances in the respective week.

Therefore, after searching for other physical activity measurement questionnaire with a different reference period, such as a typical week, the author identified and selected the Global Physical Activity Questionnaire – GPAQ. The GPAQ was developed by the World Health Organisation - WHO and was another option of a validated physical activity questionnaire because this was more suitable

in terms of wording as it mentions 'typical week' of physical activity, regardless of respondent consider themselves being physically active or not.

The GPAQ is divided into four sections: activity at work, travel to and from places, recreational activities, and sedentary time. This has guidance for calculation based on categorical and continuous indicator (World Health Organization 2002). This questionnaire was developed by a combination of positive aspects of the IPAQ short and long forms, which resulted in the sections mentioned previously. However, it is longer (16 items) than the IPAQ short form (7 items). According to Wanner et al. (2017), the GPAQ use is increasing in Europe and the authors found fair-to-moderate validity for this questionnaire and obtained the sitting and leisure time well.

Also, the author added some extra questions to explore the needs and barriers of young adults with VI. This was reading the barriers, experiences in physical activity and sport, as well as demographics. Regarding the COM-B questionnaire, the author decided to apply this questionnaire as it is a tool used in the COM-B model. The COM-B model is considered helpful in predicting physical activity behaviour and it is reliable and validated (Howlett et al. 2017; Flannery et al. 2018; Ellis et al. 2019; Keyworth et al. 2020). This model was designed on health behaviour models such as Social Cognitive Theory, as well as the Theory of Planned Behaviour, Health Belief Model, Protection Motivation Theory, Self-determination Theory, Transtheoretical Model, and the Health Action Process approach. The model is at the centre of the Behaviour Change Wheel - BCW, which is a synthesis of 19 behaviour change frameworks. This is used to guide the design of interventions and policies (Michie et al. 2011) .

Moreover, demographics questions and other questions related to experience and preferences of physical activity and sport also were considered to complement the survey. The author decided to divide the sections of the survey, in which the demographics and, experience and preferences questions were placed at the end of the survey. Only the question about age, in the demographic questions, was moved to the beginning to start the survey, this intended to remind respondents about the age inclusion criteria to take part in this study.

11.2.3 Survey development

In iSurvey, the author presented one question per page, as it would make easier navigation for VI respondents, and it would help respondents to keep focus on one question at a time. On the other hand, the Word document had a sequential structure of questions. The accessible online survey in iSurvey and the Word document (Appendix K) were divided into sections, including the age, COVID-19 impact in physical activity and feedback questions with its section titles.

The iSurvey provides the landing page in which the surveyors can add the welcome statement. However, it was added in the Word document version of the survey. This was to avoid lots of text in the Word version, as it could be provided in the email or other document. This is because the Word document would be sent to respondents along with the participant information sheet, consent form and more details via email. The entire survey in Word document was made available in case some respondents needed to fill the survey in an accessible Word document format instead of using the online survey.

In iSurvey, the first question was about age of respondents. As mentioned before, it aimed to remind respondents about the age range of the study, where the question asked the respondent their age and informed if they were under 18 years old or above 30 years old, then the respondent was not eligible and could close the web browser. If the respondent's age was within the inclusion criteria, they needed to answer by selecting their age in a list of radio buttons (18 to 30). Hence, the author relied on respondents self-reporting their age to consider the respondent in the study. The other inclusion criteria were the type of visual impairment (blind or partially sighted) of respondents. However, this question was kept at the end along with other related questions about visual impairment, e.g., cause of impairment (congenital or acquired), and other personal information, such as income, education, etc., because the priority was to start the online survey with the physical activity questionnaire as it would require more attention and focus when starting the survey.

In the welcome statement, the author initially added the participant information sheet, and after reviewing (more details in the next section) the welcome statement changed its content. Thus, the author not only provided an overview of the study, estimated duration, but also included hyperlinks for accessible Word documents and author's email address. These documents were the participant information sheet and the entire survey. The author added the hyperlinks for the accessible Word documents and edited its labels (i.e., display text) of both hyperlinks to make them easy to understand what they were linked to, e.g., the participant information sheet and entire survey documents had its display text as 'Word document' of the participant information sheet and 'Microsoft Word Version' of the survey. In addition, the author provided her email address as a hyperlink to allow respondents to directly contact her via email. Moreover, iSurvey provides a survey start confirmation text and tick box for respondents to consent their participation in the study. This was ideal to facilitate the consent given by respondents, especially for VI people.

Regarding the GPAQ and COM-B questionnaires, both questionnaires were maintained integral in the survey due to validity. The author only made small adaptation in the COM-B-Qv1, as necessary and recommended by the COM-B model, to provide specific examples related to physical activity. This

was done by replacing the text in the original examples to the specific one, such as, 'Example: have a better understanding of the benefits of [physical activity and sport]'.

In the Word document, the survey was built with headings from top-level heading 1 to heading level 5, font Calibri with size of body text minimum 13 and titles size up to 18. This was an accessible version of the online survey, without the welcome statement, it also had the ERGO reference number of the study. The questions followed the same sequence of the online survey and divided with titles as topics to inform what the questions were about. The author added check boxes to all single or multiple answers selection.

In the GPAQ Word document, the author left enough space for inputting text and number for questions about number of days, hours, and minutes. Hours and minutes were placed each one-by-one line sequentially. Moreover, in the GPAQ there are some questions that redirect the respondent to answer other question, depending on the response given.

During the COVID-19 pandemic, the author made some amendments in both versions of the survey. A question was added to ask respondents how the pandemic impacted their physical activity (e.g., 'How has your physical activity changed during the COVID-19 pandemic?'). This was necessary to explore the barriers in participating in physical activity during that period, as the survey collected data both before and during the pandemic. In addition, the author asked respondents to answer the main questions according to their experience pre-pandemic (e.g., 'Now please answer the following questions based on your experiences before the COVID-19 pandemic'). This request was placed at the beginning of both the online survey and Word survey version before the GPAQ and before the questions 40, 41 and 47.

11.2.4 Survey testing

Throughout the development of the accessible online and Word survey, an accessibility expert checked for accessibility and usability. In the initial version of the survey in iSurvey, the author included the text from the participant information sheet in the landing page (welcome statement) and more information. However, it was not recommended by the accessibility expert as it would be too much text for partially sighted to read and blind people to listen to while using a screen reader. Therefore, it was agreed to reduce the amount of text in the welcome statement by replacing the text from the participant information sheet to a hyperlink to redirect the respondent to another webpage to read or listen the content of the participant information sheet.

The reviewed welcome statement page had essential information, such as an overview of the study with hyperlinks to accessible documents (i.e., participant information sheet, Word version of the

survey) and author's university email address, and the start consent tick box. Also, it was observed that the author's email address was the long version of her university email address (e.g., G.De-Almeida-Fontinele-Zadra@soton.ac.uk), which would not be ideal for quick listening using a screen reader.

Another initial issue for screen reader users was the questions that needed to be skipped in the GPAQ. The author added the questions with the instructions to go to another question when required, e.g., 'If no, go to question x' in the iSurvey and Word survey version, as it is instructed in the validated questionnaire. After revision and meeting with an accessibility expert, it was agreed that it would be difficult for VI people to follow the instruction and read or listen through a lot of text in the questionnaire to find the respective question to answer.

This would require extra effort from VI respondents to memorise and work out what question was necessary to respond. In this case, the best solution was to reduce the amount of text to read or listen through by jumping straight to the required question to be answered. Therefore, the author went to iSurvey to find out a mechanism to do it, then identified the 'quick logic' for a given answer option to redirect the respondent to another question in a new page. This reduced the amount of text and memory load of the VI respondent.

In the Word version of the survey, the author added a hyperlink to these jumping questions. This was done by adding a hyperlink with a simple and short label (e.g., Question 4) at the end of the instruction, e.g., 'if no, go to Question 4'. This document also provided hyperlink to the author's email address.

The latest version of both accessible survey on iSurvey and Word format were checked by four people. The survey was sent by email to existing contacts at the University of Southampton and other organisations, among them were one accessibility expert, one PhD student in Digital Accessibility and two VI people.

They tested the survey in iSurvey on Google Chrome using NVDA screen reader and agreed that the survey was accessible, as well as clear and accessible for a partially sighted who tested it. One of testers informed that there were a few bugs on iSurvey that the users could not control, which might be a bit disorientating at the beginning, as the tester noticed that by pressing the enter button the survey sometimes went to a back page, once the tester realised this and went to the page where he was, the iSurvey kept all the answers. In his view, more experienced screen reader users could quickly tab back through to where they were.

The testers checked the accessible Word version of the survey and the participant information sheet on Google Chrome using NVDA as well. The Word document of the survey worked well with NVDA;

One suggestion was to increase the font size to above 12 to make the Word document a bit more readable for those with visual impairment. Also, it was noticed that there were gaps before the 'e.g.' in some questions of the COM-B-Qv1.

In addition, while the participant information sheet in the google document could not be altered on Google Drive, the suggestion was to provide it as a downloadable word document because the google document was partially accessible, as the body text was read aloud as 'blank'. On the other hand, the downloadable Word document of the survey was editable when using NVDA.

By checking for accessibility of the survey in iSurvey by using VoiceOver on iPhone, the accessibility expert reported that the iPhone seemed to be able to cope with the survey well. However, VI respondents would need to accurately select the tiny radio buttons, even when these buttons were read out very clearly and hear when they are checked. Also, these buttons were often very close to the back button or another button which meant very careful tapping. Another positive observation was that VoiceOver read out everything that had not been submitted and the error message if the user missed ticking an option radio button ('yes' or 'no') or fill in a box (hours or minutes).

After reviewing the feedback from the survey testing, the author made the necessary amendments in both versions of the survey, in iSurvey and Word mentioned previously.

11.3 Discussion

The development of both accessible online survey in iSurvey and Word document demanded lots of considerations in accessibility and usability. This was a learning process throughout development as in the literature, there is little information about designing an accessible online questionnaire for VI people. Therefore, the considerations included to make the survey easy to complete, by facilitating navigation using hyperlinks and quick logic functions and improving comprehension of the survey by VI young adults.

Other considerations included the content of the survey in terms of selecting validated and appropriate questionnaires. One was physical activity measurement level, in which GPAQ were identified as more suitable due to the use of 'typical week' context in the questionnaire and instead of the IPAQ, as it requires information based on 'last seven days'. Even though the IPAQ short form is one of the most popular physical activity questionnaires used internationally and it has been largely used in studies measuring physical activity of VI people (Haegele et al. 2018), the last seven days' recall is a short period, and it could be an atypical week for the respondent due to illness or other circumstances. Marmeleira et al. (2013) argued that IPAQ short form is not an accurate tool because it may lead to high physical activity levels.

While the COM-B-Qv1 was applied to identify and understand the factors that influence VI young adults to participate in physical activity and sport, this questionnaire was simple and easy to apply in both versions of the survey by using check boxes. Although during the survey testing, the check boxes were perceived as tiny while using the iSurvey on small screen of mobile phone, which would require the partially sighted respondent to adjust the size.

The last questions about demographics, experiences and preferences on physical activity and sport were simple to implement with radio buttons and check boxes. Although these questions aimed to obtain an overview of the characteristics of the sample, they were left to the end of the questionnaire due to the priority given to start the survey with the validated questionnaires. This priority was based on the increased focus that respondent may give to the initial part of questionnaires.

Therefore, the development of both versions of the accessible survey can inform surveyors about the accessibility and usability considerations, and contents to be added in the survey plan. This highlighted the need to select validated and suitable questionnaires related to the context of physical activity experiences. Moreover, the development process reinforced the importance of building and checking for accessibility iteratively and to provide different accessible versions of the same questionnaire. Thus, it can allow both versions be available to VI respondents, whoever needs the version that suits their needs and skills.

11.4 Summary

In this chapter, the development process and testing of the accessible online survey was presented to inform researchers, designers, and surveyors. The considerations to design the accessible online survey are emphasised for both versions, on iSurvey website and Word, as well as the participant information sheet.

Regarding the content of the survey, it involved critical evaluation and selection of validated questionnaires, GPAQ and COM-B-Qv1, alongside demographics and other questions regarding personal preferences and experiences in physical activity and sport.

Overall, this offered two accessible options for VI respondents to choose their preferred tool to answer the survey. The details of the sampling, analysis and results of this questionnaire study are discussed in the next chapter.

Chapter 12 Accessible online survey analysis and results

12.1 Introduction

The previous chapter, Accessible Online Survey Design and Development (Chapter 11) described how the accessible online survey was planned and developed either via iSurvey or Word document. This study aimed to obtain a profile of VI young adults to understand the experiences and barriers that impact the active lifestyle of VI young adults and feedback about the survey design and accessibility. The current chapter provides details of the methods applied to data collection and analysis and the results regarding respondents' characteristics, physical activity levels, views and preferences on physical activity and sport. The results provided the summary about the sample's characteristics which was not representative of the population but helped to combine the results with the other studies in this thesis. The following sections describe the study's plan for data collection and analysis, results, and discussion.

12.2 Method

The data collection method was an online questionnaire, while the method for data analysis was descriptive statistics. By using a questionnaire, researchers can identify the characteristics of a sample, frequency of opinions, experiences, behaviours, processes, or predictions (Rowley 2014). Allender et al. (2006) state that research studies on physical activity and sport participation often undertake quantitative research methods such as surveys, in which the study seeks to identify participants beliefs, attitudes, knowledge and level of physical activity. Hence, the author conducted an accessible online survey via iSurvey. Data collection took place between October 2019 and October 2021. In the accessible online survey, the author asked respondents to provide their feedback about the survey design, accessibility, and usability considerations. This study has ethical approval from the University of Southampton Research Ethics Committee, reference number ERGO/FEPS/51707 (Appendix L).

12.2.1 Sampling and recruitment

According to Flick (2014), researchers can plan a sample either at the start of the project or through a step-by-step process integrated in the data collection and analysis process. The author decided to follow a step-by-step process and the seven steps to plan a sample survey suggested by (Baker and Foy 2008): determine the aims and objectives of the survey, determine the population, recognise the sampling frame unit which is a list of elements (e.g., individuals) of the probability sampling,

procedure may include adaptive sampling designs for surveys of rare or clustered populations, determine the sample size, choosing sample units, and data collection. However, the sampling frame and elementary sampling unit were not part of this study because there was no sampling frame to select the sample from by the time of this study. This is because there was no accurate source for the number and registration of VI people.

Thus, the author was not able to run a random sampling method due to lack of a sampling frame (e.g., list of individuals) to calculate appropriate sample statistics and standard errors, from which a researcher must use a probability-based sampling methodology (Cowles and Nelson 2015). Random sampling is a method to identify randomly the research participants who meet the inclusion criteria from a population (Emerson 2015). Subsequently, the author was not able to elaborate conclusions about the entire population based on the findings from the sample of this study.

Therefore, the author chose a convenience sampling approach, as this is a nonprobability sampling used for 'doing what is fast and convenient' (Patton 2002) with 'a group of individuals that is ready and available', and can be suitable to hard-to-reach populations (Fink 2003b) due to the difficulty to identify and locate people, such as those with a particular impairment, homeless, drug addicts, etc. (Gray 2018). By conventionally selecting the elements of the population, not by judgment or probability strategies, the sample is not representative (Tull and Albaum 1973).

Tourangeau (2014) argued that it is difficult to identify members of a population that represents less than 1 percent of the general population. This was the case for VI young adults in the UK. The author contacted via email the Royal National Institute of Blind People - RNIB and obtained an estimation of 28,800 VI people between 18 to 30 years old in 2021 (ONS 2018-based population projections). This was 0.3 percent of the total population (almost 1 million) for that age group in the UK.

In this case, it was not necessary to calculate confidence intervals, margin of errors and the sample size, as the convenience sampling method can be a limitation for a researcher to generalise the findings to the whole population (Cowles and Nelson 2015). Instead, the sampling decision was based on the inclusion criteria of VI young adults from 18 to 30 years old in the UK. The author aimed to achieve between 53 to 70 respondents in the online survey as similar studies achieved a sample size between 53 to 67 participants to investigate the physical activity levels of adolescents and adults with visual impairment (Marmeleira et al. 2013; Kamelska and Mazurek 2015; Soares et al. 2019).

Participant recruitment was done online. The author created an invitation email to contact third-party organisations, known as gatekeepers, and administrators of social media groups (Gray 2018). By searching on Google and Facebook, the author identified and contacted 88 VI organisations, such as charities, companies, colleges, and universities via email, social media, and some phone calls.

When contacting the selected organisations via email, the author explained the objectives of the study, sent ethics approval documents and the participant information sheet for more information. Also, the author requested support from the organisations to share the study advert in their newsletters and social media.

As the number of respondents were initially low, the author attempted many options to advertise this study. For example, the author asked some well-known bloggers and social media influencers in the VI community to share the study advert. This was suggested by some members of organisations to help promote the online survey. However, few of them replied and agreed to share the study among their followers. The author also shared the study advert via her own Twitter page and on social media groups for VI people upon administrators' approval. The recruitment was volunteering as the offer of incentives may lead to bias from respondents answering the survey (Hsieh and Kocielnik 2016).

12.2.2 Procedure: Questionnaire Administration

In the email invitation, the author included a hyperlink to the questionnaire available on iSurvey. The author initially selected 21 organisations from the South East of England to start testing the recruitment materials, if recipients replied asking for more clarification and details of the study. The responses from organisations' emails with questions for clarifications or requests of a study advert prompted the author to modify the recruitment material, such as shortening the study advert and hyperlink and making the invitation email to organisations clearer and shorter. This initial step helped to identify improvements in the recruitment process, which was a learning process throughout this study.

Moreover, the author planned to send a reminder to organisations to reshare the study advert after ten days of the first post on social media. Several organisations agreed with this. The author checked the study advert on some posts to see if the hyperlink was working fine. There was one occasion where it was not working, and the author contacted the organisation and asked to share the study advert again. One of the contacted organisations was the Royal National Institute of Blind People - RNIB, which shared the study advert several times. The author requested it as the RNIB had a specific online group for VI people, called RNIB Connect Voices, where there were updated news and advertisement of research studies.

12.2.3 Data analysis

The author followed the data management recommendations by (Fink 2003a), that emphasised the importance of organising the data prior to the analysis. These recommendations comprise the

analysis plan, codebook, establishing reliable coding, reviewing surveys for incomplete or missing data, entering data, and validating the accuracy of the entry and cleaning the data. The analysis plan had the aim to answer the questions of the design requirements. This had the objective to obtain descriptive data of respondents by mean and percentages.

Firstly, the author downloaded the raw data from three questionnaires of the accessible online survey from iSurvey. Then, the data set was imported to Microsoft Excel and the author split it by questionnaire in three spreadsheets: 1. Global Physical Activity Questionnaire; 2. COM-B-Qv1 questionnaire; 3. Experiences and personal information. The author checked the respective responses and columns of each spreadsheet.

The author reviewed each questionnaire separately in their respective spreadsheets. The author conducted the same reviewing process for each one, by reviewing the responses and checking where there were incomplete or missing data. The author only changed the columns' name and deleted some neutral columns (e.g., section number) of the questionnaires. This data preparation was later completed in IBM SPSS in which the author devised the codebook and set the variables. After this process, the author conducted the descriptive analysis.

These variables are divided into categorical (qualitative) and scale (quantitative) in IBM SPSS. The categorical variables can be nominal or ordinal, where the former refers to unranked categories (e.g., marital status, eye colour), while the latter are ranked categories (e.g., satisfaction level, physical activity level). The scale variables are not grouped (e.g., height, weight, time, and income). Therefore, the author set the variables (e.g., yes, no) and levels of measurement (nominal, ordinal, scale).

Prior to the data analysis, the author decided to start reviewing the responses of the Global Physical Activity Questionnaire – GPAQ and subsequently the other questionnaires. This way the author applied descriptive statistics to all questionnaires and answers to open questions were added to posterior analysis of triangulation.

12.2.4 Data analysis of Global Physical Activity Questionnaire

According to the GPAQ Analysis Guide (World Health Organization 2002), there are two different approaches to describe the data, continuous and categorical indicators. The author decided to conduct the continuous indicator, which was a similar approach used in previous studies on physical activity measurement levels (Marmeleira et al. 2013; Haegele et al. 2018). This indicator helps to obtain an estimation of the survey sample's mean physical activity. To obtain this, a researcher needs to use the Metabolic Equivalents – MET. The MET are values applied to the time variables of activity levels (e.g., moderate or vigorous) to calculate total physical activity. For work, transport and

recreation domains these values are as follows: moderate MET value =4.0, vigorous MET value = 8.0, cycling and walking MET value = 4.0.

The author followed the GPAQ Analysis guide (World Health Organization 2002) recommended by the WHO for analysing the GPAQ. The author identified two versions of the GPAQ Analysis Guide, one of them recommended to download the WHO programs developed for cleaning and analysing the data in Epi Info software. However, the data did not run in this software. The other version referred to manual analysis, which was the alternative to clean the data using the recommendations from this version of the guide for cleaning and analysing the data using other software.

In Microsoft Excel, the author identified incomplete questionnaires and missing data, prepared the data, and calculated new variables before importing the data set for analysis in IBM SPSS. The author applied three calculations from the GPAQ Analysis Guide: a) total physical activity MET-minutes/week; b) sum of all activity per week; c) mean of sedentary activity in minutes per day. The author was only interested in calculating these measures, and not interested in other calculations of mean number of activities per day described in the GPAQ Analysis Guide. The author calculated the equations of a), b) and c) in Microsoft Excel and created new variables by following the GPAQ Analysis Guide.

According to GPAQ Analysis Guide (World Health Organization 2002), to include respondents in the GPAQ data analysis, they had to have a valid response for at least one domain and have no invalid responses for any domains. This approach was used to identify incomplete and missed data in the GPAQ. For example, 11 respondents only answered the first question about age. Thus, the author removed these respondents from all data analysis.

The data set presented some outliers, the format type of some answers was incorrect. For example, respondents answered in a text format the days or time instead of numbers. There were some cases, where the author could consider the answer based on other answers of the respondent. The solution to this incorrect format was to convert the data that were given in a text format or fractions into acceptable numbers. The following Table 12.1 gives examples of answers the author had to convert into numbers.

Table 12.1 Some examples of respondent' answers

Question	Given answer	Converted (calculating the average)
P2	5 to 6 days	$5 + 6 = 11/2 = 5.5$, then converted to 5.5 days.
P3a	Between 1 and 4	$1 + 4 = 5/2 = 2.5$ hours / 2 hours and 30 minutes.

P3b	60 to 240 minutes	Participant converted hours in minutes. The author converted to 2 hours and 30 minutes.

The GPAQ was partially or entirely completed. Similar previous studies of physical activity levels applied descriptive statistics analysis (Haegele et al. 2016; Haegele et al. 2018). The author used the standard MET-min/week formula by multiplying the values of days per week, minutes per day and MET intensity, which range from 4 - moderate to 8 – vigorous (World Health Organization 2002).

12.2.5 Data analysis of COM-B and physical activity preferences questionnaires

The data analysis of the COM-B questionnaire and the other questionnaire about preferences in physical activity followed the same process. In the COM-B questionnaire, there was an open question in the motivation section, such as ‘39. Something else (please specify)’. The preferences section had other questions, such as ‘10.10b Please explain why you are using them (technologies)’, ‘10.18 Is there anything not covered in this survey, and you want to make any comment?’. All the responses were further added into the triangulation analysis (Chapter 13) for data analysis from online survey, literature review, user evaluations and interviews. The triangulation is a methodological approach applied when multiple methods or sources are used in the research (Farmer et al. 2016).

12.3 Results

12.3.1 Respondents

A total of 65 participants consented and started the survey, however only 33 completed it. After cleaning and tidying the data, 11 cases were excluded because respondents only entered the age in the GPAQ and another 3 were excluded because their data included outliers. 51 respondents remained in the data set. All responses were obtained from the accessible online survey on iSurvey; no respondent used the accessible Word document form to answer the questions.

Demographics

Thirty-five out of 51 respondents completed the demographics questionnaire. The sample had more respondents that were the oldest in the age range (18 to 30 years old), respectively, 29 years old (15.7%) and 30 years old (17.6%). There was an equal number of females and males (n=17), however one person preferred to self-describe their gender as non-binary. Most respondents were severely sight impaired and were born blind (n=20), while 14 were partially sighted and 13 acquired sight loss after birth. There were slightly more full-time students (n=10) than full-time employees (n=8).

Physical activity level

Most participants in the sample (66.7%, n=34) met the WHO recommendation of at least 600 MET-minutes of a combination of moderate-vigorous-intensity physical activity per week. Regarding the total minutes of physical activity per week, this showed that male respondents were the most physically active per week (mean = 5237.5) compared to female (n=13, 76.5%, mean = 4815.38). 43 respondents had spent on average 309.21 minutes per day being sedentary.

COM-B

Thirty-six out of 51 respondents completed the COM-B questionnaire. The most chosen response was regarding those participants wanted to do more physical activity or sport (n=25, 49%), which is related to the motivation construct. This was followed by the opportunity and capability constructs, which are the need to have more time to do physical activity (n=22, 43.1%) and the need to overcome physical limitations (n=20, 39.2%), such as get around problems of disability, respectively. This is similar to the number of respondents that informed they would have to develop a habit of doing physical activity or sport (n=19, 37.3%), to have it more easily accessible (n=18, 35.3%), to know more about how to do physical activity or sport (n=17, 33.3%), and to have more support from others (n=16, 31.4%).

Physical activity preferences

34 out of 51 respondents completed this questionnaire. Respondents reported they often took part in physical activity or sport individually (n=17, 33.3%), in a team (n=4, 7.8%) or both in a team and individual (n=10, 19.6%). The activities most often done in a non-pandemic situation was walking (n=26) and fitness (n=21).

Some respondents mentioned engagement in other activities such as sailing, judo, swimming, horse riding, exercise bike, rowing, dance, yoga, cheerleading, Wii Fit. 15 (29.4%) of respondents reported that they had gym membership and 6 had both gym and sport club membership. 20 (39.2%) respondents preferred to do activities at the gym and 17 (33.3%) preferred outdoor activities, whereas sport clubs (n = 13, 25.5%) and home (n = 12, 23.5%) were the less preferred.

Future preferences

33 out of 51 respondents completed this questionnaire. 12 (23.5%) respondents had neutral interest in doing more physical activity, 10 (19.6%) equally were interested or very interested to do more physical activity and 2 (3.9%) were not interested. Most participants would like to do more fitness (n=13, 25.5%) followed by tandem cycling (n=11, 21.6%) and cycling at the gym and blind cricket (n=3, 5.9%) and netball (n=1, 2%).

A total of 26 participants provided their feedback. Participants reported that the survey was easy to understand and complete, and the layout was accessible. For example, one participant mentioned that the survey worked fine while using the screen reader NVDA and had clear labels in all edit boxes, check boxes and radio buttons. On the other hand, some participants reported issues about accessibility and confusing questions.

Regarding accessibility issues, one participant reported that was necessary to repeatedly zoom in considerably to answer the multiple-choice questions, due to the answers being too small compared to the questions, and then had to zoom out to continue the survey. Another issue was the length of boxes which was not enough to write the additional information. Other participants reported that some of their answers were deleted, or the selected tick removed. For another participant, the same question was asked twice. Another observation was about the pale colour of question title and the partially sighted participant had to ask someone to read the title.

Confusing questions were found in the GPAQ and COM-B questionnaires. In the GPAQ, one participant did not realise they had to fill in all the boxes for hours and minutes of exercises, and this participant did not want to fill in, even though, at the end of the question there was the advice to fill in the boxes even if the answer is zero (i.e., Please fill in the hours and minutes, even if it is zero). Then, this participant suggested to add a message in the question to inform that an answer is required for hours and minutes. Another participant was unsure if this question was related to hours and minutes during the pre-pandemic or pandemic period. The COM-B questionnaire was confusing for one participant that wondered if the answers to explain the reasons to do physical activity were regarding starting a new physical activity or perceived in past experiences.

12.4 Discussion

This survey comprised three parts: demographics; Global Physical Activity Questionnaire – GPAQ; Capabilities, Opportunities, Motivations, Behaviour - COM-B self-evaluation questionnaire; as well as physical activity preferences. The results provided the summary about the sample's characteristics which is not representative of the population. However, the findings contribute to inform the challenges of reaching this population and the profile of respondents.

Some previous studies have not reported detailed results about the VI young adults, instead recruiting a wide age range (Marmeleira et al. 2013; Haegele et al. 2017a) or just children or the elderly with visual impairment (Holbrook et al. 2009). This study focused onto recruiting and identifying the characteristics of VI young adults only. As the author had no prior experience in studying this population, the accessible online survey became a challenge as the number of respondents was very low for several months. The author decided to keep the accessible online

survey live for a longer period. That is why it was available online between October 2019 to October 2021. This was an opportunity also to receive emails from some respondents that completed the online survey and informed their interest to take part in potential future studies. So, it was an opportunity to keep their email address for the author's records of potential future participants. This study presented findings that only refer to the sample due to the non-probability sampling (i.e., convenience sampling) applied in this study. Therefore, it showed a profile of respondents as equally female and male where most of them were physically active, especially male respondents. The GPAQ findings showed that most participants were physically active according to the recommendations of at least 600 MET-minutes of a combination of moderate-vigorous-intensity physical activity per week.

The COM-B questionnaire showed that the most important factor for the sample was regarding motivation, the need to feel they wanted to do more physical activity or sport. Whereas the opportunity of having more time to it may influence their participation; This lack of time seemed to be associated with the priority given to other activities. Previous studies showed that motivation is unstable for young adults as they often give priorities to study, work, and time with friends and less time for physical activity and sport (National Disability Sports 2015; Bernadette et al. 2018). Also, the capability construct evidenced their need to overcome the barriers due to disability, which also relates to their need of more easily accessible physical activity, more knowledge on how to do physical activity or sport and more support from others. This was also pointed out by (Jaarsma et al. 2014) that VI people may have difficulties coping with the disability and strategies might tackle this issue.

The COM-B findings may explain the respondents' preferences and what might influence their preferences for places to get active. Self-motivation may be important for respondents, however other factors in the opportunity and capability constructs may play a role in the respondents' preferences to physical activity at the gym and outdoor, as they engaged more in walking and fitness before the COVID-19. These activities might be perceived as more accessible than others. These results are similar to previous studies in which found walking, fitness and cycling at the gym the physical activities most often mentioned by physically active VI people (Rimmer et al. 2005; Holbrook et al. 2009; Van Landingham et al. 2012; Holbrook et al. 2013; Jaarsma et al. 2014).

12.5 Summary

This chapter presented the application of an accessible online survey, where responses from the GPAQ, COM-B questionnaires, and questions on demographics, experiences and preferences in physical activity and sport were collected from VI young adults. This described the methods used to

collect data, strategies to recruit participants and analysis of the data set. The results informed the characteristics of the sample which may contribute to confirm the findings from previous studies and may help to understand the preferences and behaviour of physical activity among VI young adults. In the next chapter, the development of design guidance draft is described which points out the use of the triangulation method and results.

Chapter 13 Development of design guidance draft

13.1 Introduction

The last chapter about the Accessible Online Survey results and analysis (Chapter 12) presented the characteristics of a sample of VI young adults. In this current chapter the most relevant findings have been integrated into the triangulation along with findings of literature, interviews, and usability evaluations. The triangulation helped to converge the data set into meaningful data to develop the draft design guidance of this study.

In this chapter, the development of the design guidance is described through the application of an affinity diagram as a method to combine the large amount of data and present the final categories for design guidance. The design guidance aimed to inform designers and software developers about the design process and accessibility and usability considerations to undertake during the design of accessible and usable mobile applications. This is both for general context and specific for inclusive physical activity services for VI young adults and coaches, as a way to enhance their experience in the related services.

Therefore, this chapter discusses the development of the draft of the design guidance and points out its potential contributions for designers and software developers' knowledge. Such knowledge regards to the necessary factors and needs of VI young adults and coaches in services for inclusive physical activity and sport. The following sections describes the choice of the method and the development process of the design guidance A, diagram, and guidance B.

Aim

This chapter aimed to show the development of the design guidance based on the triangulation method.

13.2 Method

The author created a plan to develop the design guidance based on the findings obtained from the Stages 1, 2 and 3, respectively, literature review analysis, user evaluation interview analysis, and online survey analysis. The author aimed to analyse the large amount of data from the concurrent data collection methods applied in this PhD study. Hence, the author followed the concept of triangulation proposed by Flick (2014), the 'systematic triangulation of perspectives', in which triangulation is applied to combine different perspectives to analyse the data.

Hence, the author triangulated the perspectives from two different methods (i.e., qualitative and quantitative) and perspectives from two different research populations (i.e., VI young adults and coaches). The qualitative data comprised of interviews and usability evaluations, and literature review and, quantitative data from the online survey. The triangulation required a strategy to help combine the data set and synthesise meaningful findings.

The author identified different approaches, such as the triangulation protocol by Farmer et al. (2016). Although, this is described as “the most detailed description of how to carry out triangulation”, it is also recommended to be applied with expertise (O’Cathain et al. 2014). Hence, the author identified the affinity diagram as more appropriate technique to use in this study. This is considered a powerful and simple systematic method used to group and categorise a large amount of data and is used efficiently among interaction designers (Lucero 2015). Thus, this was a way to find points of connection by comparing and contrasting the findings according to the research questions SRQ1 - How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts? and SRQ2 - Does the design guidance developed provide all accessibility requirements?

13.2.1 Affinity diagram

The author decided to make an affinity diagram to combine the data from different sources of the data collection: (a) literature review, (b) think-aloud usability evaluation and interviews and (c) online survey. The respective data were as follow: categories, the key themes, and descriptive statistics and responses. The decision to apply an affinity diagram is due to the visual aid it can offer to group the data. Firstly, the author read the data to identify the most relevant data for the research questions to enter the affinity diagram process. Subsequently, the author chose to use Miro, an online whiteboard to aid visualisation tasks, such as mapping, affinity diagram, and so on. The use of Miro was an advantage to speed the process of collating the data in virtual sticky notes in whiteboards.

In the virtual sticky notes, the author added the themes, categories, and quotes from the three data analysis (a, b and c), all relevant data that could help to inform designers and developers when designing accessible mobile app in the context of physical activity, accessibility and usability. This technique usually involves a design team to produce notes to identify user experience and usability issues in the interaction designs, and to identify new requirements to add in the designs. In this study, the digital affinity diagram was convenient and allowed the author to conduct data coding and clustering, which can also be done in a collaborative analysis. All collated data were placed in its correspondent group (a, b and c). Each group was assigned a colour for easy identification of the source and a tag to identify a specific type of information (e.g., participant’s code, acronymous,

reference, etc.). The author started to read the collated data in the sticky notes and identified those that had similar meaning and grouped them together.

Further, the author rearranged the grouped notes and created connections between them which formed new themes in the diagram. From these new themes, the author grouped and created new themes to name as guidance. For example, the themes: video workouts at home, inclusive online coaching, inaccessible online workout/fitness content became the guidance 'allow coaches to create online exercises sessions'. The author reviewed the completed affinity diagram and made some changes where necessary such as rewriting the new themes (guidance) or adding connections with arrows (Figure 13.1).

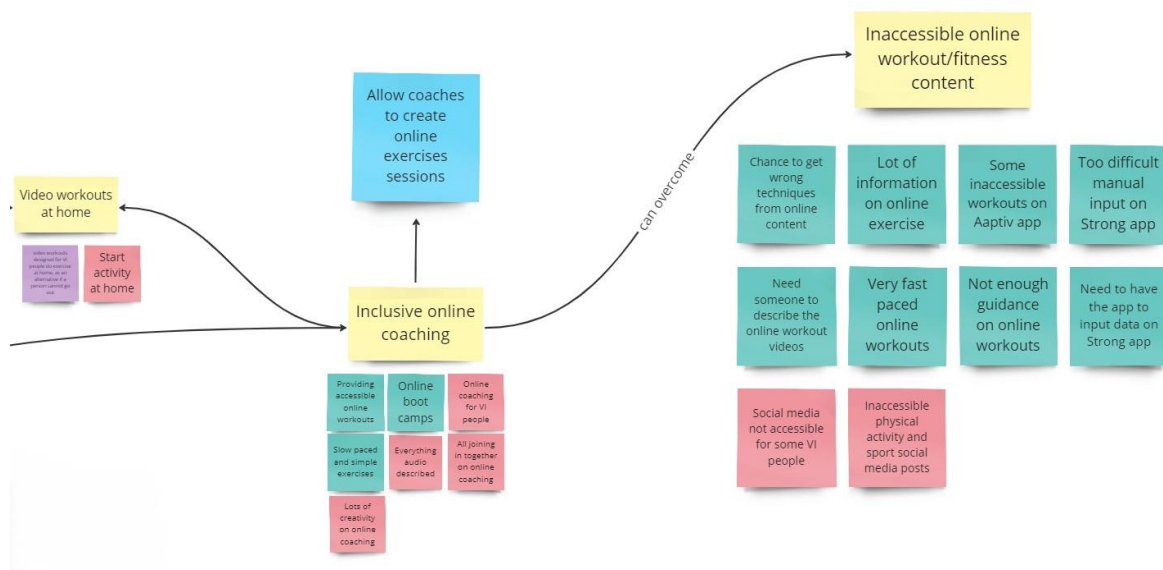


Figure 13.1 Example of a cluster and connections themes of the affinity diagram

The last step was to move the new themes (guidance) into another whiteboard to separate and group them by similarity. In this process, the author identified the themes (guidance) as general and specific to services for inclusive physical activity and sport. Thus, the author created the categories in yellow post-its for general and blue for specific guidance (Figure 13.2). These categories helped to develop two lists of design recommendations: general to mobile applications and specific for services to young adults with VI and coaches.

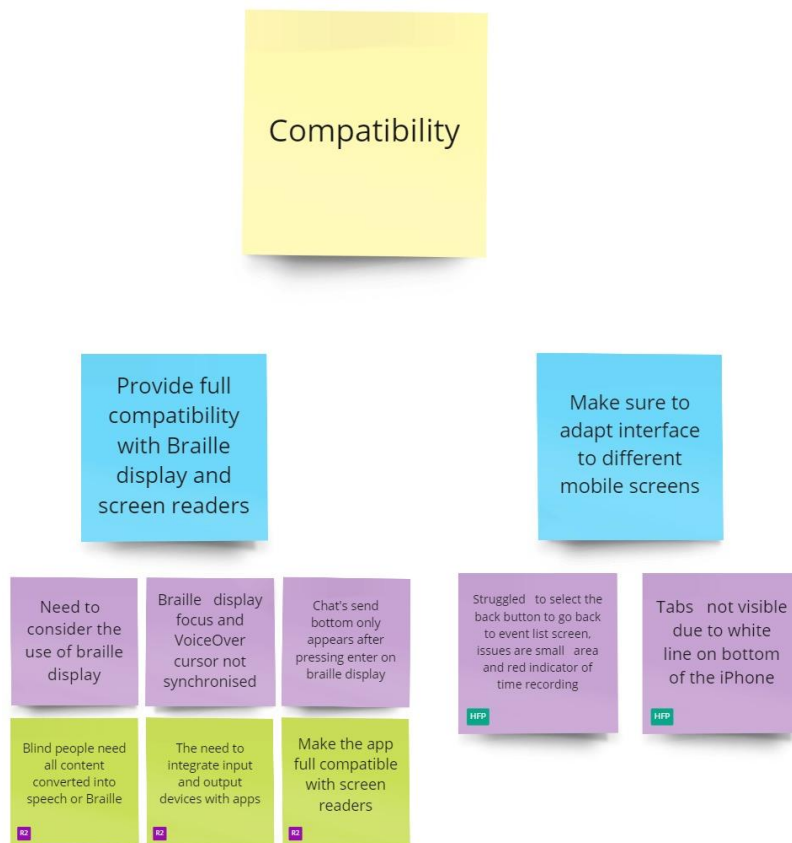


Figure 13.2 Example of a cluster of the affinity diagram.

13.3 Outcomes of design guidance development

The development of recommendations for designers and developers when building accessible and usable mobile applications for related physical activity and sport resulted in two types of guidance information. These types of guidance refer to the design process and recommendations for designing general and specific accessible and usable mobile application for physical activity and sport for VI young adults and coaches. The author divided and named the guidance as follow: guidance A (design process) (Appendix M) and guidance B (general and specific) (Appendix N). Both guidance A and B are presented in an accessible list format.

13.3.1 Development of Guidance A

The author created the guidance A for design process as it is not well-known in the literature how to conduct and include usability and accessibility into a mobile application design project for VI people (Sierra and De Togoires 2012; Correia et al. 2019; Silva et al. 2019a; Tigwell 2021). In order to aid understanding of Guidance A, the author created a diagram to demonstrate visually the design process in Microsoft Vision, where circles are steps with arrows showing the relationships between them. The diagram is accessible with alternative text to describe its content. A new version of the

diagram based on the results of the expert review (Chapter 15) had the addition of numbers to indicate the steps related to the design guidance, for this reason only the latest version of the diagram is presented in the Appendix Q.

Both guidance A and the diagram aimed to inform the steps based on the experience of the author throughout the phase 1 and phase 2 of the design process conducted in this PhD research (Chapter 1), which was based on design thinking and agile methodology. The phase 1 relates to the first iteration of the design process which starts with the user research that corresponds to the empathising and defined steps of Design Thinking and Agile method, respectively, and evolves to create initial requirements to develop an accessible mid-fidelity prototype to be tested with VI users to achieve the review of the design requirements. This phase was conducted to obtain the minimum viable product requirements and the feedback from users about the proposed concept of accessible and usable mobile application.

The phase 2 refers to the implementation phase of a mobile application, from the reviewed design requirements to the next steps that can be developed with accessibility and usability present in all stages of this phase. This means to consider coding accessible UI elements and checking for accessibility throughout development. The accessibility checking consists of using Accessibility Inspector (Apple 2015) in Xcode for iOS mobile application prior release of beta version. The Accessibility Inspector and other automated tools cannot find all accessibility flaws; thus, usability testing with the target group is always recommended to better identify the issues (Eler et al. 2018; Mateus et al. 2020). By releasing the iOS and Android as beta versions for manual checking of accessibility and usability, the checking in iOS mobile devices is exclusive done manually, whereas in Android it can be done partially with Accessibility Scanner (Android 2023b) installed in the Android device. In the checking process, software developers can register the results based on the Web Content Accessibility Guidelines Evaluation Methodology (WCAG-EM) Report Tool (Velleman and Abou-Zahra 2014).

Furthermore, the checked beta versions can progress to usability evaluation with VI users. The additional factor in the usability evaluation is to enable a built-in recorder in the mobile devices, especially in remote usability evaluations. Reviewing the design requirements can lead to another iteration or release of the product. As a result, the first version of guidance A provides a list of 14 steps of the design process.

13.3.2 Development of guidance B

The Guidance B refers to two lists of recommendations for designing accessible and usable mobile application: The general and specific list were developed from the results of the affinity diagram.

One is the general guidance that shows the 23 most relevant recommendations on accessibility and usability of mobile application that are related to existing standard accessibility guidelines that were missed or included in the implementation phase of the mobile application in this study or were not mentioned in the existing guidelines, such as the recent feature dark mode in iOS settings, dark theme in Android, and a specialist mobile phone for VI people. The author decided to include them as a guidance to consider as some of the existing accessibility guidelines are not very clear or does not provide a rationale or details on importance (Correia et al. 2019).

The author made the list accessible and added accessible hyperlinks as reference to URL of WCAG 2.1 Success Criteria, when necessary. In addition, the Appendix N of the guidance B contains examples about the recommendations and hyperlinks to facilitate the move from the recommendations to its examples and vice and versa.

On the other hand, the specific guidance B for services of inclusive physical activity and sport was divided according to the services needed for two types of users: VI young adults and coaches. In this study, the author uses the term coaches to designate those who work as coach, guide or volunteer on inclusive physical activity and sport. This guidance resulted in 35 recommendations related to services for VI young adults described in a simple list format. This guidance was wide ranging including user registration into a mobile application to searching and booking of physical activity or sport sessions, and notifications.

This may address the users' need of independence while easily signing up to an accessible mobile application, doing a quick search and booking of sessions, and less typing inputs and instead offer options to select from or voice command to eliminate the effort of typing. The guidance about services for coaches provided 16 recommendations including user registration into mobile application, making of introductory video, and promotion of sessions.

13.4 Discussion

The development of the design research of this PhD resulted in the creation of the guidance A to inform designers and software developers about the steps to consider when designing accessible and usable mobile applications for VI people. This is important because there is a lack of guidance on design steps of mobile applications involving VI people, such as systematic methods to obtain users requirements (Correia et al. 2019), adapting the prototyping stage (Metatla et al. 2015), and specific usability evaluation method or technique (Adam et al. 2020). The need to adapt the prototyping stage is relevant because the paper prototyping technique commonly used in design restricts the participation of VI people in the early stages of the design process (Metatla et al. 2015; Miao et al.

2016; Albouys-Perrois et al. 2018) as it does not allow use of screen readers which prevents the real user experience of mobile applications (Miao et al. 2016).

The design of guidance A and the diagram represented a simple and descriptive list of steps inspired by the practices of Design Thinking and Agile methods. The distinct steps presented in the guidance A are the recommendations about the development and checking for accessibility and usability in the prototyping phases.

Manual and partial automatic accessibility checking are essential to the design process and often there is a lack of knowledge among software developers about how the existing automated tools can support accessibility checking (Silva et al. 2018). In this process, it is important for designers and software developers to consider checking for accessibility as much as possible with different devices and assistive technologies. This means not excluding the use of braille display, external keyboard, magnifier, and accessibility features pre-defined in the mobile devices' settings.

In the usability evaluation it is important to consider and enable the built-in screen recorder in the user's mobile device as a support to further data analysis, especially during remote usability evaluation via an online video call with research participants.

From the affinity diagram, the author noticed that there were two types of outcomes in the guidance B: general categories of accessibility and usability of mobile applications; and specific categories for related services in physical activity and sport mobile applications for young adults with VI and coaches. These lists are Guidance B, a list of 23 general recommendations for accessible and usable mobile applications, and a specific list of 35 guidance for developing an accessible and usable mobile application regarding the physical activity and sport for VI young adults, and a list of 16 recommendations about the physical activity and sport coaches' features. The general recommendations on accessibility and usability may help to advise designers and software developers that some accessibility and usability aspects should be considered while designing and checking accessibility mobile applications.

13.5 Summary

In this chapter, the design of the design guidance A and B involved the adoption of most important recommendations and considerations of accessibility and usability throughout the design process. The next chapter presents the results of the expert evaluation of the first version of the design guidance A and diagram, and guidance B.

Chapter 14 Study 8 - Expert validation of the design guidance experimental design

14.1 Introduction

The previous chapter (Chapter 13) described the development of a proposal of design guidance for accessible and usable mobile application related to physical activity and sport services for VI young adults. The design guidance, comprised of Guidance A and B (Appendix M and Appendix N), refers to the design process and development of accessible and usable mobile application, respectively, for information about service provision and support on physical activity and sport for VI young adults.

Little is known in the literature about design recommendations about developing an accessible and usable mobile application or a digital system to aid VI people to take part in physical activity and sport (Chapter 2). In this sense, the author created a questionnaire to gather the opinions of professionals in digital accessibility, design, and software development about the understanding and potential usefulness of the Guidance A and B. It is acknowledged that ideally, this would need to also be examined while conducting a project by designers and software developers for a more experimental evaluation. However, the time constraints of a PhD did not allow this.

Therefore, this chapter presents the results of the evaluation of the design guidance by experts from the mentioned areas and presents the methods and data analysis applied to this evaluation study.

Aim

This study aimed to assess whether Guidance A and B are easy to understand and useful recommendations for designers and software developers.

14.2 Method

This expert review study applied a questionnaire (Appendix O) sent via email to participants. This study received the ethical approval from the University of Southampton Research Ethics Committee, reference number ERGO/FEPS/79406. Ideally, the evaluation would be necessary to be done by designers and software developers implementing it in a design project. However, due to limited time, it was not possible, and the author chose to conduct an expert review study to evaluate the design guidance through a questionnaire.

14.2.1 Sampling and recruitment

This study used a convenience and snowball sampling method to recruit experts. The inclusion criteria included having at least one year's experience of working in digital accessibility, user experience design or software development. Recruitment occurred for eleven days between January and February 2023. The author aimed to recruit a sample of a minimum of two professionals known by the author or suggested by other professionals. The study design is described in the ethics application (Appendix P).

14.2.2 Procedure

This study had a protocol with its research questions, aims, selection criteria, analysis method and a questionnaire structure: Demographic questions, open-ended questions, 5-point Likert scale questions. The author contacted by email the potential participants and invited them to take part in the questionnaire. In the email were the questionnaire, design guidance, participant information sheet and consent form. The author made all these materials accessible in Word format.

As a pre-test, the author asked one accessibility specialist to check the questionnaire and design guidance before sending them to participants. The feedback was satisfactory with suggested minor changes, for example, to split some questions and to make consistent question types. There were thirteen questions in the questionnaire, which included three demographic questions, seven 5-point Likert scale and three open-ended questions.

14.2.3 Expert validation

Those that agreed to take part in this study sent the signed consent form and the completed questionnaire to the author's university email address.

14.2.4 Data analysis

The author checked all received questionnaires to identify any missing responses and whether they were properly completed. Any doubts were checked with the respondent via email. All questionnaires were valid and progressed to data analysis.

All data were organised and cleaned for analysis using Microsoft Excel. All participants were given an anonymous code i.e., EXP1, EXP2, etc. The author analysed the demographic data and 5-point Likert scale's responses using descriptive statistics and responses to open-ended questions were analysed by a deductive and inductive approach of thematic analysis. The author started with a deductive approach, by starting with a list of pre-defined themes, where initial codes were drawn from the

questions and topics in the questionnaire (Azungah 2018) e.g., positive and negative opinions, suggestions of improvements, and missing information about accessibility and usability.

The author read the responses and selected some important extracts of the data set and collated them into the pre-defined themes on a Microsoft Excel spreadsheet. Subsequently, while reading and searching for important information, the author identified some extracts that were relevant to make a new theme, the 'Potential evaluation aid' theme.

14.3 Results

14.3.1 Participant characteristics

The expert validation involved 9 participants. The participants were: two accessibility specialists (5 and 9 years of work experience), five software engineers (between 1-10 years' work experience), and two designers (10 years work experience).

Table 14.1 summarises the responses of participants' familiarity with usability methods and accessibility guidelines. Participants (n=4) considered themselves to have a medium level of familiarity with usability methods and were not familiar at all with digital accessibility guidelines (n=3).

Table 14.1 Participants' accessibility and usability familiarity

Questions	Not familiar at all	Low	Medium	High	Very high
Familiarity with discount usability methods	0	2	4	3	0
Familiarity with digital accessibility guidelines	3	1	2	2	1

14.3.2 Responses to 5-point Likert scale questions

Table 14.2 shows the total number of responses to each of the 5-point Likert scale questions. Five participants strongly agreed the guidance A is easy to understand, while six people agreed they could easily understand guidance B, although one of them found it quite long. In addition, five participants believed that they could easily use both guidance and recommend to designers and developers.

Table 14.2 Number of responses assigned to each scale questions.

Questions	1-Strongly disagree	2-Disagree	3-Neither agree nor disagree	4-Agree	5-Strongly agree
I believe I could easily understand the guidance “A” for the design process to develop an accessible mobile application for visually impaired people.	0	0	0	4	5
I believe I could easily understand the guidance “B” for designing an accessible and usable mobile application for generic and specific contents related to physical activity and sport for visually impaired users.	0	0	1	6	2
I believe the guidance “A” is structured in a clear and easy way to use and apply.	0	0	1	5	3
I believe the guidance “B” is structured in a clear and easy way to use and apply.	0	0	1	5	3
I believe I could easily use both guidance “A” and “B” to design accessible and usable mobile applications.	0	0	0	5	4
I think there are specific guidelines or accessibility aspects missing.	1	3	4	1	0
I would like to recommend the guidance “A” and “B” to designers and software engineers to work with.	0	0	1	5	3

14.3.3 Themes

The deductive and inductive thematic analysis resulted in five themes: positive feedback, negative feedback, identified missing guidelines or accessibility aspects, suggested improvements, and potential evaluation aid. The results were organised by themes and by guidance: Guidance A, Guidance B and Both.

14.3.3.1 Theme 1: Positive feedback

Generally, participants found that the Guidance A helped to understand the steps of the design process and may be useful to estimate time for development. In addition, the diagram of the Guidance A was perceived as a visual aid, as it helped to better understand the iterative steps of Guidance A.

“The diagram of Guidance A helped a lot to visualise how the design process is structured. [...] Guidance A helps a software engineer understand the steps required to complete a mobile application and helps estimating how long a product might take to complete.” (EXP3)

“The visuals from Guidance A helped a lot. I wonder if you want to do the same for Guidance B.” (EXP4)

The Guidance B was perceived as easy to follow and highly useful during implementation stage of the software development. This is because it provides specific information to consider creating accessible elements in the interface that are often ignored by software developers.

“It [Guidance B] is easy to follow...” (EXP9)

“Guidance B is extremely useful during the implementation phase as it gives specific details how to build each UI components taking into consideration all the accessibility features which are often ignored.” (EXP3)

Participants expressed that both Guidance A and B were easy to understand and well prepared, which could be useful as a resource for designers and software developers to follow with links to online guidelines. Each guidance was also seen as helpful to provide instruction to organisations that have no knowledge of WCAG.

“Both guidance A and B are definitely helpful for software engineers.” (EXP3)

“...it would be great if all designers and developers of mobile applications followed such thorough methodologies for accessibility and usability. [...] Many organisations need help in understanding WCAG, and this would provide excellent local instruction.” (EXP1)

“In general, both guidance documents are well prepared. It Provides detailed information and when related, with links to an online recourse.” (EXP7)

14.3.3.2 Theme 2: Negative feedback

This theme presents the negative comments regarding to the guidance format, terminology, and length and more structural issues and concerns in the format between Guidance A, B, and the diagram.

Regarding Guidance A, EXP3 expressed that there were missing relationships between the steps of Guidance A. The content was perceived as a linear process due to the sequential structure of the text, instead of an iterative process.

“I think guidance A needs a bit more structure in the text as it looks like a linear process as opposed to the diagram which shows each step with arrows describing the relationships.” (EXP3)

Moreover, EXP8 wondered about how the agile method could be clearer in Guidance A, as it did not show how to apply the method to designers and software developers.

“What is the agile design process? I have a curiosity about the agile design process you mentioned. How to achieve that? I know agile management is widely used in internet companies and the development of their projects. Could you elaborate on some principles about that? Because that will be very useful for developers and designers.” (EXP8)

EXP8 showed some concerns towards the creativity of designers, if they would follow the steps of Guidance B. According to EXP8's rationale, it would not be possible to follow all Guidance B' steps because it would prevent designers to build creative mobile applications.

“For Guidance B, it represents the specific project that designers can follow. As guidance, that's ok. Prioritizing a project is important for designers. It is impossible to abide by every item; otherwise, (s)he cannot design a creative application.” (EXP8)

In addition, EXP8 expressed that following the Guidance B will depend on several constraints, such as project's aims, user, technology, and funding.

“It depends on some specific scenario because every project has its aims regarding the targeted user, technology-based, operator, and financial support.” (EXP8)

Regarding both Guidance A and B, participants emphasised that the guidance documents had a different format and were too long. As to the format, EXP7 reported that Guidance A had a different format compared to Guidance B.

“Guidance A is prepared in different format than Guidance B.” (EXP 7)

In the Guidance A, participant EXP2 commented that the acronymous, i.e., VI, had no previous explanation of its meaning, which could lead to misunderstanding.

“Explain acronyms before using them, for example in Guidance A, heading 2, is “VI young adults’ needs” without explaining what VI mean.” (EXP2)

Although the AMFP and AHFP had its expansion, however EXP2 found it difficult to remember of what they stand for while listening the content through the Immersive Reader in Microsoft Word.

“Also, because I used Immersive Reader’s read aloud feature for my first “read” of the document and the acronyms were hard to remember. For this document you could consider using the full version of terms like AMFP and AHFP?” (EXP2)

Similarly, EXP4 noticed that other terms used in Guidance B, for example, ‘localisation’ and ‘notification’ were not adequately applied to express the intended meaning of the content. In the Guidance B, ‘localisation’ was a term to designate the ideal position of UI elements on the interface, while ‘notification’ would refer to let the user that a button is inactive. Instead, EXP4 interpreted the former as creating a system in another language, while the latter was understood as alerts.

In addition, participants noticed that both Guidance A and B were too long.

“The Design Process of Guidance A diagram is too long.” (EXP6)

“It [guidance B] is easy to follow, but quite long”. (EXP9)

Therefore, some participants would not recommend both guidance to designers and developers until testing them out. EXP2 pointed out that it would be necessary to test both guidance and depending on the results he would be able to recommend to designers and developers.

“I would not recommend until I had a chance to work through a project using the guidance. If I will recommend something I would wait until I have direct experience with using it.” (EXP2)

EXP8 expressed that there is no certainty that someone following the guidance would make a successful project.

“The real project is more complex than we imagine before it starts. Failure is a normal phenomenon. We can’t be sure that following your guideline means being successful.” (EXP8)

14.3.3.3 Theme 3: Identified missing guidelines or accessibility aspects.

This theme refers to identified missing guidelines or accessibility aspects in the Guidance A, such content regards to accessibility recommendations. EXP1 made observations about the general

practice and its missing accessibility aspects of mobile applications and how it could be applied to this study.

For example, EXP1 expressed that there are multiple ways to navigate back to the top of the page, which is often neglected for screen reader users. He emphasised the importance of creating multiple paths to reach a certain place of the interface.

“Mobile pages often do not include a means for screen reader users to navigate back to the top of a page, and the user must navigate back up through the page...allowing multiple ways, to navigate to the same place is important in interface design.” (EXP1)

In the case of using electronic documentation, such as pdf on an application, EXP1 mentioned that it would be necessary to recommend its accessibility checking for using it within the app or opening it on a web browser.

“Will electronic documentation be required within applications or linked to on other websites? If so, the accessibility, for example of PDFs, within the app or the those to be opened on a mobile web browser would need to be checked for accessibility.” (EXP1)

Moreover, EXP1 explained that the name of a pdf document should be the same on its link's name and information regarding to that document.

“The title of the PDF itself should be the same for any link or information in-app that points to that document.” (EXP1)

Also, information about how to navigate back to the application from a web browser should be mentioned in the accessibility statement.

“If navigation is required away from the app to a mobile web browser, for example a company's web page, information about how to get back to the app must be provided in an accessibility statement.” (EXP1)

EXP1 reminded that there is a need to mention that permissions regarding personal information need to be set for applications.

“Permissions need to be set for the application, particularly where Personally Identifiable Information (PII) is recorded to overcome issues with GDPR.” (EXP1)

In addition, EXP1 highlighted the relevance to sign post the future WCAG 2.2 success criteria (SC.3.3.8) Accessible Authentication. This is because of its importance for future reference, especially if payment would be a feature in an accessible mobile application.

“It would also be worth adding in the Guidance B reference to WCAG 2.2 criteria for Accessible Authentication (SC.3.3.8). This will need to be flagged for future road map considerations, particularly if payment will be required in app and because the release of WCAG 2.2 is imminent.” (EXP1)

14.3.3.4 Theme 4: Suggested improvements

This theme refers to participants’ suggestions to improve both Guidance A and B. The suggested improvements for Guidance A were regarding to encourage thinking about accessibility throughout the design process and split the long diagram of Guidance A. For example, EXP1 suggested to encourage designers and software developers to ask themselves throughout the process of designing application if they would be accessible.

“One way to define accessibility is the phrase, ‘is it useable by disabled people?’ Encourage the designer or developer from day one of the lifecycle to be asking that question.” (EXP1)

While EXP6 reported that the diagram of Guidance A was quite long with two phases distinguished by two colours (blue and purple). EXP6 suggested that the diagram could be more explicit by splitting into two phases with its expected milestone.

“The Design Process of Guidance A diagram is too long. It appears, to me, to be two different phases (represented using the blue and purple colours in the diagram), but maybe this separation of phases should be represented more explicitly, with the respective expected milestone. For example, Phase 1: Focused on designing the application and doing both the verification and validation of the requirements and elements of design in multiple ways (including the VI elements). In this phase, the expected output would be a set of requirements designed according to the guidelines. The second phase seems more focused on coding the application and assuring all the elements from the guidance were implemented. The two “phases” doesn’t appear to be strongly related more than in a sequential way. So, maybe they could be split.” (EXP6)

Another participant suggested to add numbers to the diagram to be consistent with the text in the Guidance A, as it would become easier to read the text and follow the diagram.

“I would also add some numbers to the diagram, to keep consistency with the document itself and because it would be easier to compare the diagram and the guidance A document itself.” (EXP6)

Regarding Guidance B, EXP1 recommended applying one single sign-in to mobile applications with not many functions.

“Single sign-in to mobile applications is desirable and to keep mobile applications to perform a specific task. Sometimes corporations developing apps try to make the app do too much and have two separate sign-ins on the same app. This is not recommended.” (EXP1)

Moreover, EXP1 suggested to substitute the WCAG 2.1 success criteria mentioned in the accessibility recommendations of the Guidance B to links to the respective success criteria in the How to Meet WCAG Quick Reference filtered to WCAG 2.1.

“I would recommend providing a mapping in Guidance B for the specified criteria to the How to Meet WCAG Quick Reference filtered to WCAG 2.1.” (EXP1)

According to EXP4, the Guidance B’s specific physical activity and sport related recommendations could be organised by categories to make it easier to designer and software developers to follow.

“Also, the specific guidance could be improved maybe by grouping per ‘element’ as it can make easier for the designer/developer to follow.” (EXP4)

EXP8 expressed that the Guidance B is in an early stage and needs to run into many projects and be refined.

“This is the very beginning version of guidance B; it must experience plenty of projects and refine the content continuously.” (EXP8)

Both guidance A and B need to have date and version information, in the case of continuous revision, as suggested by EXP7.

“If this document potentially been updating time to time, consider informing guidance version or date in it for better developer reference.” (EXP7)

Overall, EXP1 expressed that it is necessary to provide recommendations of training in digital accessibility and give a demonstration of a specific barrier to a person living with visual impairment to inform designers and software developers.

“They [designers and software developers] need to understand the ‘why’ digital accessibility is important. For example, a brief demo of what happens when a visually impaired person comes across a barrier...The information about digital accessibility from the University of Southampton Future Learn course is in the public domain.” (EXP1)

14.3.3.5 Theme 5: Potential evaluation aid

This theme refers to the potential use of Guidance A and B as an evaluation tool in the future. As EXP4 explained that it could become a heuristics evaluation to guide designers and software

developers to check the recommendations were accomplished during the mobile application development.

“Perhaps a future work can be transforming it into Heuristics, so developers and designers can revise the application and score it.” (EXP4)

“But it could be included as a software inspection checklist not just to guide the design and implementation, but also to check whether the aspects were followed during the process.” (EXP6)

14.4 Discussion

Participants evaluated the Guidance A and B aimed to design an accessible and usable mobile application for general use and specific for physical activity and sport services for VI young adults. In this chapter, themes regarded to the positive and negative comments about the structure of both guidance A and B as well as the visual aid of the Guidance A’s diagram. Although, one expert recommended to split the diagram in the Guidance A, generally, participants reported that both guidance were easy to understand and helpful to designers, software developers and organisations. Participants recognised that these professionals and organisations need support to understand the WCAG 2.1 and digital accessibility. Therefore, recommendations such as providing links to existing online resources about accessibility guidelines are useful, as it is provided in Guidance B. However, this Guidance needs to refer to the current WCAG links to the ‘How to Meet WCAG Quick Reference filtered to WCAG 2.1’, as a quick resource to access information about the WCAG 2.1 success criteria.

Regarding the specific recommendations for physical activity and sport services in mobile application design, participants suggested to improve these recommendations by grouping them per ‘element’ to become easier to follow. There is a need to add general accessibility information regarding the single sign in to the mobile application, the multiple ways to navigate back to the top of the page interface, make requirements to check accessibility of electronic documents (i.e., pdf) and its title and link name be matched for easy identification, to add information in the accessibility statement to inform how the user could navigate back to the mobile application, as well as make sure to set permissions for personally identifiable information for users. Therefore, Guidance B seemed to have a potential use as a heuristic’s evaluation tool, although the design guidance still needs to be tested out. There are better methods to evaluate design guidelines beyond just collecting expert opinions. While expert feedback is valuable, a more comprehensive approach could involve applying the guidance in a practical setting. The approaches would be a case study with a design team following the design guidance while developing a mobile app, thus the process and outcomes can be assessed to evaluate how well the guidance supports accessibility, usability, and user experience. Another alternative is to ask experts to create an app using the design guidance and doing usability testing

with the target group to identify whether the app tackle the user needs. These approaches were not conducted due to the limited time in this PhD study.

The Guidance A and B would be useful to encourage thinking about digital accessibility and usability by encouraging designers and software developers to ask themselves about the accessibility of each UI elements in the interface. It is also important to reinforce it through the suggestion of digital accessibility training for those involved in the mobile application design. This seemed to be relevant to show the importance of digital accessibility and usability as well as to provide better understanding through demo of what VI people experience as users. This is important because digital accessibility is often ignored by software developers, designers, and organisations (Sierra and De Togores 2012; Silva et al. 2019a) as designers and software developers might have other priorities as described by one of participants in this study, such as creativity, funding and so on.

14.5 Summary

This chapter presented the results from the evaluation of Guidance A and B from designers, software developers and accessibility specialists of the evaluation of both guidance. The findings included positive and negative comments as well as some suggestions for changes in the structure and format of both guidance to make them easy to read and follow by designers and software developers. In addition, Guidance B received more suggestions to include some useful accessibility considerations related to general mobile applications. The next chapter refers to the review of the results of this chapter and redesign of the design guidance.

Chapter 15 Final version of the design guidance

15.1 Introduction

The last chapter presented the study about the evaluation of the design guidance by experts in digital accessibility, design, and software development (Chapter 14). The study was conducted through a questionnaire and analysed by descriptive statistics and thematic analysis. The results showed the opinions of professionals that evaluated the Guidance A and B as useful for designers and software engineers with some suggestion for changes in the structure, terminologies, additional recommendations for accessibility and visual format. Therefore, the suggestions were used to refine both Guidance A and B.

In this chapter, the responses from the questionnaire were further analysed and organised to produce a new proposal of design guidance for developing accessible and usable mobile application for physical activity and sport related services and support for VI young adults, which also contains a list of general accessibility considerations. The following sections describes the reviewing process of the design guidance A and B.

Aim

This study aimed to revise and redesign the design guidance based upon the findings of the expert evaluation (Chapter 14).

15.2 Method

This study conducted an approach similar to previous studies (Zaphiris et al. 2007; Kapsi et al. 2009; Amershi et al. 2019; Diehl et al. 2022) where the development of design recommendations followed a systematic approach. According to Zaphiris et al. (2007), a systematic method to design and validate design guidelines is often “overlooked”. This may be because there are not many studies addressing the topic in which the terms ‘design,’ ‘guidelines,’ ‘guidance’ are not presented clearly (Amershi et al. 2019). The author observed this issue while searching for references about this topic.

The author decided to follow a systematic approach to revisit the findings of the design guidance evaluation obtained in the previous chapter in order to provide a new version of the design guidance. Systematically, the approach started by (1) reading again the themes obtained in the expert evaluation of design guidance A and B, (2) reading more literature on development of

recommendations of software design, (3) redesign of the design guidance and diagram A and guidance B.

15.2.1 Revisiting the design guidance evaluation's results

The first step adopted in this study was reading again the themes and comments of experts regarding both guidance and diagram A and guidance B. The author organised the design recommendations based on (a) terminology and content of the design guidance and (b) structure of each design guidance and diagram, similarly to a previous study on design of recommendations to user interface design (Diehl et al. 2022). The author identified from the experts' evaluation in the previous chapter some categories to facilitate the organisation of the design guidance.

15.3 Results of redesign of design guidance

Regarding (a), the author identified 4 rewriting and 13 new suggestions from experts to change the design guidance A and B. Most of the suggestions were to add content to guidance B, such as missed accessibility guidelines, single sign-in, mapping to WCAG quick reference, group specific guidance by elements, table of contents, guidance version and date, whereas rewriting was more suggested for guidance A, in which agile methodology needed to be made clear in the design process. Experts suggested to add number in the diagram to become consistent with the numbers in guidance A and acronyms such as VI and AMFP and AHFP needed its expansion to visual impairment, accessible mid-fidelity prototype and accessible high-fidelity prototype, respectively.

Whereas (b) had more comments from experts regarding the guidance A and its diagram, both were perceived as long with no clear relationship and needed to improve them with the addition of the expected milestone from each phase. Also, experts saw that guidance A and B had different formats and no relationship between them.

The author organised the revision of (a) and (b) in a Microsoft Excel spreadsheet which could separate the findings into guidance A and B. After this process, the author started with changes in (a), firstly made changes of the content in guidance A as it had few items to add and rewrite. These changes done in the first version of guidance A in Word document were saved with highlights and tracking of the revision to remind the author of the changes and the respective data in Microsoft Excel spreadsheet were highlighted to inform the changes done. These changes in the content of guidance A were the addition of important notes, such as about training courses in digital accessibility, advice to think about the accessibility of UI elements throughout design and prototype phases, date and revision information and rewriting the expansion of acronyms. Whereas in the content of the design guidance B, the author started by grouping the specific recommendations

(regarding to inclusive physical activity and sport services) according to EXP4's suggestion to group them by elements to facilitate its use for designers and developers.

"Also, the specific guidance could be improved maybe by grouping per 'element' as it can make easier for the designer/developer to follow." (EXP4)

Re-reading the guidance B, the author noticed that some of the general recommendations were specific to some scenarios in the physical activity and sport experience. For example, the recommendation to make a button inactive when information is not available, in which the example referred to sport event or session, was moved from the 'notification' category in the general guidance to the new category 'searching for transport' in the specific recommendations. The author also moved other recommendations from the general to specific guidance, such as the following in the first version of guidance B: 'reminders', 'visual', 'grouped information and functions', 'copy and paste', and 'quick information and actions'. Although, these recommendations seemed to apply for generic related services in mobile application, the author decided to move them to the specific recommendations as it would make clearer the importance of the accessibility and usability with the rationale given in the guidance B. The rationale is important in design guidance as recommendations can be better understood and designers and software developers can identify the importance of each recommendation. Therefore, in the new version of design guidance B there is a column 'example/explanation', where example of applying the recommendations is given when necessary to make the guidance clear and the explanation to describe the scenario or expected need of the VI young adults.

The author also removed some recommendations in the general guidance as they were too general and already exist in standard accessibility and usability guidelines and less relevant to the guidance, such as the built-in speech. The removed recommendations regarding built-in speech as optional, simple, and consistent interfaces design, feedback and help. Although, other general recommendations already exist in standard and accessibility guidelines, the author decided to keep them with additional information that were observed during the usability evaluation, such as compatibility of specialist mobile phone for VI users and braille display. Thus, this may reinforce the need to consider these assistive technologies throughout the design process, as other recommendations may be frequently ignored by designers and software developers, even though there are accessibility guidelines available.

Regarding (b), the author decided to prioritise the changes in the structure of the design guidance. The first step was to change the previous list format to a new format by creating a table for each guidance A and B (specific recommendations), while the guidance B (general recommendations)

remained as a list as it was not directly related to services of inclusive physical activity and sport for VI people. In this case, the table format seemed to be more consistent with similar columns.

“Guidance A is prepared in different format than Guidance B.” (EXP7)

Also, more importantly the table format may help to show the respective phases in which the design process relates to the recommendations and diagram, as it was expected by experts.

“I didn’t notice if the Guidance B document is explicitly included as a step in Guidance A.” (EXP6)

“I think guidance A needs a bit more structure in the text as it looks like a linear process as opposed to the diagram which shows each step with arrows describing the relationships.” (EXP3)

However, the author decided to keep the structure of the diagram of guidance A as it is and did not split it as one expert wondered if it would make the diagram to evidence more explicitly show the distinction of the two phases and its expected milestones.

“...maybe this separation of phases should be represented more explicitly, with the respective expected milestone. [...] The two “phases” doesn’t appear to be strongly related more than in a sequential way. So, maybe they could be split.” (EXP6)

15.4 Discussion

The redesign of the design guidance resulted in the amendments and additions of the 17 suggestions regarding terminology and content of guidance A, diagram A (Appendix Q) and guidance B (Appendix R). While both guidance A and B were changed to table format; all tables have the phase corresponding to the steps in the design process, which are called ‘actions’ with its related design thinking and agile practices in the guidance A. The author kept the content of the phases in the guidance A and only added advice for designers and software developers about training courses in digital accessibility and the importance of accessibility by checking whether the UI elements are accessible throughout the implementation and evaluation of the mobile application.

The guidance B kept its two parts as general and specific recommendations for services of inclusive physical activity and sport, however with the table format similar to the guidance A. In the guidance B, the users 1 are VI young adults and users 2 are coaches or volunteers; it also has categories addressing the meaning of the recommendations, and example or explanation to aid the comprehension and importance of the recommendations.

In this study, the author did not conduct another expert evaluation due to time restrictions of the project. Therefore, it would be necessary to evaluate the new version of the guidance A and B, and diagram A through an experimental study as future work.

15.5 Summary

In this chapter, the redesign of the design guidance involved the adoption of a systematic approach to reanalyse the feedback of experts in digital accessibility, design, and software development. The redesign of the design guidance was based on the experts' comments and suggestions about the first version of the design guidance. The usability and accessibility of the design guidance need to be considered while designing the structure and content of recommendations. In the next chapter 'General discussion', the final discussion about the results and contributions of the current PhD project is presented.

Chapter 16 General discussion

16.1 Introduction

The current thesis comprised studies which aimed to develop and evaluate a proposed guidance on designing and evaluating accessible and usable physical activity information and support to VI young adults. The research programme was devised primarily to undertake a practical approach as evidence to inform designers and developers about strategies in design process and insights for physical activity participation of the target audience. From an applied perspective, integration of accessibility, usability and user experience aligned with behaviour change theories are important to support the practice of designers and developers into design and software development processes.

Several previous studies have provided support and applied Design Thinking and Agile UX methodologies to foster research and innovation (Gurusamy et al. 2016; Corral and Fronza 2018; Nedeltcheva and Shoikova 2018; Pereira and Russo 2018). However, there have been scarce considerations on the needs of disabled people in such approaches. The current thesis aimed to develop a guidance on how to design and evaluate accessible and usable technology in the context of physical activity participation of VI young adults. According to participants in this study, the proposed mobile app could be beneficial to all age groups, not only the VI young adults. VI young adults may benefit the most as the app could facilitate the identification of inclusive physical activity by age, visual impairment and physical activity level, similar peers, and help learning more about inclusive physical activity. It could help obtain direct support from coaches, and provide transport information, which may help them and their parents to gain awareness of the opportunities which may lead to build their confidence, especially those who have safety concerns. This can be associated with the capability construct (i.e., knowledge and skills) which was also identified in the COM-B questionnaire as some of the construct impacted motivation of VI young adults to do physical activity. Further research could address these issues for more clarification.

The findings from the studies supported the development of recommendations which incorporated the empirical evidence of the design process, especially in terms of considering accessibility in rapid prototyping, online survey design, and adapting online user evaluations, which helped to obtain insights from VI young adults and coaches regarding inclusive physical activity networks. The design guidance from this research can be extended, adapted, and tested with a broader range of users, including other disabled and non-disabled adults. This could help improve mainstream physical activity apps to better accommodate the needs of visually impaired (VI) users, ensuring easy access to content and support necessary for getting active. Improvements may include accessible, detailed

information about sessions, peers, and coaches to build user confidence in the service provided. Future research involving a more diverse sample, such as non-disabled young people, could further refine and enrich the design guidance.

The present thesis seems to be the first to conduct research to support a mobile design and development process associated with mobile accessibility, usability, and user experience in the context of physical activity. This chapter discusses the findings and limitations of all studies.

16.2 Key Findings

This study carried out eight studies which obtained results from the user evaluation of mid-fidelity prototype (Chapter 4) and Minimum Viable Product (Chapter 5, Chapter 8 and Chapter 10), interviews with VI young adults (Chapter 7) and coaches (Chapter 9), as well as the accessible online survey (Chapter 12) and the expert validation of design guidance (Chapter 14). The design guidance was created iteratively and concurrently while developing the mobile app. This study conducted one iteration, in Agile terms - early iteration (sprint 1), because it was not possible to conduct the next iteration of the app development using the latest findings and guidance due to the limited time and resources of a PhD study. Therefore, future work is necessary to further test and evaluate the design guidance. The next sub-sections present the key findings of this research.

16.2.1 Accessibility integrated in Rapid Prototyping allowed validation of concept and requirements through accessible mid-fidelity prototype in PowerPoint

In order to establish requirements, the communication between the author and MSc student using personas and user stories were essential for understanding the user needs and basic use of assistive technologies. This study (Chapter 4) aimed to assess the concept of the app and the initial design requirements; thus, it developed an accessible alternative in Microsoft PowerPoint. Other options were not feasible due to inaccessibility of the typical paper or tactile low-fidelity prototyping. Therefore, it was an intermediate tool between low-fidelity and high-fidelity prototyping; this enabled use of the bottom-up approach to create a best guess design of a new product in which feedback was used to create functional requirements (Wilson and Rosenberg 1988; Engelberg and Seffah 2002). Additionally, it was not feasible to build a high-fidelity prototype at this phase as it is too time consuming, and it would not be necessary while evaluating the concept (Wilson and Rosenberg 1988).

Validated initial design requirements of the accessible mid-fidelity prototype confirmed the potential advantage of quick development and brief accessibility checking in Microsoft PowerPoint. The rapid prototyping approach proposed by Engelberg and Seffah (2002) for website prototype in Microsoft

PowerPoint was adapted for accessibility considerations for the app to allow VI participants to interact to the simulated design solution through assistive technologies.

As mid-fidelity is used for usability validation, it then served this purpose to validate the initial requirements in terms of navigation, features, information, and layout, and to confirm the acceptance of the concept. Although checking acceptance is usually done with low-fidelity prototyping (Engelberg and Seffah 2002), however it was not feasible to use it due to the accessibility issue mentioned earlier. Therefore, the accessible mid-fidelity prototype helped to gain feedback from VI participants about the usefulness of the app for searching physical activity information and their suggested improvements.

The reduced visualisation of custom portrait in the landscape view in Microsoft PowerPoint appeared as a limitation for user evaluation, however, this issue was tackled by fixing the vertical position using another tool. In this study, the user evaluation was conducted freely for exploratory purposes to learn the content of the app as the objective was to confirm the initial design requirements which addressed the sub-research questions SQR1 and SQR2, by understanding the needs of the target audience and accessibility and usability issues.

In line with previous studies (Sierra and De Toghres 2012; de Godoi et al. 2020; Rosa and Valentim 2020) this study confirms the importance to define accessibility, usability, and user experience at the beginning of the project, and which were further reviewed in the design requirements. The addition of accessibility to the rapid prototyping approach implies its application to any type of digital prototype using Microsoft PowerPoint. This phase identifies the Design Thinking phase of Ideate and Prototyping to help elicit the user requirements (Gurusamy et al. 2016).

16.2.2 Minimum viable product prioritised functional requirements including accessibility, usability, and UX aspects, but some issues and features needed improvement

The implementation of the mobile app in React Native aimed to allow user evaluation of functional requirements in both iOS and Android mobile apps. However, at this phase only an Android version was evaluated by VI young adults due to the availability of mobile phones and beta version in Android. Beta release of Android is easier and quicker to obtain compared to iOS as the process is simpler and does not take much time as compared with iOS. The implementation followed the prioritisation of the functional requirements after mid-fidelity user evaluation, as discussed in Chapter 5. This allowed the use of essential features to provide the feel of a simple, usable, and searchable tool and helpful communication with providers, alongside accessibility, easy navigation flow and useful content. The approach was to integrate not only accessibility and usability, but also some aspects linked to the context of use and usefulness of the app (Morville 2005).

The database of VI sports helped to simulate the user tasks, such as the searching for sport, coaches, as well as recommending sports events in the home screen. Also, the design and implementation of the app provided insights to inform the design guidance to designers and developers about devising an accessible and usable mobile application for physical activity for VI young adults. The design was a learning process from refinement of requirements and feasibility to build a cross-platform app with sport database. A challenge was to address the accessibility guidelines during a short period of time for both author and MSc student, due to confusing technical jargons and unclear explanations and examples (Silva et al. 2019a; Tigwell 2021).

In contrast to recommendations of making usability changes in the minimum viable product at last iterations as it is not ideal to rely only on issues pointed out by one participant at the beginning of the process (Kieffer et al. 2017), this thesis points out that this approach may not work in the case of severe accessibility issues. This is because such issues can prevent users in the next iterations for progressing the user evaluation and it would not allow the user to experience the product. This issue happened in this phase with the first round of user evaluation (i.e., sprint 1), while a blind participant could not access a list of sports, thus preventing the user to interact with the rest of functionalities. This issue was one issue easily fixed (e.g., model-selector) in the app during update in the phase 3.

16.2.3 Considerations for updating mobile app and checking accessibility

The app update was also a learning process in terms of the difficulty to identify a new developer with expertise in mobile development available to fix and create certifications to release the beta version of Android and iOS. The new developer was able to fix the bugs, dependencies, libraries, as well as few minor accessibility issues identified by the author while using Accessibility Inspector or identified in the first round of user evaluation such as the modal selector to list the sports, which was necessary to be fixed to allow participants to perform the searching task to understand its functionality and progress to other tasks. The app release and its technical process, especially the release of iOS app through TestFlight, can only be done by a mobile developer expert. Therefore, the author should have foreseen the need for technical support to anticipate the search for a new developer.

Accessibility checking through automated tools, such as Accessibility Scanner and Accessibility Inspector, need to be done throughout the implementation phase, as it seems to be easier and quicker to review the accessibility attributes while running the project. As not all WCAG 2.1 accessibility criteria can be checked in the automated tools, developers need to do a manual check for accessibility of a beta version in mobile devices, if possible, with braille display or external keyboard.

16.2.4 Accessibility considerations in remote user evaluation of Minimum Viable Product and further insights for app development based on VI young adults and coaches' views

16.2.4.1 Continuous Requirements Elicitation

In this phase, VI young adults and coaches participated in online interviews and evaluations of the app. This phase aimed to recruit more participants to gather further feedback on user requirements and usefulness of the app, as well as to interview the target audience about their physical activity experience and coaches' perspective of this experience and the service provision. The interviews with both groups aimed to better understand the needs of VI young adults and the service provision, which helped to answer the design questions to feed insights and to address the sub-research questions SRQ1 and SRQ2. For instance, these insights were related to the need of creating a network for users to meet other peers to play or exercise, coaches' collaboration, online exercise sessions, physical activity sessions' promotion, number of attendees, age group, more personalised information and so on, which helped to inform the design guidance. This study is one of a few studies (National Disability Sports 2015; Jaarsma et al. 2019) that investigated this topic with both VI young adults and coaches. This approach aligned with the Design Thinking's continuous strategy, in which identification of new user requirements is continuous throughout the whole project (Hehn et al. 2020).

16.2.4.2 Remote interviews and user evaluations with VI young adults

The interviews about physical activity experience were conducted prior the user evaluation to avoid participants' responses being influenced by the app functionalities (Chapter 7 and Chapter 8). These interviews aimed to better understand participants' views and experience in physical activity and provided context to the use of the app. This means that for participants not being part of VI community or network implies not being aware of inclusive physical activity opportunities, which confirms the study from Jaarsma et al. (2019). Moreover, interviews revealed user needs according to user types, such as physically active who have to explain visual impairment and their needs at every start of new physical activity, to search new inclusive physical activity at local mainstream gym and sport clubs, accessible online workout sessions, peers to exercise with, and inclusive sessions with sighted and VI people. Physically inactive people however need assurance of safety in the sessions, to build trust in coaches and support to understand how to do physical activity.

Regarding the user evaluation, the challenge of online sessions was how to observe remotely the interaction of VI young adults and follow their actions and eventual issues while doing the tasks. The decision to undertake online sessions was due to COVID-19 social restrictions and the sessions had to be adapted for VI young adults. However, some strategies helped to overcome the challenge. The

strategy of using a pile of books to raise up a second mobile device or using a webcam stand to film the interaction of VI young adults worked well to identify issues and participants' suggestions to discuss during debriefing. Not all participants had one of these devices which required the author's constant follow up of participants interaction and to navigate the app at the same time as participants' screen interaction. This demanded more effort to understand what participants were doing on the screen while not interrupting the think aloud technique or prompting them to think aloud. In this case, debriefing helped to clarify and review participants' actions. The use of built-in screen recording and sessions' video recording also helped to clarify some unclear issues during data analysis. The online sessions helped to observe live participants' reactions, issues, use of assistive technology, such as braille display, and to ask questions when during the sessions. Additionally, this study emphasises the importance of compatibility and focus synchronisation of apps' screen reader with braille display and specialist mobile phone for VI people to allow user evaluations.

Regarding the app features, VI young adults appreciated the recommended sport events, saving physical activity information into calendar app, searching for physical activity and suggested improvements to search by postcode or nearest opportunities. Suggestions also included the detailed physical activity information along with direct and different options of contact with coaches and service providers, such as chat, email, phone call, as well as direct link to public transport via navigational app and suggested options of other more accessible apps. Generally, they expressed their wish to get active and be involved in inclusive physical activity with sighted people and VI people. The study in Chapter 8 and the study in Chapter 5 together had 10 participants in the think aloud user evaluation which can be considered an acceptable number as the minimum of 9 test users is necessary to identify 80% of usability problems (Hwang and Salvendy 2010).

16.2.4.3 Remote interviews and app demonstration with coaches

Coaches' perspectives of VI young adults' participation in physical activity and service provision refers to lack of support of parents of VI young adults being a possible important barrier. This contrasts with what was reported by VI young adults during interviews. Therefore, during the demonstration coaches noticed that the app may be a good resource to help parents to know about the opportunities and credibility of coaches. Additionally, lack of coaches' confidence with VI people also limits opportunities of inclusive physical activity in local areas, which could be enhanced by inclusive coaching training and a collaboration network. The app demonstration sessions with coaches aimed to gather their feedback on the app and insights to improve it for both coaches and VI young adults. This was important to better understand the current service provided and perceived experiences for VI young adults, which relates to poor target audience's adverts, the need of detailed information by searching on age group, nearest sessions, physical activity level. Further research would need to

interview more coaches to gather more insights to improve the service they provide for VI people, as this study had six participants.

16.2.5 Accessible online survey suggests that physically active VI young adults may want to do more physical activity and identified perceived barriers to physical activity among this group

This study aimed to identify the profile of VI young adults related to physical activity. From a researcher perspective, this helped the author to learn to design an online and accessible questionnaire and how difficult it is to get participants' responses. The findings are unlikely to represent the target population due to the convenience sampling method, which was the method selected as there was no list frame to run a probability sampling. Therefore, most participants were physically active, and they wanted to do more physical activity.

However, COM-B components showed the most reported barrier was motivation which may be influenced by other barriers such as disability, inaccessible physical activity, needing more support from others and to know more how to do exercises and sports. Interviews and accessible online survey revealed the preferences of VI young adults for more inclusive options beyond VI sports, such as fitness, running and mainstream gyms with inclusive approach. Such options were not provided in the app as the database source was originally based on VI sports data only.

16.2.6 Reviewed design guidance of design process and design components of general and specific for physical activity mobile app for VI users and coaches

The results from interviews and user evaluations, accessible online survey and literature review converged in recommendations to design accessible and usable mobile apps, which may be applied to other technologies. These recommendations were regarding the software development process and design components for physical activity services, accessibility, usability, and user experience aspects to consider when designing mobile app for physical activity. Regarding process, this was based on the study practical stages.

Based on the views of experts, the guidance for design and development process, and general and specific for designing components of a physical activity app were easy to understand, and they made suggestions for improvements in terms of structure, terminologies, and some other accessibility considerations to help improve the user experience of a mobile app. The design guidance gives directions based on the experiments which is not enough. Developers and designers need training about accessibility coding and practices for iOS and Android and test the code while implementing the app. Also, designers and developers need to consider offering websites as an alternative format

to allow people with impairments that do not use smartphones to have access to the content in web browser on laptops or desktops.

Recommendations for any type of physical activity app which may consider VI people and coaches with or without visual impairment are regarding to accessible features and components, such as accessible registration, creation of user profile with required answers for visual impairment level, physical activity level, needed support, accessible list of physical activity in alphabetic order, optional voice assistant, and more as described in Appendix R.

The improvements to the study's app, and the recommendations in the guidance are to provide efficient personalised search results for physical activity based on user profile (i.e., visual impairment level, physical activity level and preferences, location); for instance, search for physical activity needs to be based near the user or on postcode, which can facilitate their mobility. Otherwise, information about public transport can be available and succinct and link to choose existing navigation apps. Coaches' profiles need to present details of work and licenses to help VI young adults to build trust in coaches. Sighted people can sign up to know the inclusive physical activities to take part in. VI Young adults, as users of the app, can provide details about the physical activity and coaches to their parents in order to help overcome the barrier around fear of injuries or parents can sign up to better understand the physical activities. Chat with coaches was perceived as a straightforward communication that may work well, especially for physically inactive users to obtain easy and quick support. Learning about VI physical activity can help VI users to identify and how to take part in new physical activities.

16.3 Limitations

A number of limitations impacted the outcomes of the studies. Restricted time to interview and inexperience of interviewers (i.e., author and MSc student) and the small number of participants (n=3) were the limitations in the first study of accessible mid-fidelity prototype in Microsoft PowerPoint (Chapter 4) which affected the amount of feedback from participants. To overcome this issue, it would be necessary to have more time to interview each participant and better strategies for participants' recruitment.

Number of participants were a challenge and limitation in other studies, such as the accessible online survey (Chapter 12), even though this study remained open for a long period of time. A more creative approach to advertise this study could have improved the numbers, such as accessible video, image which were used later in the study adverts used to recruit participants for user evaluation (Chapter 8) and demonstrations (Chapter 10) of the minimum viable product. Another limitation regarding some outliers in the accessible online survey were about text format in responses to hours and days of the

week doing physical activity in the Global Physical Activity Questionnaire – GPAQ. In the questionnaire, explanation, or examples of format of the answers may avoid any misunderstanding.

Another limitation was regarding the use of author's and MSc student's Android mobile phones in the first evaluation of the app (Chapter 4), as participants who were VoiceOver users were not familiar with TalkBack, so it may have impacted their navigation and their perspectives about the app. Therefore, participants using their own devices can provide better results as the devices have their users' defined accessibility settings familiar to them.

Restricting the target audience to VI young adults removed the chance to gather feedback about the app from other age groups. Another limitation identified in Chapter 8 not providing an accessible web application to be used in a desktop as an alternative way to allow the participant who does not use smartphones to evaluate the system. The next chapter is the conclusion of this study.

Chapter 17 Conclusion and future directions

This thesis's motivation was the lack of guidance to aid developers and designers with the designing and evaluation of accessible and usable technology solutions, especially in mobile app development in the context of physical activity information and support for VI young adults. This last chapter summarises the contributions to research and recommends further work.

The guidance A about design process presents the essential stages and considerations to integrate accessibility, usability, and user experience from the beginning of the software development lifecycle, which can serve as reference for a general guidance to technology solutions. The guidance B with specific and general recommendations focuses on accessibility requirements for any related fitness app and the study's app for physical activity for VI people. Therefore, this guidance could be expanded to other impairment type or multiple impairments to further the research.

The findings achieved through the adapted approaches and techniques contributed to the development of the research as significant evidence to inform developers and designers about design and evaluation of user requirements and accessibility considerations. Although, the provided guidance needs further evaluation in practical settings, the thesis' contributions address the original question posed in this study on how guidelines can be developed to support designers and software developers to design and develop a mobile application to aid VI young adults to take part in physical activity, followed by the future directions.

17.1 Research Contributions

This last chapter presents the overall conclusions from different points of this study, which addressed the research questions by adapting methods and approaches to integrate accessibility, usability, and user experience into a combination of Design Thinking and Agile UX development methodologies. As a result, the contributions of this study answer the main and sub-research questions.

How can guidelines be developed to support designers and software developers to design and develop a mobile application to aid VI young adults to take part in physical activity?

This study explored design approaches in mobile applications, focusing on accessibility, usability, and user experience. The author simultaneously conducted and developed the design process and requirements to guide designers and developers in creating an accessible mobile application for VI young adults in the context of physical activity. The research opportunity involved iteratively developing design guidance, including recommendations for the design process, based on Design

Thinking and Agile methodologies, and specific requirements for an inclusive physical activity app. The outcome was a set of guidelines for adapting methods to gather user needs and requirements, testing for accessibility, and enhancing the accessibility, usability, and overall user experience for VI users in accessing physical activity information and support.

SRQ1: How can relevant design guidance be developed that are appropriate for designers and developers who are not accessibility experts?

The development of relevant design guidance for designers and developers without accessibility expertise involved various considerations and approaches for building an accessible mobile application. This process followed an iterative design approach, where adapted methods and outcomes continuously informed and refined the design process and requirements. The evolving design requirements for the mobile app created an opportunity to apply and review the design process. In the design process, accessibility, usability, and user experience approaches and considerations started from the beginning of the design project of the mobile application. The design process combined the Design Thinking phases and Agile UX approaches to understand how to design and develop a mobile application in the context of the physical activity participation experience of VI young adults.

The entire design process evolved based on the Design Thinking phases (empathy, define, ideate, prototype and test) to help devise the design process and requirements of the accessible mobile application, aiming to create the adequate recommendations on accessibility, usability and user experience to designers and developers. The design process involved adaptations of methods and techniques which resulted in relevant findings to inform the design guidance for designers and developers. The empathy phase helped to understand the barriers and facilitators of physical activity experience of VI young adults. As a result, the author identified the categories in the literature review that helped to elaborate initial ideas for an accessible system for physical activity information and support and the creation of accessible personas to communicate the context of use of mobile applications and assistive technologies by VI people. This was useful to facilitate the communication with developers about the user needs and elicitation of the design requirements.

As the design of the mobile application needed evaluation by VI young adults and other stakeholders, the author investigated ways to make an accessible prototype. There are several approaches adapting the traditional paper and tactile prototyping for co-design and user evaluation sessions with VI participants but not accessible and useful to mobile application evaluation because these techniques do not allow use of screen reader (Metatla et al. 2015; Miao et al. 2016; Albouys-Perrois et al. 2018; Adam et al. 2020; Gupta and Bruce 2021; Jantan et al. 2023). The author selected and adapted the 'generic rapid prototyping method for mid-fidelity prototypes' (Engelberg and Seffah

2002) by making an accessible prototype in Microsoft PowerPoint, this helped to identify that this method allowed the author to do accessibility checks on PowerPoint and allowed VI users to evaluate the prototype. The outcomes fed the design requirements and process. Similarly, the prototyping and evaluation of the high-fidelity prototype developed in React Native provided significant findings, including the design and implementation in the cross-platform cannot support all accessibility aspects as iOS and Android native components. The manual and automated accessibility testing proved to be effective during implementation and update of the app, as it can be done in each iteration of the design process. However, automated testing cannot identify all accessibility issues, so manual testing based on WCAG-EM and user evaluation are recommended.

The design process enabled the elicitation of design requirements of the mobile app for physical activity information and support, which gave context about the user experience of VI young adults and informed the features that could help them to tackle social and physical activity information barriers. This helped to understand that iteratively co-designing the features with VI users and coaches helped to inform the accessibility, usability, and the overall user experience of stakeholders around the physical activity service.

Overall, this study generated design guidance relevant for accessibility, usability, and user experience of mobile application in physical activity context, and it aimed to verify whether designers and developers with limited accessibility experience can effectively understand and consider the design guidance as a resource for mobile accessibility design and development.

SRQ2: Does the design guidance developed provide all accessibility requirements?

The developed and reviewed design guidance outlines all necessary accessibility requirements for mobile application design and development, incorporating feedback and suggestions from designers, developers, and accessibility specialists. Experts who reviewed the guidance reported positively on its potential to promote accessibility within design and development teams. They noted that the guidance enables designers and developers to easily understand how to integrate accessibility, usability, and user experience into mobile app design. Additionally, Design Thinking, as a mindset and strategy, can help designers and developers gain a deeper understanding of accessibility issues related to user experience, going beyond just accessibility standards and stakeholder considerations throughout the software lifecycle. Therefore, further research is needed to test the design guidance in a practical setting for its validation.

17.2 Future Directions

Potential software development checklist and heuristics

A Senior Lecturer in Interaction Design and a PhD student in Computer Science, as expert reviewers of the design guidance, suggested further application of the guidance. It would be useful also as a software inspection checklist to verify whether the recommendations were addressed throughout the development process, and it would be helpful if transformed into heuristics to revise and score an accessible and usable app.

Future case studies for designing technology solutions

There is a need to conduct future case studies to apply the design guidance regarding the design process to check with developers and designers how it would be useful in a more realistic Agile setting in mobile development lifecycle. By doing this, it would be relevant to identify and establish an approximate duration of each iteration, especially the accessibility testing as it can be time consuming, and how the development and design team can be organised. Several teams could apply the design guidance in agile software development approaches, such as SCRUM, which could be useful and relevant to know how the guidance can be helpful for designers and developers in different projects.

Future experiments to evaluate the user experience of the app produced by the design guidance

Further work could compare the results from an experiment with VI users and their satisfaction with mobile apps developed by one group of designers and developers who used the proposed design guidance and another group who did not use it.

Further development of physical activity information services with coaches

Further development and evaluation could be of a system service for physical activity information for coaches for training in inclusive physical activity, network for collaboration between coaches and organisations, and support to people interested in taking part in inclusive physical activity.

Support to report manual and automatic accessibility testing of mobile applications

It will be important that future research could continue to explore the improvements to the WCAG-EM and its report and Web2Access to record the results of accessibility testing of mobile apps, in order to aid developers in accessibility testing throughout the software development lifecycle.

Educational Source

The scope of the design guidance may potentially serve as a reference for educational purposes in higher education in Computer Science and Design Schools. It might be useful to guide students in how to undertake some methods for learning in educational projects.

All age and impairment groups

Future work could fruitfully investigate and expand the design guidance to address the needs of people of all age groups, people with other types of impairment (e.g., hearing, physical) other than visual impairment, and people with multiple impairments (e.g., hearing and VI).

Further research into health behavioural change interventions

Future work is needed to better use the approaches of health behaviour change research to be applied in the context of physical activity information for targeting and tailoring materials for knowledge and promotion.

Appendix A Personas, scenarios and user stories

A.1 Personas and scenarios

Personas, scenarios and user stories were extracted from the Master dissertation (Chrysostomou, 2019, p. 15-18).

A.1.1 Persona: Partially sighted

Name: John Johnson

Demographics:

- 20 years old
- Single
- High school graduate

Technological knowledge: very good

Motivation:

- Keeps in touch with friends using technology.
- Enjoy sports (especially cycling)
- Organises his weekly program.

Frustration:

- Difficult to find other activities that are safe for him.
- Stress during revision for exams.
- Difficult to find apps that he can easily use.

The Scenario of a partially sighted user:

John lives in Manchester, and he is studying psychology at the University of Manchester. John has deuteranopia; as a result, he has reduced sensitivity to green light.

Next week, John is going to London to meet his brother that works there. During his visit, he plans to explore the city and discover sports activities that he can do. John has recently downloaded a mobile application that helps visually impaired people to find physical and sports activities. He opens the app and gets surprised as text and buttons were large enough. Therefore, John can create an account without using the magnification tool. Also, the contrast between background and elements is clear, and he can distinguish them. After logging in, he goes to find events screen where he enters the

location (London) and the sports activities that he is interested in (cycling, football). John clicks the find button, and a list of sports events is shown at the next screen. He finds a cycling event at 3:00 pm and he clicks it for more information. After reading the event information, he decides to call the event organizer to ask if he can bring his own bicycle. This is easy as there is a “call now” button in the event information screen. Finally, John adds the event to his calendar for a reminder by clicking the “add to calendar button”.

A.1.2 Persona: Blind

Name: Mary Brown

Demographics:

- 28 years old
- Married
- No children
- London music school graduate

Technological knowledge: good

Motivation:

- Walking with her husband
- Meeting other visually impaired people
- Discovering new places to walk

Frustration:

- Having trouble doing activities by herself
- Difficult to discover places to walk without her husband because she cannot drive.

The Scenario of a blind user:

Mary lives in an apartment in the Centre of London with her husband. She is a pianist and performs three times a week in a restaurant next to her house. Also, when her husband is free, they go for a trip to the mountains so they can walk in nature. Lately, her husband is very busy with his work, and she spends a lot of time at home as she is afraid of going out alone.

Today, Mary has received an email from a blind friend with an advertisement for a mobile application that promotes physical and sports activities for visually impaired people. Her friend told her to try this app to find a coach to go walking with her. Mary likes the idea and immediately downloads the app. She is using VoiceOver to assist her navigate through the screens and interact with the

elements. After installing the app, she logs in using Facebook as it is faster for her. Mary navigates through the screens and eventually finds the find coach option. Then she selects London as the location and walking from the activity list. There is only one coach on the list, and she clicks to look at his profile. She decides to send him a message through the chat within the app, and she asks him whether he is available for walking tomorrow. The coach replied to her message, telling her that he will attend a walking event (rambling) in Southampton. That was interesting for her, so she finds the event using the app. Then Mary asks her husband if he will be available tomorrow, but he will not. So, she tries to find transport within the app. After clicking the find transport button in the event information screen, a list with several routes appears on the screen. She picks the route 2, which does not require any travel by train. The route details are presented to her. Mary liked this feature, as she could find transport for an event without using any other apps. Also, she can start the map navigation directly through the app. The next day, she successfully attended to the event using the route suggested by the app.

A.1.3 Persona: Coach

Name: Mikel Carter

Demographics:

- 35 years old
- Married
- Father of two children
- College graduate

Technological knowledge: good

Motivation:

- Likes to exercise.
- Likes extreme sports.
- Likes to help other people to do physical activities.

Frustration:

- Difficult for him to find disabled people that need help with physical activities.
- Upset when people underestimate disabled people.

The scenario of a coach:

Mikel lives in Winchester with his family, and he loves to exercise and do sports. This is the reason that became a personal trainer. Two years ago, he got his certification, and he can train and help people with disabilities. He is also a member of the local goalball team.

At the moment he works at his local gym. Mikel noticed that in the last two years, there was only one disabled person that visited the gym. He is not very happy about this, as he is always promoting the gym to attract more disabled people and motivate them into sports. He recently downloaded the ActiveVI app and created an account listing himself as a goalball coach. Today, Mikel received a message in the app from a blind woman asking him whether he will be available next Tuesday to assist her in a goalball event in Winchester. He replied to her telling her that he is free that day and she can call him at any time to arrange the meeting. Mikel is happy, as this app allowed him to promote himself and assist people that need help.

A.2 User stories

Table A.1 User stories and priority ranking

User story	Priority (1-3)
As a visually impaired user, I want to find events at a specific location, so that I can choose which one I want to do when I visit this location.	1
As a visually impaired user, I want to find events based on date or time, so that I can see which event fits in my timetable.	2
As a visually impaired user, I want to find events for specific activities, so that I can choose the most suitable for me.	1
As a visually impaired user, I want to see more information about an event, so that I can decide if I will go or not.	1
As a visually impaired user, I want to find information for physical and sports activities, so that I can learn more about it.	3
As a visually impaired user, I want to see the available public transport for a specific event, so that I can choose which one I can use to go to an event.	2
As a visually impaired user, I want several available coaches to be displayed, so that I can choose one to communicate with to help me with the activity.	2
As a visually impaired user, I want to see more information about a coach, so that I can decide if I want to contact him.	2
As a visually impaired user, I want to add my activity to my calendar, so that I can have them organized.	3
As a visually impaired user, I want to create a profile, so that I can get recommendations.	3

Table A.1 Continued

User story	Priority (1-3)
As a coach, I want to create my profile, so that I can add my personal information and bio.	1
As a coach, I want to list myself, so that I can offer my services.	1
As a coach, I want to communicate with visually impaired users, so that I can arrange an activity with them.	2

Appendix B Mid-fidelity prototype screens

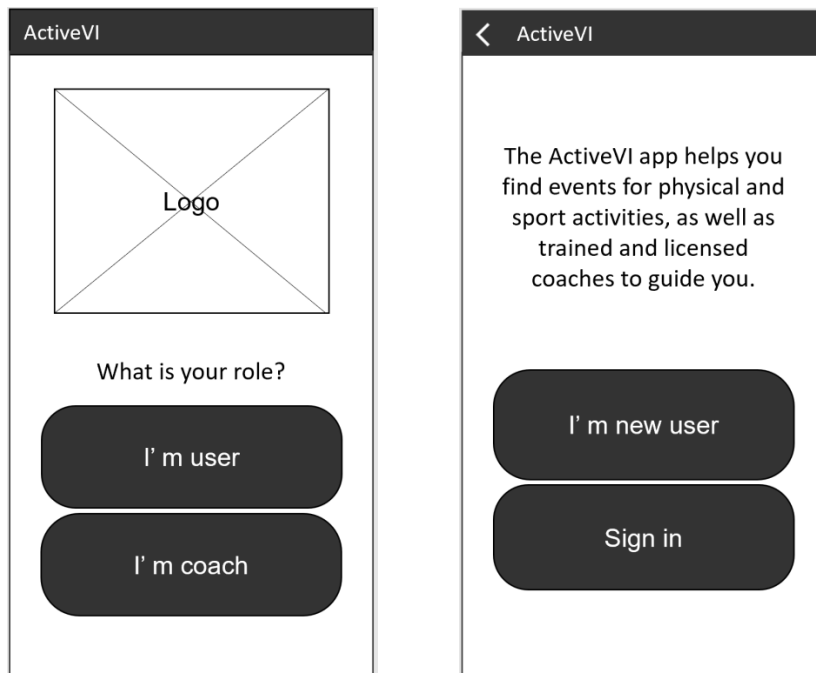


Figure B.1 Initial sign up and sign in screens

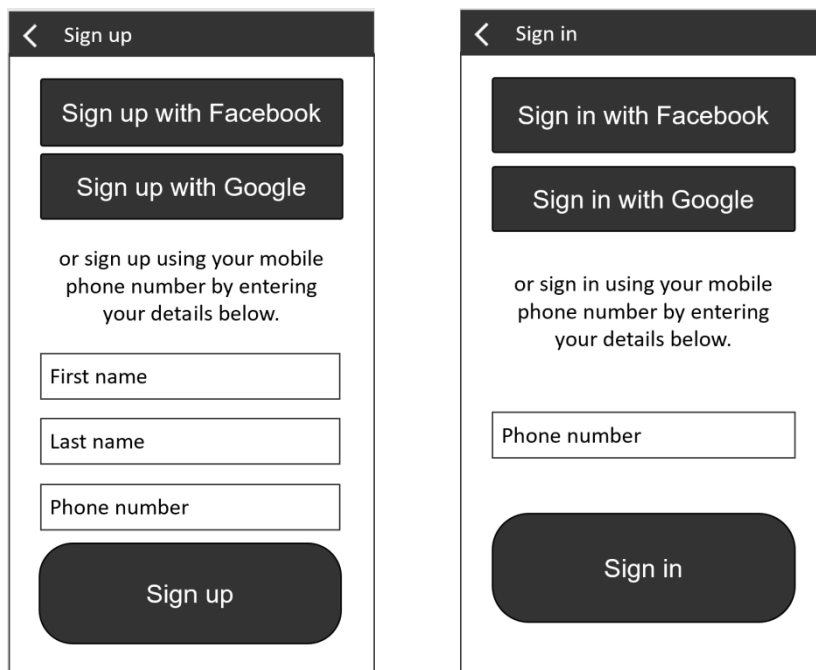


Figure B.2 Sign up and sign in main screens.

Appendix B

Find Event

Enter the location, the activity and time of event that you would like to find below:

Location:

Activity:

Activity Start Time:

Activity End Time:

Find

Find event

Find coach

Activity List

Find Event

Learn Blind Tennis
Date: 17 July
Time: 6.00pm - 8.00pm
Location: Islington Tennis Centre (ITC), Market Road, London

Learn Blind Tennis
Date: 17 July
Time: 6.00pm - 8.00pm
Location: Islington Tennis Centre (ITC), Market Road, London

Learn Blind Tennis
Date: 17 July
Time: 6.00pm - 8.00pm
Location: Islington Tennis Centre (ITC), Market Road, London

Learn Blind Tennis
Date: 17 July
Time: 6.00pm - 8.00pm
Location: Islington Tennis Centre (ITC), Market Road, London

Find event

Find coach

Activity List

Figure B.3 Find event: Search and list of events' screens.

Event Information

Event Details

Find coach for this event

Find transport for this event

Time:

Add to Calendar

Cost:

Address:

Phone:

Call Now

Find event

Find coach

Activity List

Figure B.4 Event information screen

Find coach

Enter the location and the activity to find a coach for it:

Location:
London

Activity:
Any activity

Find

Find event Find coach Activity List

Figure B.5 Find coach: main search screen.

Find Coach

Enter the location and the activity to find a coach for it:

← London

London UK

London Road Southampton, UK

London Heathrow Airport Longford, UK

London Euston London, UK

London Luton Airport Airport Way, Luton, UK

Find coach

Enter the location and the activity to find a coach for it:

Activity Location:
London

← Any activity

Any Activity

Archery

Bowls

Cricket

Cycling

Football

Figure B.6 Find coach: Location and activity selection screens.

Appendix B

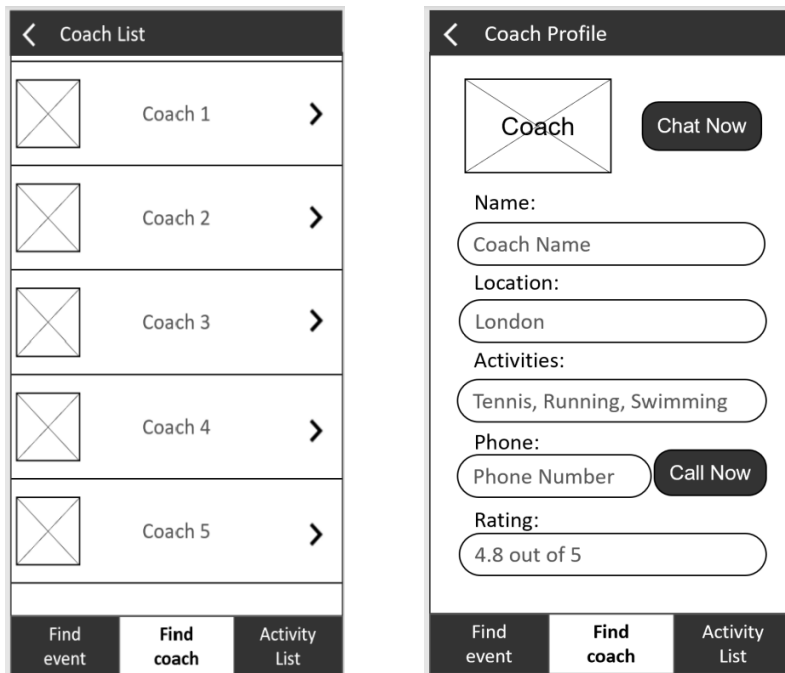


Figure B.7 Coach list and coach profile screens

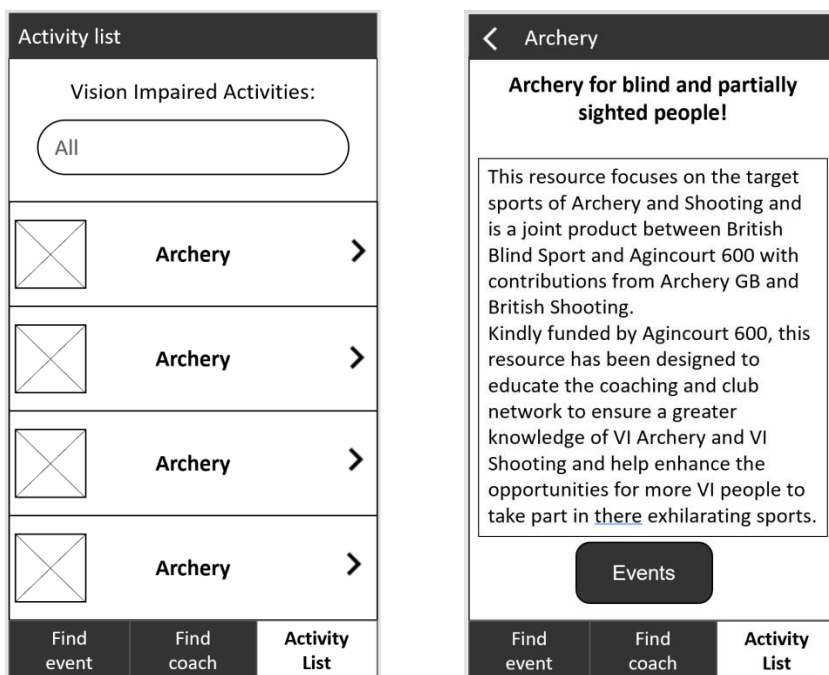


Figure B.8 Activity list: List of VI sports' screen and selected activity information screen

Appendix C Interview questions about Mid-fidelity prototype

1. What do you think about this app?
2. What do you think is this app for? How would you describe this app in your own words?
3. Do you like to receive reminders, suggestions and advice from others?
4. Would you like to get reminders, suggestions and advice of sport and physical activities on your mobile phone?
5. When you are signing up in this app, would you like to give more information about you? E.g. saying what your needs and requirements are for doing sport or physical activity. Would you like to share it with coaches in the app?
6. Would you like to add something in this app? What do you prefer to have on this app?
7. What do you need to do more physical activity or sport?
8. Would you like to have more features in this app like online community?
9. Would you like to find a partner to do physical activities in this app?
10. Would you like to learn more about sport and physical activity through this app?

Appendix D

Screenshots of Active VI app

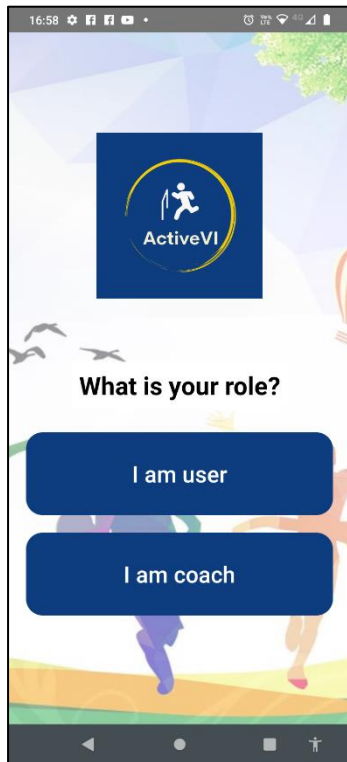


Figure D.1 Screenshot of initial screen of the ActiveVI app

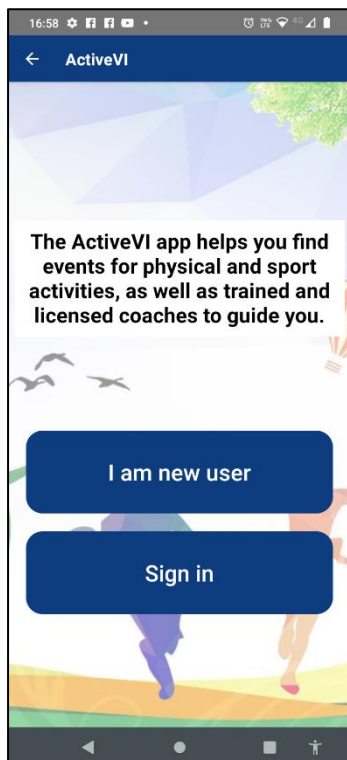


Figure D.2 Screenshot of sing up and sign in options.

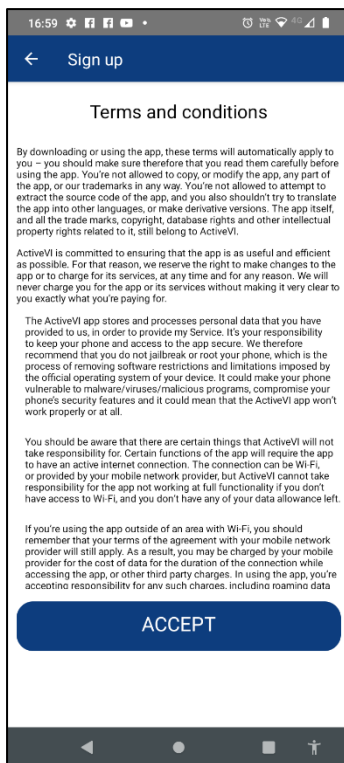


Figure D.3 Screenshot of terms and conditions of ActiveVI app

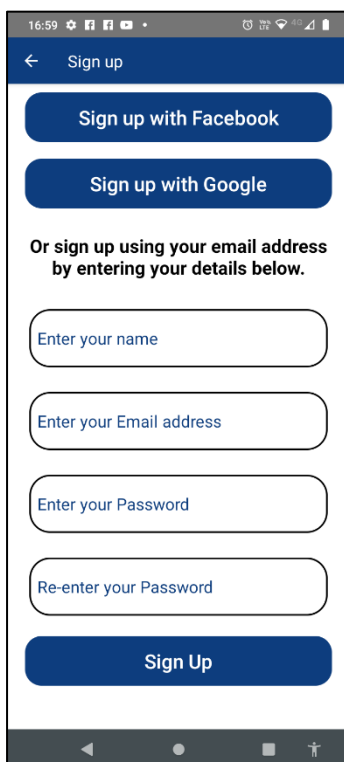


Figure D.4 Screenshot of sign-up details

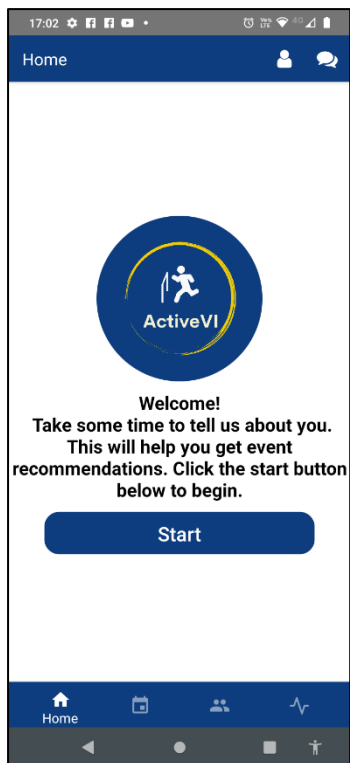


Figure D.5 Screenshot of the welcome page



Figure D.6 Screenshot of a question about physical activity

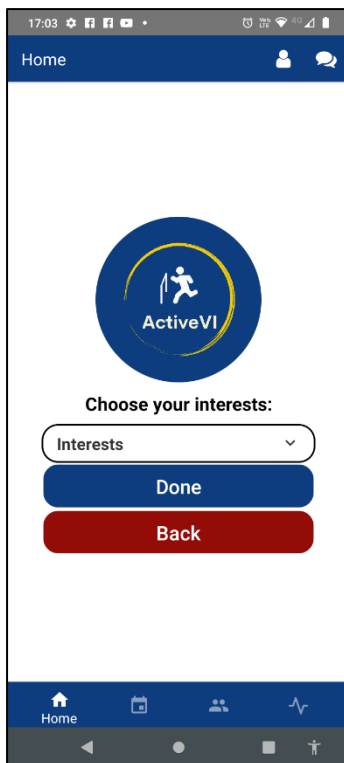


Figure D.7 Screenshot of the selection of user's interest in VI sports

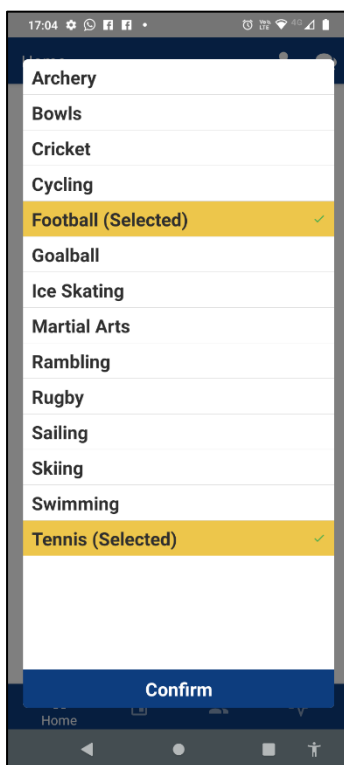


Figure D.8 Screenshot of a list of VI sports to the user select their interests.



Figure D.9 Screenshot of a list of VI sports' recommendations

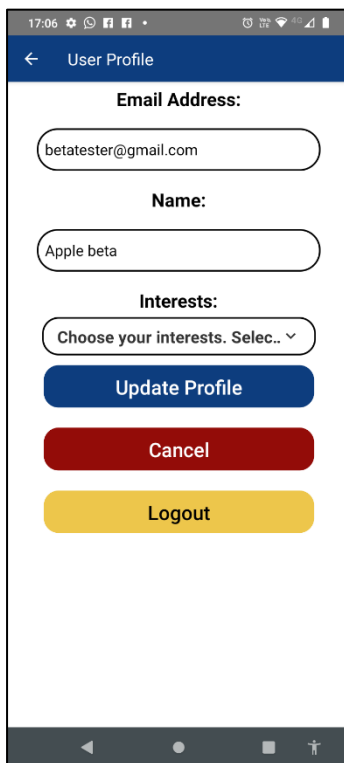


Figure D.10 Screenshot of user profile

The screenshot shows a mobile application interface for finding events. At the top, there is a blue header with the text 'Find Event' and two icons: a person and a speech bubble. Below the header, the text 'Choose the location, the activity and date of event that you would like to find below:' is displayed. There are three input fields: 'Location' with the text 'London', 'Activity' with the text 'Goalball', and 'Event Month' with the text 'August'. Below these fields is a yellow button with the text 'Find Event'. At the bottom of the screen is a blue navigation bar with four icons: a home icon, a calendar icon labeled 'Find Event', a group of people icon, and a pulse line icon.

Figure D.11 Screenshot of search for VI sport event

The screenshot shows a mobile application interface for a list of events. At the top, there is a blue header with a back arrow and the text 'Event List'. Below the header, there are three event cards. Each card has a title, a date, a location, a time, and a link to more details. The events are: 'Junior Goalball' (Date: Friday, July 21st 2023, Location: London, Time: 10:00), 'Goalball in Croydon' (Date: Friday, July 21st 2023, Location: London, Time: 17:30), and 'Goalball' (Date: Friday, July 21st 2023, Location: London, Time: 18:00). Below the event cards is a colorful abstract graphic with a rainbow and a blue shape. At the bottom of the screen is a blue navigation bar with four icons: a home icon, a calendar icon labeled 'Find Event', a group of people icon, and a pulse line icon.

Figure D.12 Screenshot of a list of events of a VI sport

← Event Details

Junior Goalball

New Junior Goalball Sessions Join us as we learn the basics of goalball and put our new found skills to the test with matches against each other. Working with Goalball UK, you'll be taught by the experts to attack and defend in this indoor, 3-side team sport.

Find coach for this event

Time:

10:00 AM - 12:00 PM

Add event to calendar

Cost:

Not given

Home Find Event People Heart

Figure D.13 Screenshot of information about a VI sport (part 1)

← Event Details

Cost:

Not given

Address:

Our Lady's High School, 6-16 Amhurst Park, London, N16 5AF

Find transport

Email Address:

ginisha.vekaria@rsbc.org.uk

Phone:

+447775218579

Call Now

Home Find Event People Heart

Figure D.14 Screenshot of information about a VI sport (part 2)

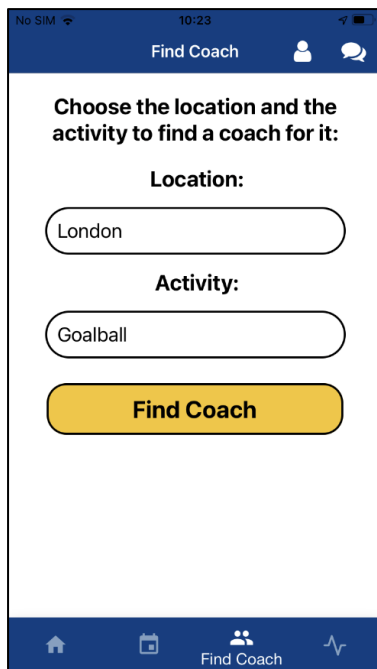


Figure D.15 Screenshot of search for a coach



Figure D.16 Screenshot of a list of coaches

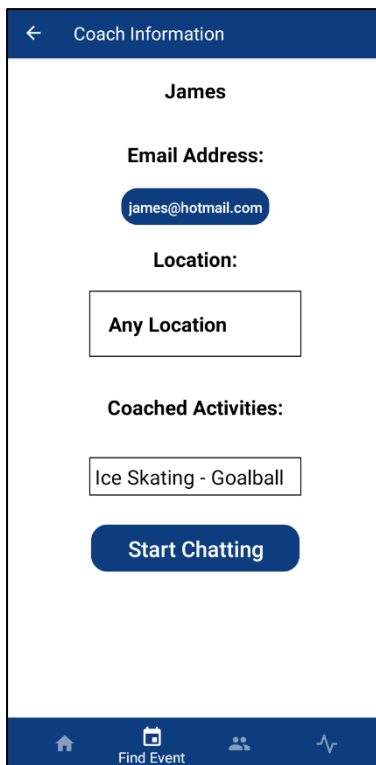


Figure D.17 Screenshot of a coach profile

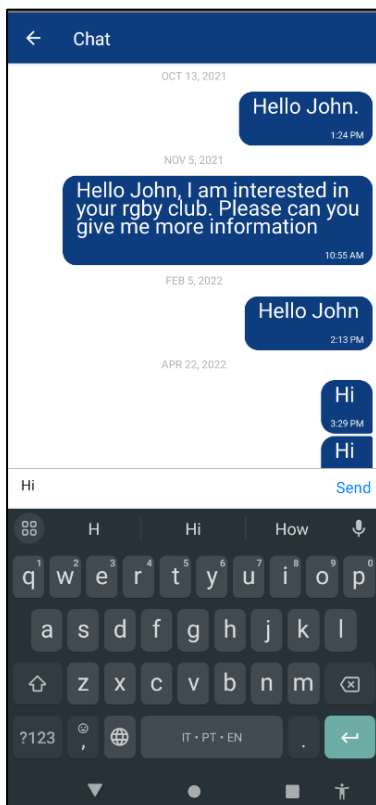


Figure D.18 Screenshot of a chat sent to a coach.

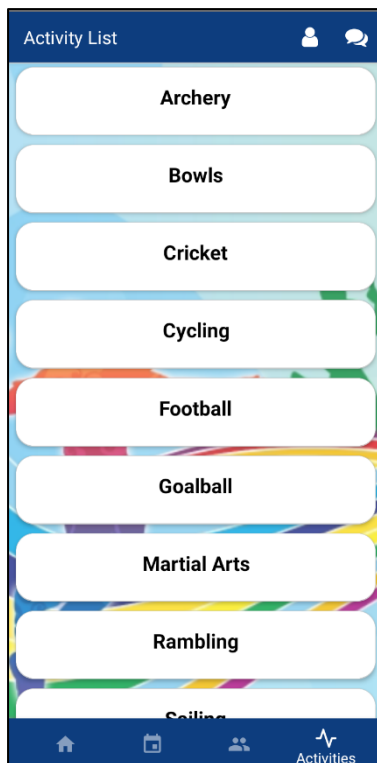


Figure D.19 Screenshot of a list of VI sports

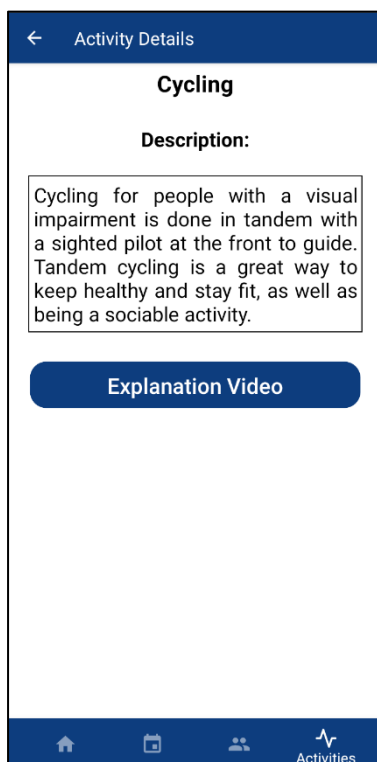


Figure D.20 Screenshot of a VI sport description and video's button

Appendix E Automated and manual accessibility testing

E.1 Automated testing: Accessibility Inspector

Table E.1 Sample: Sign up screen

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Hit area	Back button	Run Audit	Failed	2.5.5 Target Size	The size is 48x26	It should be at least 44 x 44 CSS pixels.
Dynamic text	Text field	Run Audit	Failed	1.4.4 Resize text	This text does not support dynamic type.	Consider using a UIFont preferred font and setting adjustsFontForContentSizeCategory to YES
Inspected elements	Sign Up buttons	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need to add the word 'button' in the label. Missing out the trait button. 'The type of information is contained in the traits attribute of the element and should never be repeated in the label' (Accessibility programming guide for iOS).	Add the trait only and not extra accessibility label
Inspected elements	Back button	Researcher Observation	Passed	4.1.2 Name, Role, Value	No comments	No comments
Inspected elements	Title header	Researcher Observation	Passed	4.1.2 Name, Role, Value	No comments	No comments

Table E.1 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Inspected elements	Static text	Researcher Observation	Failed	4.1.2 Name, Role, Value	The type of information is contained in the traits attribute of the element and should never be repeated in the label' (Accessibility programming guide for iOS).	No need to add the word 'label' in the AccessibilityLabel. Add the trait button only.
Inspected elements	Static text	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the word 'editbox' and the text 'double tap to enter text'.	No need to add the word 'editbox' and 'double tap to enter text' in the AccessibilityLabel. Add the trait button only.
Inspected elements	Text field	Researcher Observation	Passed	1.3.1 Info and Relationships	No required fields to fill in. Adjusting bold is a technique, the text inserted in the text fields becomes bold when the Bold Text is activated.	No comments
Inspected elements	Text field	Researcher Observation	Passed	1.3.2 Meaningful Sequence	No comments	No comments
Inspected elements	Text field	Researcher Observation	Not present	1.3.5 Identity Input Purpose	No autocomplete. It is not possible to test on Accessibility Inspector.	No comments
Inspected elements	Text field	Researcher Observation	Not present	1.3.6 Identity Purpose	No comments	No comments
Inspected elements	Text field	Researcher Observation	Failed	1.4.1 Use of colour	No use of colour to indicate required fields.	Use colour to indicate required fields in an error collection bucket summary at the top of the screen and local (next) field level error messaging

Table E.1 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Inspected elements	Text field	Researcher Observation	Passed	2.4.3 Focus Order	Logical tab order	No comments
Inspected elements	Text field	Researcher Observation	Passed	2.4.6 Headings and Labels	Correct labels	No comments
Inspected elements	Text field	Researcher Observation	Passed	2.5.3 Label in Name	'In the absence of any other nearby text string (as described in the preceding list), if an input contains placeholder text, such text may be a candidate for Label in Name.'	No comments
Additional Inspector settings	All	Researcher Observation	Failed	1.4.1 Use of colour	No comments	No comments
Additional Inspector settings	All	Researcher Observation	Failed	1.4.3 Colour contrast	Does not increase contrast.	Allow the user interface to change the colour contrast
Additional Inspector settings	All	Researcher Observation	Passed	Invert colour	It reverts the colours in the screen.	No comments
Colour contrast calculator (CCC)	All	CCC	Passed	1.4.6 Colour contrast	13.3:1 for blue background and white text; 21.0:1 for white background and black text; The text inserted in the text fields becomes bold when the Bold Text is activated.	No comments

Table E.1 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Environment Overrides	screen	Environment Overrides	Failed	Dark Mode	It does not change the colour of the background and elements on the screen. When typing in the text fields, the characters do not appear.	Allow the user interface to swap the white background colour for black background
Environment Overrides	screen	Environment Overrides	Passed	Smart Invert	It changes the colour of the background and elements on the screen.	No comments
Orientation	screen	Simulator	Passed	1.3.4 Orientation	No comments	No comments

Table E.2 Sample: Find coach

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Hit area	Profile and chat buttons	Run Audit	Failed	2.5.5 Target size	Hit area is too small. The size is 48x26.	It should be at least 44 x 44 CSS pixels.
Dynamic text	Text field	Run Audit	Caution	1.4.4 Resize text	The text on the text boxes do not wrap properly. E.g. Select locatio-n, Southa-mpton, Manches-ter. In the menu list of activities, the words rambling and swimming are 'broken' e.g. ramblin-g, swimmi-ng. Font size doesn't adapt adequately in the location text field for Southampton and Manchester.	Allow all text wrap according to the chosen resize
Inspected elements	Title header	Researcher Observation	Failed	4.1.2 Name, Role, Value	The trait is set as Static Text.	Add the trait Header
Inspected elements	Profile button	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need to add the word 'button' in the label. Missing out the trait button. 'The type of information is contained in the traits attribute of the element and should never be repeated in the label' (Accessibility programming guide for iOS).	Add the trait Button

Table E.2 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Inspected elements	Chat button	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need to add the word 'button' in the label. Missing out the trait button. 'The type of information is contained in the traits attribute of the element and should never be repeated in the label' (Accessibility programming guide for iOS).	Add the trait Button
Inspected elements	Introduction text	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need to add the word 'label' in the label.	Add the trait Static text
Inspected elements	Location and activity text	Researcher Observation	Passed	4.1.2 Name, Role, Value	Correct label and trait.	No comments
Inspected elements	Text field	Researcher Observation	Failed	4.1.2 Name, Role, Value	Remove the text 'double tap to see the list of locations' in the label. It should be a Hint.	Add in the Hint trait brief indication of user action
Inspected elements	Select location	Researcher Observation	Failed	4.1.2 Name, Role, Value	No traits in the elements of locations, activities, and the cancel button. No need of the text 'double tap to select' and 'double tap to activate.	It should be only the location name, and the word 'cancel' for the Button trait
Inspected elements	Find coach button	Researcher Observation	Failed	4.1.2 Name, Role, Value	The trait is set as Static Text. It could be added the Button.	Add the trait Button
Inspected elements	Find coach tab	Researcher Observation	Failed	4.1.2 Name, Role, Value	Remove the text 'Tab three out of four' in the label. It should be a Hint.	Add the trait Hint

Table E.2 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Additional Inspector settings	All	Researcher Observation	Not present	1.4.1 Use of colour	No comments	No comments
Additional Inspector settings	All	Researcher Observation	Failed	1.4.3 Colour contrast (Minimum)	Does not increase contrast.	Allow the user interface to change the colour contrast
Additional Inspector settings	All	Researcher Observation	Passed	Invert colour	No comments	No comments
Colour contrast calculator (CCC)	All	CCC	Passed	1.4.6 Colour contrast (Enhanced)	11.7:1 Yellow background and black text for button. 21.0:1 for white background and black text. 13.3:1 for heading colour contrast. 13.0:1 for tab text (Find coach)	No comments
Environment Overrides	screen	Environment Overrides	Failed	Dark Mode	It does not change the colour of the background and elements on the screen. The selected text in the combo boxes does not appear	Allow the user interface to swap the white background colour for black background
Environment Overrides	screen	Environment Overrides	Passed	Smart Invert	It changes the colour of the background and elements on the screen.	No comments
Orientation	screen	Simulator	Passed	1.3.4 Orientation	No comments	No comments

Table E.3 Sample: Event details

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Inspected elements	Event list back button	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the words 'event list' in the label	Only the work 'back' is enough.
Inspected elements	Title header	Researcher Observation	Passed	4.1.2 Name, Role, Value	Correct label. Missing one trait. The trait is set as Static Text. It could be added the Header.	No comments
Inspected elements	Event name	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the words 'event name' in the label.	Only the name of the event is enough
Inspected elements	Event description	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the 'event description' in the label.	Remove the label 'event description' in the screen and AccessibilityLabel
Inspected elements	All buttons	Researcher Observation	Failed	4.1.2 Name, Role, Value	Incorrect label. Missing traits. Missing the Button trait.	No need of the word 'Button' in the label, as well as the text 'for this event. Double tap to activate'.
Inspected elements	All labels	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the word 'Label' in the label, as well as the text 'below you can find the...'.	Remove the words 'label' and in the phrase 'below you can find the' in the AccessibilityLabel
Inspected elements	Time, cost, address, email address, phone number	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the text 'Time: from', 'event cost', 'event address' in the label.	Remove the unnecessary words in the AccessibilityLabel
Inspected elements	Email address link	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the text 'double tap to send an email'. Missing a Link trait.	Add Link trait and remove the unnecessary words in the AccessibilityLabel

Table E.3 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Inspected elements	Find event tab	Researcher Observation	Caution	4.1.2 Name, Role, Value	Incorrect label. Correct traits.	Remove the text 'Tab two out of four' in the label. It should be a Hint.
Additional Inspector settings	All	Researcher Observation	Not present	1.4.1 Use of colour	No comments	No comments
Additional Inspector settings	All	Researcher Observation	Caution	1.4.4 Resize text	Font size doesn't adapt adequately in the 'Find transport' button, e.g. 'Find transport-t'.	Set the <code>adjustsFontForContentSizeCategory</code> to YES
Additional Inspector settings	All	Researcher Observation	Failed	1.4.3 Colour contrast	Does not increase contrast	Allow the user interface to change the colour contrast
Additional Inspector settings	All	Researcher Observation	Passed	Invert colour	User interface inverts colours	No comments
Colour contrast calculator (CCC)	All	CCC	Passed	1.4.6 Colour contrast	13.1:1 for 'Event List' back button; 13.3:1 for blue background and white text; 21.0:1 for white background and black text;	No comments
Environment Overrides	screen	Environment Overrides	Failed	Dark Mode	It does not change the colour of the background and elements on the screen.	Allow the user interface to swap the white background colour for black background
Environment Overrides	screen	Environment Overrides	Passed	Smart Invert	It changes the colour of the background and elements on the screen.	No comments
Orientation	screen	Simulator	Passed	1.3.4 Orientation	No comments	No comments

Table E.4 Sample: Activity list screen

Features	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Hit area	Profile and chat buttons	Run Audit	Failed	2.5.5 Target size	Hit area is too small. The size is 48x26.	It should be at least 44 x 44 CSS pixels.
Potentially inaccessible text	List of buttons	Run Audit	Failed	1.3.1 Info and Relationships	This element appears to display text that should be represented using the accessibility API.	Determine if any part of the content should be exposed as separate accessibility children.
Inspected elements	Title header	Researcher Observation	Caution	4.1.2 Name, Role, Value	Correct label. Missing one trait. The trait is set as Static Text.	Add the trait, Header.
Inspected elements	All buttons	Researcher Observation	Failed	4.1.2 Name, Role, Value	No need of the word 'Button' in the label, as well as the text 'Double tap to activate'. Missing the Button trait.	Add the trait Button. Remove the unnecessary in the AccessibilityLabel
Inspected elements	Activity tab	Researcher Observation	Caution	4.1.2 Name, Role, Value	Incorrect label. Correct traits.	Remove the text 'Tab four out of four' in the label. It should be a Hint.
Additional Inspector settings	All	Researcher Observation	Not present	1.4.1 Use of colour	Does not invert colours	No instructions or elements that would rely on colour and more information.
Additional Inspector settings	All	Researcher Observation	Caution	1.4.4 Resize text	Font size doesn't adapt adequately for two words, e.g. Ramblin-g, swimmi-ng.	Set the adjustsFontForContentSizeCategory to YES
Additional Inspector settings	All	Researcher Observation	Failed	1.4.3 Colour contrast	Does not increase contrast	Allow the user interface to change the colour contrast
Additional Inspector settings	All	Researcher Observation	Passed	Invert colour	No comments	No comments

Table E.4 Continued

Features	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Colour contrast calculator (CCC)	All	CCC	Passed	1.4.6 Colour contrast	13.3:1 for blue background and white text; 21.0:1 for white background and black text;	No comments
Environment Overrides	screen	Environment Overrides	Failed	Dark Mode	It does not change the colour of the background and elements on the screen.	Allow the user interface to swap the white background colour for black background
Environment Overrides	screen	Environment Overrides	Caution	Smart Invert	It changes the colour of the background and elements on the header and tabs areas. The table list (buttons) does not change.	Allow the buttons to invert colours
Orientation	screen	Simulator	Passed	1.3.4 Orientation	No comments	No comments

Table E.5 Sample: Chat screen

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Hit area	Text message box (text field)	Run Audit	Failed	2.5.5 Target size	Hit area is too small. The current size is 380x33.	It is suggested to increase height above 44.
Element has no description	Text message box (text field)	Run Audit	Failed	4.1.2 Name, Role, Value	Missing useful accessibility information. Missing accessibility label	Add a single word to describe the message box in the AccessibilityLabel
Inspected elements	Back button	Researcher Observation	Passed	4.1.2 Name, Role, Value	Correct label and trait	No comments
Inspected elements	Title header	Researcher Observation	Caution	4.1.2 Name, Role, Value	Correct label. Missing one trait. The trait is set as Static Text. It could be added the Header.	Add the trait, Header.
Inspected elements	Labels	Researcher Observation	Caution	4.1.2 Name, Role, Value	Correct label date/time. Missing the traits.	Add the trait Static text
Additional Inspector settings	All	Researcher Observation	Not present	1.4.1 Use of colour	Does not invert colours	No instructions or elements that would rely on colour and more information.
Additional Inspector settings	All	Researcher Observation	Failed	1.4.4 Resize text	Font size doesn't adapt adequately	Set the adjustsFontForContentSizeCategory to YES
Additional Inspector settings	All	Researcher Observation	Failed	1.4.3 Colour contrast	Does not increase contrast	Allow the user interface to change the colour contrast
Additional Inspector settings	All	Researcher Observation	Passed	Invert colour	No comments	No comments

Table E.5 Continued

Feature	Elements	Audit	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Colour contrast calculator (CCC)	Message	CCC	Passed	1.4.6 Colour contrast	13.3:1 for blue background and white text	No comments
Environment Overrides	Date and time label	CCC	Failed	1.4.3/6 Colour contrast	13.3:1 for blue background and white text (passed) / 2.5:1 for the date and time label (failed)	Increase the font size and colour contrast of the date and time
Environment Overrides	screen	Dark Mode	Failed	Dark Mode	It does not change the colour of the background and elements on the screen.	Allow the user interface to swap the white background colour for black background
Environment Overrides	screen	Smart Invert	Passed	Smart Invert	It changes the colour of the background and elements on the screen.	No comments
Orientation	screen	Simulator	Passed	1.3.4 Orientation	No comments	No comments

E.2 Automated testing: Accessibility Scanner

Table E.6 Sample: Sign up screen

Feature	Elements	Alert	WCAG 2.1 SC	Comments:	Expected Outcomes (Recommendations)
Touch target	Back button	Failed	2.5.5 Target size	Item size is 30dp x 30dp	Consider increase the touch area to 48dp x 48dp
Item type label	Buttons	Failed	4.1.2 Name, Role, Value	The alert applies for all buttons. This item's android:contentDescription, 'Button. Sign up with (Facebook/Google/Sign Up). Double tap to; activate.,' contains the item type 'button'; contains the action 'tap'.	Remove unnecessary text about type (button) or state (tap) within the label
Item type label	Text field	Failed	4.1.2 Name, Role, Value	The alert applies for all text fields. This item's android:contentDescription, 'Enter your (name/email address/password). editbox. double tap to enter text, ', contains the action 'tap'.	Remove unnecessary text about type (editbox) or action (tap) within the label

Table E.7 Sample: Find coach screen

Feature	Elements	Alert	WCAG 2.1 SC	Comments:	Expected Outcomes (Recommendations)
Touch target	Profile and chat buttons	Failed	2.5.5 Target size	This item's height is 26dp.	Consider making the height of this touch target 48dp or larger.
Item type label	Profile, chat buttons and 'find coach' button	Failed	4.1.2 Name, Role, Value	This item's android:contentDescription, 'Profile button/My Chats button. Double tap to go to your profile/chats.', contains the item type 'button'; contains the action 'tap'.	Remove unnecessary text about type (button) or action (tap) within the label
Item type label	Text fields	Failed	4.1.2 Name, Role, Value	This item's android:contentDescription, 'Selected: London; Double tap to see the list of Locations, ', contains the state 'selected'; contains the action 'tap'.	Remove unnecessary text about state (selected) or action (tap) within the label
Text contrast	Tabs	Failed	1.4.3 Colour contrast/1.4.6	The item's text contrast ratio is 3.86. This ratio is based on an estimated foreground colour of #869EBF and an estimated background colour of #0D3D7E.	Consider using colours that result in a contrast ratio greater than 4.50 for small text, or 3.00 for large text. This item may be obscured by other on-screen content. Consider manually testing this item's contrast.

Table E.8 Sample: Event details

Feature	Elements	Alert	WCAG 2.1 SC	Comments:	Expected Outcomes (Recommendations)
Touch target	Back button	Failed	2.5.5 Target size	This item's size is 30dp x 30dp.	Consider making this touch target 48dp wide and 48dp high or larger.
Item type label	Buttons	Failed	4.1.2 Name, Role, Value	This item's android:contentDescription, contains the item type 'button' and contains the action 'tap'.	Remove unnecessary text about type (button) or action (tap) within the label
Text contrast	Tabs	Failed	1.4.3 Colour contrast/1.4.6	The item's text contrast ratio is 3.86. This ratio is based on an estimated foreground colour of #869EBF and an estimated background colour of #0D3D7E.	Consider using colours that result in a contrast ratio greater than 4.50 for small text, or 3.00 for large text. This item may be obscured by other on-screen content. Consider manually testing this item's contrast.

Table E.9 Sample: Activity list

Feature	Elements	Alert	WCAG 2.1 SC	Comments:	Expected Outcomes (Recommendations)
Touch target	Profile and chat buttons	Failed	2.5.5 Target size	This item's height is 26dp.	Consider making the height of this touch target 48dp or larger.
Item type label	Profile and chat buttons	Failed	4.1.2 Name, Role, Value	This item's android:contentDescription, 'Profile button/My Chats button. Double tap to go to your profile/chats.', contains the item type 'button'; contains the action 'tap'.	Remove unnecessary text about type (button) or action (tap) within the label
Item type label	Buttons	Failed	4.1.2 Name, Role, Value	This item's android:contentDescription, 'Button (*activity name). double tap to activate.', contains the item type 'button'; contains the action 'tap'.	Remove unnecessary text about type (button) or action (tap) within the label
Text contrast	Tabs	Failed	1.4.3 Colour contrast/1.4.6	The item's text contrast ratio is 3.86. This ratio is based on an estimated foreground colour of #869EBF and an estimated background colour of #0D3D7E.	Consider using colours that result in a contrast ratio greater than 4.50 for small text, or 3.00 for large text. This item may be obscured by other on-screen content. Consider manually testing this item's contrast.

Table E.10 Sample: Chat screen

Feature	Elements	Alert	WCAG 2.1 SC	Comments:	Expected Outcomes (Recommendations)
Touch target	Back button	Failed	2.5.5 Target size	This item's size is 30dp x 30dp.	Consider making this touch target 48dp wide and 48dp high or larger.
Editable item label	Text message box	Failed	4.1.2 Name, Role, Value	This editable TextView has an android:contentDescription. A screen reader may read this attribute instead of the editable content when the user is navigating.	Add descriptive label informing its purpose and hint
Text contrast	Date and time	Failed	1.4.3 Colour contrast/1.4.6	The item's text contrast ratio is 2.12. This ratio is based on an estimated foreground colour of #B2B2B2 and an estimated background colour of #FFFFFF.	Consider using colours that result in a contrast ratio greater than 4.50 for small text, or 3.00 for large text.

E.3 Manual testing: iOS

Table E.11 Sample: Sign up

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
VoiceOver	Passed	1.3.1 Info and Relationships	All elements have label, and it is described by the VoiceOver.	No recommendations
VoiceOver	Passed	1.3.2 Meaningful Sequence	Logical sequence working fine.	No recommendations
Not present	Not present	1.3.3 Sensory Characteristics	No comments	No recommendations
Screen	Passed	1.3.4 Orientation	No comments	No recommendations
Form Inputs	Not present	1.3.5 Identity Input Purpose	The virtual keyboard is enabled. However, by placing the cursor inside the input field the keyboard does not change to have the @ key. The autocomplete function is not available, which is not applicable to native mobile apps.	No recommendations
Icons and Links	Not present	1.3.6 Identity Purpose	No icons or symbols on the screen that would require a label.	No recommendations
Form Inputs	Not present	1.4.1 Use of colour	There is no message indicating the required fields on the screen. The textfields show a black border focus when it is activated.	No recommendations
Built-in speech	Failed	1.4.2 Audio Control	Built-in speaking overlaps VoiceOver speak output. The built-in speak output gives brief summary of the screen. However, it is not easy to understand because it overlaps with what VoiceOver reads on the screen.	Remove the built-in speak output.

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Text field	Failed	1.4.3 Contrast (Minimum)	It does not change the contrast when it is enabled on the iPhone accessibility settings.	Create a control on the screen to change the contrast.
Dark Mode	Failed	1.4.3 Contrast (Minimum)	It does not change the colour of the background and elements on the screen. The text field does not appear.	Allow the user interface to swap the white background colour for black background
Smart Invert	Passed	1.4.3 Contrast (Minimum)	It passes on screens without image. This function does not invert colours of images and media.	No recommendations
Classic Invert	Passed	1.4.3 Contrast (Minimum)	By activating the Classic Invert option on Display & Text Size on iPhone Accessibility Settings.	No recommendations
Text	Passed	1.4.4 Resize text	The user can scroll up and down using the two fingers.	No recommendations
Dynamic Text	Failed	1.4.4 Resize text	Font size in the buttons does not adapt adequately. The body text does wraps properly. There is no custom control to select the size on the screen.	Create a control on the screen to change the font size. Make sure font size adapts in the buttons
Not present	Not present	1.4.5 Images of text	No comments	No recommendations
Screen	Failed	1.4.6 Contrast (Enhanced)	It does not change the contrast when it is enabled on the iPhone accessibility settings.	Create a control on the screen to change the contrast.
Not present	Not present	1.4.7 Low or No background Audio	No comments	No recommendations
Screen	Failed	1.4.8 Visual Presentation	Not possible to customise/select background and foreground colours. Neither to resize the text on the screen.	Create a control on the screen to change the colours and font size.

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	1.4.9 Images of Text	No comments	No recommendations
Text	Passed	1.4.10 Reflow	It automatically reflows the body text according to the pre-defined resize setting on the mobile device.	No recommendations
Text field	Failed	1.4.11 Non-text Contrast	It does not show or highlight visually the focus on the text field when not using the VoiceOver. But the cursor provides visual indication. The border must meet 3:1 contrast ratio, which can be checked on Accessibility. On Accessibility Inspector, the colour contrast says 21:0.1 Inspector.	Highlight the text field that requires an input when using or not using the screen reader.
Text	Not present	1.4.12 Text Spacing	Does not provide a control for users to make changes. It does not require that content implement its own mechanisms to allow users to do this. It is not a failure of the content if a user agent or platform does not provide a way for users to do this.	No recommendations
Not present	Not present	1.4.13 Content on Hover or Focus	It does not apply to the content.	No recommendations

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	Enabled the 'Full keyboard access' on the iPhone Accessibility Settings. By using the tab key, the focus moved from the back button to the screen view only. By using the left and right arrow keys, it allows navigation by moving between the buttons and the text fields, which in turn highlighted these elements with a black line, but after pressing the Tab key the blue highlight appears and then disappears. The user can activate an option (e.g. a button) and the textfields by using the space bar. The use of the space bar can be changed on Accessibility settings. While typing a name or password the cursor focus goes away, then the user cannot use the down arrow key to move to the next text field. The user has to press the tab key to get the screen view highlighted, and the respective text field enabled by the focus, then press the tab key again to navigate to the back button (with focus) and then press the arrow key to move to the next text field where the user can start typing or select a button. The static text is not highlighted when navigating through the screen. The user cannot sign up with Google account in the Google sign in screen using the VoiceOver and the external keyboard at the same time. It is possible to select the Google account to sign up using the external keyboard only.	The user should be able to navigate using the Tab key/gesture to each element on the screen, for example, Sign up buttons, name, email address, password.

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.2 No keyboard trap	If the user gets an error or missing message (pop up window), the user cannot close the pop-up window while using the external keyboard by pressing the Tab or Up and Down arrow keys.	The user should be able to navigate using the Tab key/gesture to reach the pop-up window and close it by pressing the Okay button using the Tab key.
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
Speech Input/Voice Recognition	Not present	2.1.4 Character Key Shortcuts	It does not apply to the content. It supports speech input.	No recommendations
Not present	Not present	2.2 Enough Time (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.3 Seizures and Physical Reactions (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.2.5 Re-authenticating	It does not apply to the content.	No recommendations

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
VoiceOver and External keyboard	Caution	2.4.3 Focus Order	By using the VoiceOver, it passed. It failed when using the external keyboard. By pressing the Tab key, the main screen and the first button (Sign Up with Facebook) are blue highlighted and pressing the Tab key again the focus goes to the Back button only. By pressing the down arrow key, the focus moves to the next button and skips the text, and the focus moves through text fields up to Sign Up button. It goes backwards using the up-arrow key. By pressing the Tab key, then the focus goes to the Back button. If the button Sign Up with Google is highlighted, the user can press the space bar and can sign in using their account. If the user wanted to fill in the text field, the user needs to press the space bar to enable the cursor to start typing the text and press enter to move to other text field.	Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
Not present	Not present	2.4.4 Link Purpose (In context)	It does not apply to the content.	No recommendations
Header title and labels	Passed	2.4.6 Headings and Labels	Content of the labels and the header title are clear and descriptive.	No recommendations
External keyboard	Failed	2.4.7 Focus Visible	The text field and buttons are not receiving focus, for example, the text fields are not displaying a vertical bar or not highlighted indicating the user can type in, the buttons are displaying a visible border highlighting it to indicate the user can type in.	Text fields and buttons should receive focus when using an external keyboard, by displaying a vertical bar in the text field or highlighting the text to indicate the user can start typing, and by highlighting the buttons through a visible border around the button.
Screen	Passed	2.4.8 Location	No comments	No recommendations

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	2.4.9 Link Purpose (Link Only)	It does not apply to the content.	No recommendations
Not present	Not present	2.4.10 Section Headings	It does not apply to the content.	No recommendations
Speech Input/Voice Recognition	Not present	2.5.3 Label in Name	The visible text label matches the accessible name. However, this criterion refers to speech input, which does not apply to the app.	No recommendations
Back button	Failed	2.5.5 Target Size	Assessment done on Accessibility Inspector	The size is 48x26.It should be at least 44 x 44 CSS pixels.
External keyboard	Passed	2.5.6 Concurrent Input Mechanisms	No comments	No recommendations
Not present	Not present	3.1.1 Language of page	It does not apply to the content.	No recommendations
	Passed	3.2.1 On Focus	It does not apply to the content. A UI receives focus and does not initiate a change of context.	No recommendations
Form Inputs	Passed	3.2.2 In Focus	Form does not auto-submit when all fields are completed, and the focus does not jump to the next field.	No recommendations
Form Inputs	Passed	3.2.5 Change on Request	Form does not auto-submit when all fields are completed.	No recommendations

Table E.11 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Form Inputs	Failed	3.3.1 Error Identification	It provides error messages by text and by speech (VoiceOver), such as 'please enter a valid name', 'please enter a valid email address' or 'please enter your email, which informs the incorrect or missing field. However, it does not provide more cues, such as a highlight for the incorrect or missing field. The focus from the screen does not move automatically to the pop-up window where the error message and the okay button are.	Highlight the text field that is missing an input or has an error, for example, displaying a red highlight around the text field. Make the focus to move from the screen to the pop-up window.
Form Inputs	Passed	3.3.2 Labels or Instructions	Controls and text field have labels.	No recommendations
Form Inputs	Failed	3.3.3 Error Suggestion	There is no suggestion to fix an error on an input.	Provide brief information on how to fix an error next to the input.
Form Inputs	Not present	3.3.4 Error Prevention (Legal, Financial, Data)	No comments	No recommendations
Form Inputs	Failed	3.3.6 Error Prevention (All)	By submitting data, the submission should be reversible, checked, and confirmed. This is not happening in the app.	Provide a summary of the submitted data for review and confirmation
VoiceOver	Caution	4.1.1 Parsing	All content is read. However, by deleting a character in the text field the VoiceOver does not read aloud which character is deleted. The on-screen keyboard is not fully accessible.	Implement accessible on-screen keyboard
VoiceOver	Passed	4.1.2 Name, Role, Value	UI element's role is announced.	No recommendations

Table E.12 Sample: Find coach

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
UI	Failed	1.1.1 Non-text Content	The icons (profile, chat) do not have a visible name near them.	Add a name below/beside the icons.
Not present	Not present	1.2 Time-based Media	No media present on the screen.	No recommendations
VoiceOver	Passed	1.3.1 Info and Relationships	All elements have label, and it is described by the VoiceOver.	No recommendations
VoiceOver	Passed	1.3.2 Meaningful Sequence	Logical sequence working fine.	No recommendations
Icons and Links	Failed	1.3.3 Sensory Characteristics	The icons for profile and chat on the top should have text label to these elements.	Provide text label alongside an icon
screen	Passed	1.3.4 Orientation	No comments	No recommendations
Form Inputs	Not present	1.3.5 Identity Input Purpose	Not applicable. This criterion only applies to inputs about the user. Also, it is not applicable to native mobile apps because there is no programmatic method.	No recommendations
Icons and Links	Failed	1.3.6 Identify Purpose	The icons for 'Profile' and 'Chat' does not have a label above or next to each of them.	Provide text label alongside an icon
Text field	Passed	1.4.1 Use of colour	No need of a message indicating the required fields on the screen. The combo boxes show a black border focus when it is activated.	No recommendations
Built-in speech	Failed	1.4.2 Audio Control	Built-in speaking overlaps VoiceOver speak output. The built-in speak output gives brief summary of the screen. However, it is not easy to understand because it overlaps with what VoiceOver reads on the screen.	Remove the built-in speak output.

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
All	Passed	1.4.3 Contrast (Minimum)	11.7:1 Yellow background and black text for button. 21.0:1 for white background and black text. 13.3:1 for heading colour contrast. 13.0:1 for tab text (Find coach)	No recommendations
Dark Mode	Failed	1.4.3 Contrast (Minimum)	It does not change the colour of the background and elements on the screen. The selected text in the combo boxes does not appear. Same result on Accessibility Inspector.	Allow the user interface to swap the white background colour for black background
Smart Invert	Caution	1.4.3 Contrast (Minimum)	It passes on screens without image.	No recommendations
Classic Invert	Passed	1.4.3 Contrast (Minimum)	No comments	No recommendations
Zoom	Passed	1.4.4 Resize text	All elements on the screen adapt adequately. Except for the 'Find coach' label below the icon, which label loss visibility.	No recommendations
Dynamic Text	Caution	1.4.4 Resize text	All elements on the screen adapt adequately. Except for the 'Find coach' label below the icon, which becomes a white line. Same results on Accessibility Inspector.	Create a control on the screen to change the font size. Make sure font size adapts in the buttons
Not present	Not present	1.4.5 Images of text	No comments	No recommendations
All	Passed	1.4.6 Contrast (Enhanced)	11.7:1 Yellow background and black text for button. 21.0:1 for white background and black text. 13.3:1 for heading colour contrast. 13.0:1 for tab text (Find coach)	No recommendations
Not present	Not present	1.4.7 Low or No background Audio	No comments	No recommendations

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
screen	Failed	1.4.8 Visual Presentation	Not possible to customise/select background and foreground colours. Neither to resize the text on the screen.	Create a control on the screen to change the colours and font size.
Not present	Not present	1.4.9 Images of Text	No comments	No recommendations
Text	Passed	1.4.10 Reflow	It automatically reflows the body text according to the pre-defined resize setting on the mobile device. However, the label 'find coach' above its icon on the tab disappears. In the pop-up window from the location combo box, the words Selection, Southampton and Manchester do not wrap appropriately.	No recommendations
Not present	Not present	1.4.11 Non-text Contrast	No comments	No recommendations
Not present	Not present	1.4.12 Text Spacing	Does not provide a control for users to make changes. It does not require that content implement its own mechanisms to allow users to do this. It is not a failure of the content if a user agent or platform does not provide a way for users to do this.	No recommendations
Not present	Not present	1.4.13 Content on Hover or Focus	It does not apply to the content.	No recommendations

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	By using the external keyboard, it was necessary to enable the 'Full keyboard access' on the iPhone Accessibility Settings. By using the tab key, the focus was moving back and forward (Tab+Shift) from the screen view to the four tabs (home, find event, etc.) and profile and chat buttons only. The user would be able to access the combo boxes from the highlighted screen view because the location combo box is highlighted by using the up and down arrow keys, it allows navigation by moving between the combo boxes and the find coach button. The user can select an option from the location and activity combo boxes by using the space bar. The use of the space bar can be changed on iPhone Accessibility settings. In addition, the static text and header are not highlighted when navigating through the screen, so it is not receiving focus. Once the use of up and down arrow keys is activated, the user can move the focus back and forward between the elements on the screen.	The user should be able to navigate using the Tab key/gesture to each element on the screen, for example, Sign up buttons, name, email address, password.
External keyboard	Not present	2.1.2 No keyboard trap	No comments	No recommendations
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Speech Input/Voice Recognition	Not present	2.1.4 Character Key Shortcuts	It does not apply to the content. It supports speech input.	No recommendations
Not present	Not present	2.2 Enough Time (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.3 Seizures and Physical Reactions (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.2.5 Re-authenticating	No comments	No recommendations
VoiceOver and External keyboard	Failed	2.4.3 Focus Order	The gesture focus is moving from the screen view and the Location combo box directly to the Home tab.	Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
Not present	Not present	2.4.4 Link Purpose (In context)	It does not apply to the content.	No recommendations
VoiceOver	Passed	2.4.6 Headings and Labels	Content of the labels and the header title are clear and descriptive.	No recommendations
External keyboard	Failed	2.4.7 Focus Visible	The combo boxes and find coach button on main screen are not receiving focus.	Components should receive focus when using an external keyboard, by highlighting the components through a visible border around them.

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
screen	Caution	2.4.8 Location	The header and tab named Find coach can visually let the user know where they are in the app, however it is may not be clear if the user is using the VoiceOver and the external keyboard, as the header does not receive focus when using the tab key on the external keyboard.	Apply consistent focus on all components
Not present	Not present	2.4.9 Link Purpose (Link Only)	It does not apply to the content.	No recommendations
Not present	Not present	2.4.10 Section Headings	It does not apply to the content.	No recommendations
Speech Input/Voice Recognition	Not present	2.5.3 Label in Name	The visible text label matches the accessible name. However, this criterion refers to speech input, which does not apply to the app.	No recommendations
All	Caution	2.5.5 Target Size	Large size for model selectors and button, and for bottom tab (e.g. Find coach). However, the icons profile and chats on the top are small - (Assessment done on Accessibility Inspector).	Profile and chat icons should be at least 44 x 44 CSS pixels.
External keyboard	Passed	2.5.6 Concurrent Input Mechanisms	No comments	No recommendations
Not present	Not present	3.1.1 Language of page	It does not apply to the content.	No recommendations
VoiceOver	Passed	3.2.1 On Focus	It does not apply to the content. A UI receives focus and does not initiate a change of context.	No recommendations

Table E.12 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Form Inputs	Passed	3.2.2 On Input	Form does not auto-submit when all fields are completed, and the focus does not jump to the next element once a selection is made on the model selector.	No recommendations
Form Inputs	Passed	3.2.5 Change on Request	Form does not auto-submit when all fields are completed.	No recommendations
Form Inputs	Not present	3.3.1 Error Identification	No comments	No recommendations
Form Inputs	Passed	3.3.2 Labels or Instructions	Controls and combo boxes have labels.	No recommendations
Not present	Not present	3.3.3 Error Suggestion	There is no suggestion to fix an error on an input.	No recommendations
Not present	Not present	3.3.4 Error Prevention (Legal, Financial, Data)	It does not apply to the content.	No recommendations
Not present	Not present	3.3.6 Error Prevention (All)	It does not apply to the content.	No recommendations
VoiceOver	Passed	4.1.1 Parsing	All content is read.	No recommendations
VoiceOver	Passed	4.1.2 Name, Role, Value	UI element's role is announced.	No recommendations

Table E.13 Sample: Event details

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	From 1.1 to 1.2.9	No text alternatives needed and no media present on the screen.	No recommendations
VoiceOver	Passed	1.3.1 Info and Relationships	All elements have label, and it is described by the VoiceOver.	No recommendations
VoiceOver	Passed	1.3.2 Meaningful Sequence	Logical sequence working fine.	No recommendations
Not present	Not present	1.3.3 Sensory Characteristics	No comments	No recommendations
Screen	Passed	1.3.4 Orientation	No comments	No recommendations
Form Inputs	Not present	1.3.5 Identity Input Purpose	Not applicable. This criterion only applies to inputs about the user. Also, it is not applicable to native mobile apps because there is no programmatic method.	No recommendations
Icons and Links	Caution	1.3.6 Identity Purpose	Icon and label for 'Find Event' are visible on the screen. However, when enabling 'Larger Text' on iOS Accessibility settings, the text below the icon does not appear.	Make sure text label of icons appears when increasing the font size
Not present	Not present	1.4.1 Use of colour	No need of a message indicating the required fields on the screen.	No recommendations
Built-in speech	Failed	1.4.2 Audio Control	Built-in speaking overlaps VoiceOver speak output. The built-in speak output gives brief summary of the screen. However, it is not easy to understand because it overlaps with what VoiceOver reads on the screen.	Remove the built-in speak output.
All	Passed	1.4.3 Contrast (Minimum)	13.1:1 for 'Event List' back button; 13.3:1 for blue background and white text; 21.0:1 for white background and black text;	No recommendations

Table E.13 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Dark Mode	Failed	1.4.3 Contrast (Minimum)	It does not change the colour of the background and elements on the screen. Same result on Accessibility Inspector.	Allow the user interface to swap the white background colour for black background
Smart Invert	Passed	1.4.3 Contrast (Minimum)	It passes on screens without image, while it fails when there is a background image.	No recommendations
Classic Invert	Passed	1.4.3 Contrast (Minimum)	No comments	No recommendations
Zoom	Failed	1.4.4 Resize text	The user cannot use the two fingers to scroll up and down to all elements on the screen.	Create a control on the screen to change the font size. Make sure font size adapts in the buttons
Dynamic Text	Failed	1.4.4 Resize text	Font size doesn't adapt adequately in the 'Find transport' button, e.g. 'Find transpor-t'. The label 'Find events' is not visible, it becomes a white line. The same results found on Accessibility Inspector.	Allow all text wrap according to the chosen resize
Not present	Not present	1.4.5 Images of text	No comments	No recommendations
All	Passed	1.4.6 Contrast (Enhanced)	13.1:1 for 'Event List' back button; 13.3:1 for blue background and white text; 21.0:1 for white background and black text;	No recommendations
Not present	Not present	1.4.7 Low or No background Audio	No comments	No recommendations
Screen	Failed	1.4.8 Visual Presentation	Not possible to customise/select background and foreground colours. Neither to resize the text on the screen.	Create a control on the screen to change the colours and font size.
Not present	Not present	1.4.9 Images of Text	No comments	No recommendations

Table E.13 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Text	Passed	1.4.10 Reflow	It automatically reflows the body text according to the pre-defined resize setting on the mobile device.	No recommendations
Text field	Failed	1.4.11 Non-text Contrast	It does not show or highlight visually the focus on the text field when not using the VoiceOver. But the cursor provides visual indication.	The border must meet 3:1 contrast ratio, which can be checked on Accessibility. On Accessibility Inspector, the colour contrast says 21:0.1 Inspector.
Not present	Not present	1.4.12 Text Spacing	Does not provide a control for users to make changes. It does not require that content implement its own mechanisms to allow users to do this. It is not a failure of the content if a user agent or platform does not provide a way for users to do this.	No recommendations
Not present	Not present	1.4.13 Content on Hover or Focus	It does not apply to the content.	No recommendations

Table E.13 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	By using the external keyboard, it was necessary to enable the 'Full keyboard access' on the iPhone Accessibility Settings. By using the tab key, the focus was moving back and forward (Tab+Shift) from the back button to the four tabs (home, find event, etc.) and the screen view only. When the screen view is highlighted, the find coach for this event is also highlighted and from that the user can use the up and down arrow keys, it allows navigation by moving back and forward between the buttons and the four tabs. The user can select an option from the location and activity model selectors by using the space bar. The use of the space bar can be changed on iPhone Accessibility settings. In addition, any static text and the header are not highlighted when navigating through the screen, so it is not receiving focus. Once the use of up and down arrow keys is activated, the user can move the focus back and forward between the elements on the screen.	The user should be able to navigate using the Tab key/gesture to each element on the screen, for example, Sign up buttons, name, email address, password. Provide focus to all elements.
External keyboard	Passed	2.1.2 No keyboard trap	No comments	No recommendations
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
Speech Input/Voice Recognition	Not present	2.1.4 Character Key Shortcuts	It does not apply to the content. It supports speech input.	No recommendations

Table E.13 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	2.2 Enough Time (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.3 Seizures and Physical Reactions (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.2.5 Re-authenticating	It does not apply to the content.	No recommendations
VoiceOver and External keyboard	Failed	2.4.3 Focus Order	The focus order is not following a logical order. The focus starts at back button and moves to the first tab or the last tab on the bottom of the screen and then it moves to the screen view where the user can access to the elements.	Apply reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
Not present	Not present	2.4.4 Link Purpose (In context)	It does not apply to the content.	No recommendations
VoiceOver	Passed	2.4.6 Headings and Labels	Content of the labels and the header title are clear and descriptive.	No recommendations
External keyboard	Caution	2.4.7 Focus Visible	The focus is visible only for the back button, the tabs on the bottom of the screen and the screen view.	Components should receive focus when using an external keyboard, by highlighting the components through a visible border around them.
Screen	Passed	2.4.8 Location	The tabs on the bottom (Find Event tab highlighted) are visible. Event Details heading also provides orientation for the user. The back button Event List provides orientation to the user indicating the back button goes to the previous list of events.	No recommendations
Not present	Not present	2.4.9 Link Purpose (Link Only)	It does not apply to the content.	No recommendations

Table E.13 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	2.4.10 Section Headings	It does not apply to the content.	No recommendations
Speech Input/Voice Recognition	Not present	2.5.3 Label in Name	The visible text label matches the accessible name. However, this criterion refers to speech input, which does not apply to the app.	No recommendations
All	Passed	2.5.5 Target Size	Large buttons and areas e.g. Event List (back button), Find Event.	No recommendations
External keyboard	Passed	2.5.6 Concurrent Input Mechanisms	No comments	No recommendations
Not present	Not present	3.1.1 Language of page	It does not apply to the content.	No recommendations
VoiceOver	Passed	3.2.1 On Focus	It does not apply to the content. A UI receives focus and does not initiate a change of context.	No recommendations
Form Inputs	Not present	3.2.2 On Input	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.2.5 Change on Request	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.1 Error Identification	It does not apply to the content.	No recommendations
Form Inputs	Passed	3.3.2 Labels or Instructions	Buttons have labels on it.	No recommendations
Form Inputs	Not present	3.3.3 Error Suggestion	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.4 Error Prevention (Legal, Financial, Data)	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.6 Error Prevention (All)	It does not apply to the content.	No recommendations
VoiceOver	Passed	4.1.1 Parsing	All content is read.	No recommendations
VoiceOver	Passed	4.1.2 Name, Role, Value	UI element's role is announced.	No recommendations

Table E.14 Sample: Activity list

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
UI	Failed	1.1.1 Non-text Content	The icons (profile, chat) do not have a visible name near them	Add a name below/beside the icons.
Not present	Not present	1.2 Time-based Media	No media present on the screen.	No recommendations
VoiceOver	Passed	1.3.1 Info and Relationships	All elements have label, and it is described by the VoiceOver.	No recommendations
VoiceOver	Passed	1.3.2 Meaningful Sequence	Logical sequence working fine.	No recommendations
Icons and Links	Failed	1.3.3 Sensory Characteristics	Activities icon on the bottom tab does not represent the meaning of activities. The icons for profile and chat on the top should have text label to these elements.	Change the icon of Activities tab on the bottom bar to a meaningful one and provide text label alongside an icon
Screen	Passed	1.3.4 Orientation	No comments	No recommendations
Not present	Not present	1.3.5 Identity Input Purpose	Not applicable. This criterion only applies to inputs about the user. Also, it is not applicable to native mobile apps because there is no programmatic method.	No recommendations
Icons and Links	Failed	1.3.6 Identify Purpose	The icons for 'Profile' and 'Chat' does not have a label above or next to each of them.	Add a name below/beside the icons.
Not present	Not present	1.4.1 Use of colour	No need of a message indicating the required fields on the screen.	No recommendations
Not present	Not present	1.4.2 Audio Control	No comments	No recommendations
All	Passed	1.4.3 Contrast (Minimum)	13.3:1 for blue background and white text; 21.0:1 for white background and black text; (Result from Accessibility Inspector)	No recommendations
Dark Mode	Failed	1.4.3 Contrast (Minimum)	It does not change the colour of the background and elements on the screen. Same result on Accessibility Inspector.	Allow the user interface to swap the white background colour for black background

Table E.14 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Smart Invert	Failed	1.4.3 Contrast (Minimum)	It fails when there is a background image.	Allow the user interface to invert colours when there is a background image
Classic Invert	Passed	1.4.3 Contrast (Minimum)	No comments	No recommendations
Zoom	Failed	1.4.4 Resize text	The user cannot use the two fingers to scroll up and down the screen	Create a control on the screen to change the font size. Make sure font size adapts in the screen and allow scrolling
Dynamic Text	Caution	1.4.4 Resize text	Font size doesn't adapt adequately for two words, e.g. Ramblin-g, swimmi-ng.	Allow all text wrap according to the chosen resize
Not present	Not present	1.4.5 Images of text	No comments	No recommendations
All	Passed	1.4.6 Contrast (Enhanced)	13.3:1 for blue background and white text; 21.0:1 for white background and black text;	No recommendations
Not present	Not present	1.4.7 Low or No background Audio	No comments	No recommendations
Screen	Failed	1.4.8 Visual Presentation	Not possible to customise/select background and foreground colours. Neither to resize the text on the screen.	Create a control on the screen to change the font size and colours.
Not present	Not present	1.4.9 Images of Text	No comments	No recommendations
Text	Passed	1.4.10 Reflow	It automatically reflows the body text according to the pre-defined resize setting on the mobile device.	No recommendations
Text field	Failed	1.4.11 Non-text Contrast	It does not show or highlight visually the focus on the text field when not using the VoiceOver. But the cursor provides visual indication.	The border must meet 3:1 contrast ratio, which can be checked on Accessibility. On Accessibility Inspector, the colour contrast says 21:0.1 Inspector.

Table E.14 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	1.4.12 Text Spacing	Does not provide a control for users to make changes. It does not require that content implement its own mechanisms to allow users to do this. It is not a failure of the content if a user agent or platform does not provide a way for users to do this.	No recommendations
Not present	Not present	1.4.13 Content on Hover or Focus	It does not apply to the content.	No recommendations
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	By using the external keyboard, it was necessary to enable the 'Full keyboard access' on the iPhone Accessibility Settings. By using the tab key, the focus was moving back and forward (Tab+Shift) from the profile and chat button to the home button, the screen view and then the other three tabs only. When the screen view is highlighted, the first activity is also highlighted and from that the user can use the up and down arrow keys, it allows navigation by moving back and forward between the buttons and the find event tab. The user can select an activity from the table list by using the space bar. The use of the space bar can be changed on iPhone Accessibility settings. In addition, the header is not highlighted when navigating through the screen, so it is not receiving focus. Once the use of up and down arrow keys is activated, the user can move the focus back and forward between the elements on the screen.	The user should be able to navigate using the Tab key/gesture to each element on the screen, for example, Sign up buttons, name, email address, password.

Table E.14 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Not present	2.1.2 No keyboard trap	No comments	No recommendations
External keyboard	Not present	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	No recommendations
Speech Input/Voice Recognition	Not present	2.1.4 Character Key Shortcuts	It does not apply to the content. It supports speech input.	No recommendations
Not present	Not present	2.2 Enough Time (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.3 Seizures and Physical Reactions (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.2.5 Re-authenticating	It does not apply to the content.	No recommendations
VoiceOver and External keyboard	Failed	2.4.3 Focus Order	The order starts from the profile button and chat and moves to the first tab (Home) at the bottom of the screen, and then to the screen view, and moves to the second tab (Find event) and moves to the other tabs. The header does not receive focus, then the entire navigation has no logical sequence.	Apply reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
Not present	Not present	2.4.4 Link Purpose (In context)	It does not apply to the content.	No recommendations
VoiceOver	Passed	2.4.6 Headings and Labels	Content of the labels and the header title are clear and descriptive.	No recommendations

Table E.14 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Caution	2.4.7 Focus Visible	The visible focus is on the button at the top of the screen (profile and chat) and on the four tabs and the screen view only.	Components should receive focus when using an external keyboard, by highlighting the components through a visible border around them.
Screen	Passed	2.4.8 Location	The tabs on the bottom (activities tab highlighted) and icons on top are visible. Activity List heading also provides orientation for the user.	No recommendations
Not present	Not present	2.4.9 Link Purpose (Link Only)	It does not apply to the content.	No recommendations
Not present	Not present	2.4.10 Section Headings	It does not apply to the content.	No recommendations
Speech Input/Voice Recognition	Not present	2.5.3 Label in Name	The visible text label matches the accessible name. However, this criterion refers to speech input, which does not apply to the app.	No recommendations
Buttons and icons	Caution	2.5.5 Target Size	Large size for buttons and for bottom tab (e.g. Activities). However, the icons profile and chats on the top are small - (Assessment done on Accessibility Inspector).	Increase size of icons to 44dp x 44dp
External keyboard	Passed	2.5.6 Concurrent Input Mechanisms	No comments	No recommendations
Not present	Not present	3.1.1 Language of page	It does not apply to the content.	No recommendations
VoiceOver	Passed	3.2.1 On Focus	It does not apply to the content. A UI receives focus and does not initiate a change of context.	No recommendations
Form Inputs	Not present	3.2.2 On Input	It does not apply to the content.	No recommendations

Table E.14 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Form Inputs	Not present	3.2.5 Change on Request	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.1 Error Identification	It does not apply to the content.	No recommendations
Form Inputs	Passed	3.3.2 Labels or Instructions	Buttons have labels on it.	No recommendations
Form Inputs	Not present	3.3.3 Error Suggestion	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.4 Error Prevention (Legal, Financial, Data)	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.6 Error Prevention (All)	It does not apply to the content.	No recommendations
VoiceOver	Passed	4.1.1 Parsing	All content is read.	No recommendations
VoiceOver	Passed	4.1.2 Name, Role, Value	UI element's role is announced.	No recommendations

Table E.15 Sample: Chat screen

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	From 1.1 to 1.2.9	No text alternatives needed and no media present on the screen.	No recommendations
All	Passed	1.3.1 Info and Relationships	All elements have label, and it is described by the VoiceOver.	No recommendations
All	Passed	1.3.2 Meaningful Sequence	Logical sequence working fine.	No recommendations
Not present	Not present	1.3.3 Sensory Characteristics	No comments	No recommendations
Screen	Passed	1.3.4 Orientation	No comments	No recommendations
Form Inputs	Not present	1.3.5 Identity Input Purpose	Not applicable. This criterion only applies to inputs about the user. Also, it is not applicable to native mobile apps because there is no programmatic method.	No recommendations
Icons and Links	Not present	1.3.6 Identity Purpose	No icons or symbols on the screen that would require a label.	No recommendations
Not present	Not present	1.4.1 Use of colour	No instructions or elements that would rely on colour and more information.	No recommendations
Built-in speech	Caution	1.4.2 Audio Control	Built-in speaking does not overlap VoiceOver speak output. The built-in speak output gives brief summary of the screen. However, there is no control to enable or disable the audio on the screen.	Remove the built-in speak output.
All	Caution	1.4.3 Contrast (Minimum)	13.3:1 for blue background and white text (passed) / 2.5:1 for the date and time label (failed) - Results from Accessibility Inspector.	Increase contrast of date and time labels
Dark Mode	Failed	1.4.3 Contrast (Minimum)	It does not change the colour of the background and elements on the screen. Same result on Accessibility Inspector.	Allow the user interface to swap the white background colour for black background

Table E.15 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Smart Invert	Passed	1.4.3 Contrast (Minimum)	It passes on screens without image, while it fails when there is a background image.	No recommendations
Classic Invert	Passed	1.4.3 Contrast (Minimum)	No comments	No recommendations
Zoom	Passed	1.4.4 Resize text	The user can use the two fingers to scroll up and down to all messages.	No recommendations
Dynamic Text	Caution	1.4.4 Resize text	Font size doesn't adapt adequately	Allow all text wrap according to the chosen resize
Not present	Not present	1.4.5 Images of text	No comments	No recommendations
All	Passed	1.4.6 Contrast (Enhanced)	13.3:1 for blue background and white text	No recommendations
Not present	Not present	1.4.7 Low or No background Audio	No comments	No recommendations
Screen	Failed	1.4.8 Visual Presentation	Not possible to customise/select background and foreground colours. Neither to resize the text on the screen.	Create a control on the screen to change the font size and colours.
Not present	Not present	1.4.9 Images of Text	No comments	No recommendations
Text	Passed	1.4.10 Reflow	It automatically reflows the body text according to the pre-defined resize setting on the mobile device.	No recommendations
Text field	Failed	1.4.11 Non-text Contrast	It does not show or highlight visually the focus on the text field when not using the VoiceOver. But the cursor provides visual indication.	The border must meet 3:1 contrast ratio, which can be checked on Accessibility. On Accessibility Inspector, the colour contrast says 21:0.1 Inspector.

Table E.15 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Not present	Not present	1.4.12 Text Spacing	Does not provide a control for users to make changes. It does not require that content implement its own mechanisms to allow users to do this. It is not a failure of the content if a user agent or platform does not provide a way for users to do this.	No recommendations
Not present	Not present	1.4.13 Content on Hover or Focus	It does not apply to the content.	No recommendations
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	By using the external keyboard, it was necessary to enable the 'Full keyboard access' on the iPhone Accessibility Settings. By using the tab key, the focus was moving back and forward (Tab+Shift) from the back button to the screen view. When the screen view is highlighted, the first chat is also highlighted and from that the user can open the chat by pressing the space bar. The use of the space bar can be changed on iPhone Accessibility settings. After the chat is selected, the focus goes to the chat text field and the cursor is available and the user can type in a message. The text field and text size are small.	The user should be able to navigate using the Tab key/gesture to each element on the screen, for example, Sign up buttons, name, email address, password.
External keyboard	Passed	2.1.2 No keyboard trap	The user can move from the chat text field to select other element on the screen, for example, the send button by pressing the Shift+Tab key which focus goes to the screen view and then pressing the arrow key to move the focus to the Send button.	No recommendations

Table E.15 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Caution	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
Speech Input/Voice Recognition	Not present	2.1.4 Character Key Shortcuts	It does not apply to the content.	No recommendations
Not present	Not present	2.2 Enough Time (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.3 Seizures and Physical Reactions (All)	It does not apply to the content.	No recommendations
Not present	Not present	2.2.5 Re-authenticating	It does not apply to the content.	No recommendations
VoiceOver and External keyboard	Failed	2.4.3 Focus Order	If the user wants to start a chat, the focus starts from the chat box and does not move to other elements on the screen. If the user wants to visualise all the chats on the main chat screen, the order starts from the back button and moves back and forward to the screen view. So, the focus does not move to each of the chats on the main screen. The header does not receive focus, then the entire navigation has no logical sequence.	Apply reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
Hyperlinks	Not present	2.4.4 Link Purpose (In context)	It does not apply to the content.	No recommendations
VoiceOver	Passed	2.4.6 Headings and Labels	My chats have descriptive label and symbol. Chat heading has a single label which is enough.	No recommendations

Table E.15 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Caution	2.4.7 Focus Visible	The focus is visible only for the back button and screen view.	Components should receive focus when using an external keyboard, by highlighting the components through a visible border around them.
Screen	Caution	2.4.8 Location	It does not provide a link/button to the home screen. The back button My chats provides orientation to the user indicating the back button goes to the previous chats screen.	Allow the navigation bottom tabs to be visible in all screens
Not present	Not present	2.4.9 Link Purpose (Link Only)	It does not apply to the content.	No recommendations
Not present	Not present	2.4.10 Section Headings	It does not apply to the content.	No recommendations
Speech Input/Voice Recognition	Not present	2.5.3 Label in Name	The visible text label matches the accessible name. However, this criterion refers to speech input, which does not apply to the app.	No recommendations
	Failed	2.5.5 Target Size	Text field hit area is too small. The current size is 380x33.	It is suggested to increase height above 44.
External keyboard	Passed	2.5.6 Concurrent Input Mechanisms	No comments	No recommendations
	Not present	3.1.1 Language of page	It does not apply to the content.	No recommendations
Form Inputs	Passed	3.2.1 On Focus	It does not apply to the content. A UI receives focus and does not initiate a change of context.	No recommendations
Form Inputs	Not present	3.2.2 On Input	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.2.5 Change on Request	It does not apply to the content.	No recommendations

Table E.15 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
Form Inputs	Not present	3.3.1 Error Identification	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.2 Labels or Instructions	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.3 Error Suggestion	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.4 Error Prevention (Legal, Financial, Data)	It does not apply to the content.	No recommendations
Form Inputs	Not present	3.3.6 Error Prevention (All)	It does not apply to the content.	No recommendations
VoiceOver	Passed	4.1.1 Parsing	All content is read.	No recommendations
VoiceOver	Passed	4.1.2 Name, Role, Value	UI element's role is announced.	No recommendations

E.4 Manual testing: Android

Table E.16 Sample: Sign up

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	The focus has a light colour highlight. It is difficult to understand where the focus is. By using the tab key on the keyboard, the focus moves from the back button to the first two buttons and the first text field only. It does not move forward from there. It can move forward by pressing the arrow down key until to get the Sign Up button and move backwards pressing the arrow up key. The text field is not activated, there is no cursor, so the user cannot type in. By pressing the Sign Up button, the focus moves to the pop-up window error message and the user can exit it by pressing tab and the focus moves to the okay button and the error message closes.	Better colour contrast for the highlight line of the focus. Adjust the reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
External keyboard	Failed	2.1.2 No keyboard trap	As the user cannot type in the text fields, so the user gets an error message 'please enter your name'. So, the user is not able to sign up.	The user should be able to navigate using the Tab key/gesture to reach the pop-up window and close it by pressing the Okay button using the Tab key.
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2

Table E.16 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
TalkBack and External keyboard	Failed	2.4.3 Focus Order	It passed using TalkBack. By using the Tab key, the focus order works fine from the back button until to reach the first field input (Enter your name) only, from this point the Tab key doesn't work. The user will need to use the up/down arrow keys to move between the other field inputs.	Adjust the reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
External keyboard	Failed	2.4.7 Focus Visible	The elements receive focus, but the colour highlight is very light, it is not well visible and clear where the focus is.	Better colour contrast for the highlight line of the focus.

Table E.17 Sample: Find coach

Elements	Result	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Caution	2.1.1 Keyboard/Gesture Accessible	The focus has a light colour highlight. It is difficult to understand where the focus is. The Tab key goes through all the elements on the screen. However, there are two layers of focus on the model selectors, in which the user can open the model selector by pressing Enter in the first time the focus appears, if the user presses the Tab twice, the focus moves to the second layer, then it is not possible to open the model selector. In order to move from one model selector to another, the user have to press the Tab key twice. The model selector pops up window works fine when using the Tab key and up/down key arrows.	Better colour contrast for the highlight line of the focus. Adjust the reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
External keyboard	Caution	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
TalkBack and External keyboard	Failed	2.4.3 Focus Order	The focus order is partially working fine. By pressing the Tab key to move the focus from chat button, it disappears, and the user has to press the Tab key again to get the focus in the next element (location model selector), from there the user have to press the Tab key twice in order to move to the next element (activity model selector), which is not ideal.	Adjust the reading order. Check compatibility of the app with other devices and assistive technologies, or the use of native code provided by operating systems may allow the compatibility.
External keyboard	Failed	2.4.7 Focus Visible	The elements receive focus, but the colour highlight is very light, it is not well visible and clear where the focus is.	Better colour contrast for the highlight line of the focus.

Table E.18 Sample: Event details

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	The focus only moves between buttons, it does not allow the user to move through all the static texts. It would not be ideal for someone using the keyboard and TalkBack at the same time.	Provide focus to all elements in the screen.
External keyboard	Failed	2.1.2 No keyboard trap	If the user selects a button but does want to select the options available, the user cannot go back to the screen.	Adjust the reading order
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
TalkBack and External keyboard	Failed	2.4.3 Focus Order	The focus order is not following a logical order. The focus starts at 'Find coach for this event' button. By using the Tab key, the focus is jumping the static texts on the screen, the focus is moving between the buttons only and it does not make the screen scroll down, so it is not possible to see where the focus is. By using the up/down keys the focus moves between the buttons only as well, but it scrolls down when moving the focus to other elements on the bottom of the screen.	Provide focus to all elements in the screen. Adjust the reading order.
External keyboard	Failed	2.4.7 Focus Visible	The elements receive focus, but the colour highlight is very light, it is not well visible and clear where the focus is.	Better colour contrast for the highlight line of the focus.

Table E.19 Sample: Activity list

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Caution	2.1.1 Keyboard/Gesture Accessible	By using the tab key, the focus has a light highlighted, not very well visible. The user can select an activity from the table list by pressing the space bar or enter. Here, the user needs to press only once the space bar or enter to select and open the respective screen. In addition, the header is not highlighted when navigating through the screen, so it is not receiving focus.	Provide focus to all elements in the screen. Adjust the reading order.
TalkBack and External keyboard	Caution	2.4.3 Focus Order	By using the Tab key, the order starts from the profile button and chat and moves to the first element (archery) on the table list and moves through the others. However, the screen does not scroll down when the focus is moving to the elements at the bottom of the table list. So, the last item in the list is not visible. The header does not receive focus. By using the up/down arrow key the screen scrolls down and up, and the user must use the left/right arrow keys to move across the tabs on the bottom of the screen.	Provide focus to all elements in the screen. Adjust the reading order.
External keyboard	Failed	2.4.7 Focus Visible	The elements receive focus, but the colour highlight is very light, it is not well visible and clear where the focus is.	Better colour contrast for the highlight line of the focus.

Table E.20 Sample: Chat screen

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.1.1 Keyboard/Gesture Accessible	As the chat field and cursor is enabled, the user can type in a text in the chat field and press the tab key to select the 'send button' and press the space bar or enter. Once the text is submitted, the focus does not go back to the chat field again not either by pressing the tab or up/down arrow keys. So, the user cannot type in more messages.	Adjust the reading order.
External keyboard	Failed	2.1.2 No keyboard trap	By using the Tab key, the user can move from the chat text field to select other element on the screen (e.g. existing messages), but the focus does not move from there anymore. It gets stuck in the last message sent in the chat. The user can only move the focus from an existing message to the back button by pressing the up-arrow key. The user cannot select the text field to type a text in.	Adjust the reading order.
External keyboard	Failed	2.1.3 Keyboard (No exception)	Refer to 2.1.1 and 2.1.2	Refer to 2.1.1 and 2.1.2
TalkBack and External keyboard	Failed	2.4.3 Focus Order	If the user wants to start a chat, the focus starts from the chat box and the cursor is enabled. From the text field, the focus can move to other elements on the screen, by pressing the tab key + shift key, but it cannot move from an existing message, the focus does not move by using the Tab key or the up/down arrow keys. The header does not receive focus, then the entire navigation has no logical sequence.	Provide focus to all elements in the screen. Adjust the reading order.

Table E.20 Continued

Elements	Alert	WCAG 2.1 SC	Comments	Expected Outcomes (Recommendations)
External keyboard	Failed	2.4.7 Focus Visible	The elements receive focus, but the colour highlight is very light, it is not well visible and clear where the focus is.	Better colour contrast for the highlight line of the focus.

Appendix F Ethics application for interviews and user evaluation of the app

FEPS Ethics Committee

FEPS Ethics Application Form Ver 3

Refer to the *Instructions* and to the *Guide* documents for a glossary of the key phrases in **bold** and for an explanation of the information required in each section. The *Templates* document provides some text that may be helpful in preparing some of the required appendices.

Replace the highlighted text with the appropriate information.

Note that the size of the text entry boxes provided on this form does not indicate the expected amount of information; instead, refer to the Instructions and to the Guide documents in providing the complete information required in each section. Do not duplicate information from one text box to another. Do not otherwise edit this form.

Reference number: ERGO/FEPS/53732 Submission version: 5 Date: 2021-11-24

Name of investigator(s): Geane de Almeida Fontinele Zadra

Name of supervisor(s) (if student investigator(s)): Mike Wald

Title of study: Interview Study-VI young adults and physical activity and sport experiences

Note that failure to follow the University's policy on Ethics may lead to disciplinary action concerning Misconduct or a breach of Academic Integrity.

By submitting this application, the investigator(s) undertake to:

- Conduct the study in accordance with University policies governing:

Ethics (<http://www.southampton.ac.uk/ris/policies/ethics.html>);

Data management (<http://www.southampton.ac.uk/library/research/researchdata/>);

Health and Safety (<http://www.southampton.ac.uk/healthandsafety>);

Academic Integrity (<http://www.calendar.soton.ac.uk/sectionIV/academic-integrity-statement.html>).

- Ensure the study Reference number ERGO/FEPS/xxxx is prominently displayed on all advertising and study materials, and is reported on all media and in all publications;

Conduct the study in accordance with the information provided in the application, its appendices, and any other documents submitted;

- Submit the study for re-review (as an amendment through ERGO) or seek FEPS EC advice if any changes, circumstances, or outcomes materially affect the study or the information given;
- Promptly advise an appropriate authority (Research Integrity and Governance team) of any adverse study outcomes;
- Submit an end-of-study form if required to do so.

Refer to the Instructions and Guide documents when completing this form and the Templates document when preparing the required appendices.

Study details

What are the aims and objectives of this study?

This study aims to understand the experiences and behaviours that impact the active lifestyle of young adults with visual impairment aged between 18 to 30 years old, with no other type of impairment and no mental health problems. This study intends to conduct interviews and app testing with potential participants who are young adults with visual impairment and experts who have work experience with visually impaired young adults.

Background of the study *(a brief rationale for conducting the study)*

There are few studies about factors that determine the engagement and participation of visually impaired adults in physical activity and sport through a theory-based perspective (Haegele et al. 2018), as well as their sedentary behaviour (Haegele et al. 2017). Some current research findings have been inconsistent on demographics, personal, environmental, and social factors; also, some of these studies have not reported accurate results based on a wide age range.

Key research question *(Specify hypothesis if applicable)*

- 1) What experiences do visually impaired (VI) young adults aged between 18 to 30 years old have of physical activity/sport in the UK?

The focus is to understand their needs, experiences, views, and intentions regarded to physical activity/sport.

- 2) What are the perceptions of experts about the participation of VI young adults aged between 18 to 30 years old in physical activity/sport?

It aims to comprehend their viewpoints on the experiences of the target group in doing physical activity/sport.

3) What is the evaluation of the prospective app for physical activity and sport by the VI young adults aged between 18 to 30 years old and experts?

The focus is to identify relevant opinions and insights of the respective users about the concept and idea of the app.

Study design (*Give a **brief** outline of the study design and why it is being used*)

I am aiming to recruit 20 participants who are visually impaired (blind or partially sighted) aged between 18 to 30 years old, as well as 20 experts who have at least one year of work experience in the field of physical activity and sport for visually impaired people.

Pre-study

Characterise the proposed **participants**

Participants are young adults from 18 to 30 years old with visual impairment (partially sighted or blind) in good mental health and physically active.

Other participants are experts who have at least one year of work experience in the field of physical activity and sport for visually impaired people.

Describe how **participants** will be approached

If any e-mail lists are used, including FEPS distribution lists, justify their use *here*

I will use my university e-mail to contact charities, colleges, universities, and organisations in the field of visual impairment across the UK. I will identify their e-mail address through the internet and send an email to each organisation requesting to share my invitation to their members with visual impairment and staff members to participate in this study. A short description of the study and the Participant Information Sheet will be provided by email. Prospective participants will be able to contact me by email to participate.

Another strategy to recruit visually impaired participants is by a direct advertising of my study in social media groups for visually impaired people, after the approval of the group organiser. Also, I will ask the participants to invite other prospective participants in order to increase the number of participants.

Describe how inclusion / exclusion criteria will be applied (if any)

Criteria for visually impaired participants:

- Inclusion criteria: participants aged 18 to 30 years old with visual impairment (partially sighted or blind) only.
- Exclusion criteria: No other type of impairment and mental health problems.

Criteria for experts: at least one year of work experience in the field of physical activity and sport for visually impaired people.

Describe how **participants** will decide whether or not to take part

Participants can decide to participate once they will be alerted to this research project through the study invitation published by visually impaired organisations on their social media, newsletters and so on.

The strategy for recruiting participants includes - website

(<https://activevistudy.wixsite.com/activevistudy>), both image with text and video inviting participants to take part in my study, study advert for each group: VI young adults and experts (coaches/guides).

The website was created based on Web Content Accessibility Guidelines (WCAG 2.1) by using the features, settings available on the Wix website editor. This blog is also available in a mobile format. I used the Windows Narrator screen reader, NVDA, VoiceOver and TalkBack to check accessibility.

On the website, there is a form titled 'Interested to take part?' (in the home page), where there is the following guidance to participants: *"If you are between 18 to 30 years old with visual impairment, please fill in this form and the demographic survey (in the Information page). If you are a coach or guide, please fill in this form only. I will contact you all to send instructions to download the app and to arrange the interview."* So, those potential participants can send their name, phone number (if they prefer) and email address. By receiving their email address, I will be able to contact them and send instructions to download the app prototype and to arrange the interview. Their information will be safely stored in my university email inbox (gdaz1e17@soton.ac.uk).

The image with text and video also is available on the website. In addition, these materials can be shared together with their respective study advert (for each group: VI young adults and experts) in social media. I will ask organisations and social media group organisers to share these materials and the link to access the website. I will also share it in social media groups (upon approval from group organisers).

The video will be shared with the Advert to VI young adults: "Are you 18-30 years old with visual impairment? Researchers at University of Southampton are looking to find ways to support visually

impaired young adults to get active. You can help by taking part in an online interview to share your views and experiences of getting active or taking part in sport, and to get your feedback on an app we developed to support people with visual impairment to get active. Your contribution could make a positive impact on the lifestyle of visually impaired young adults. Find out more about this research on our Active VI website. If you are interested, please email Geane on gdaz1e17@soton.ac.uk. This study has been approved by the University of Southampton Ethics Committee (Ref: ERGO/FEPS/53732)."

The image with text will be shared with the Advert to experts: "Are you a coach or guide who supports visually impaired people to get into sport and exercise? Would you like to take part in research at the University of Southampton looking at ways to support young adults with visual impairment to get active? It would be wonderful if you could participate in an online interview to share your views on the support available for visually impaired people and the challenges you might face when helping young adults with visual impairment to get active. You can also give your feedback on an app we developed to support them to get active. Your contribution could make a positive impact on the lifestyle of many visually impaired young adults. Find out more about this research on our Active VI website. If you are interested, please email Geane on gdaz1e17@soton.ac.uk. This study has been approved by the University of Southampton Ethics Committee (Ref: ERGO/FEPS/53732)."

I can request to visually impaired social group organisers on Facebook to support and share my study advert among their members, if it is in accordance with the terms and conditions of the social media. Participants can also decide to take part in this research by downloading an accessible digital copy of the Participant Information Sheet which will be available through a link on the website. This link will provide an accessible Word document of the Participant Information Sheet that will be stored on my Google Drive account. Otherwise, I will send participants a copy of this accessible digital document of Participant Information Sheet by email. I will have their email address once they will have sent an email to me informing their interest to participate in this study or by filling in the form in the website. Participants who are severely sight impaired (blind) can access this document using a screen reader (such as NVDA, VoiceOver for Mac, Narrator for Windows) available on their computer or mobile phone. A screen reader uses a speech synthesis to convert text into speech, this allows the user to hear the information in the document. Participants who are sight impaired (partially sighted) can read the Participant Information Sheet using accessibility tools, for example, screen magnification built into Windows, Android, and iOS operating systems. These are the most popular software among visually impaired people. (AbilityNet 2019; American Foundation for the Blind 2017).

All the documents to be sent to participants have been checked by an accessibility expert using the Windows Narrator screen reader, NVDA and VoiceOver for Mac. The Microsoft Accessibility Checker for Word was used to check for failures based on Web Content Accessibility Guidelines (WCAG 2.1) criteria to ensure the documents also complied with the Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018.

After getting access to the Participant Information Sheet, participants can choose to accept or not accept to participate in this study, and they can withdraw at any time. They can confirm their participation by emailing to me.

Participant Information (Appendix (i))

Provide the **Participant Information** in the form that it will be given to **participants** as Appendix (i). All studies must provide **participant information**.

Consent Form/Information (Appendix (iii))

Provide the **Consent Form** (or the request for consent) in the form that it will be given to **participants** as Appendix (iii). All studies must obtain **participant** consent. Some studies may obtain verbal consent (and only present consent information), other studies will require written consent, as explained in the *Instructions*, *Guide*, and *Templates* documents.

During the study

Describe the study procedures as they will be experienced by the participants

Based on the social media advertising, all participants interested in taking part in this study need to send an email to me on gdaz1e17@soton.ac.uk. Other way to contact me is directly sending me their contact details by filling in a form titled 'Interested to take part?' in the website's home page. I will reply and send to all participants an accessible digital copy of the participant information sheet, in case, they have not had access to it through the study invitation or website (in the Information page) that will have been shared in organisations' social media, newsletters, website, etc.

Both groups of participants (young adults with visual impairment and experts) will also be informed about the procedures of this study by email. In the email to be sent to each young adult with visual impairment, I will let them know that they will be given a demographics questionnaire (available on iSurvey), in the case they did not access it on the website (in the Information page) and that they will do a remote prototype app testing and interview. The experts will do the remote prototype app testing and interview only.

- Consent

Appendix F

I will ask participants to confirm their participation in this study by email, which includes the online demographics questionnaire, remote user testing of the app prototype and interview. I will inform them that they will be able to consent through the demographic questionnaire available on iSurvey. I will send them the link to this survey via email. Or the participant can fill in this survey by accessing the link on the website (in the Information page). In the welcome page of this survey, participants can tick a box with the following sentence 'Please tick (check) this box to indicate that you consent to taking part in this survey, as well as the upcoming interview and testing of an app prototype.'

Participants will make use of assistive technologies, such as a screen reader on their computer or mobile phone, as well as the iSurvey accessibility toolbar, to be able to listen to or read, and answer the questions. In the survey's Welcome page, I will provide the following information: number of questions, estimated time to complete, a link to an accessible digital copy of the Participant Information Sheet, Consent Form and the demographics questionnaire in Word format. I will provide the demographics questionnaire in an accessible Word format because some participants may prefer to fill in a questionnaire using a Word document rather than an online questionnaire. I will ask participants to send their completed questionnaire to my email address. In this situation, I will ask them to download the consent form and send it with their signature or a cross, if they cannot make a signature, to my email.

Regarding the consent of other participants (those partially sighted and experts who are sighted or partially sighted people), I will send them a copy of the consent form via email and ask them to read, fill in and sign it and send me back via email before the app testing and interview session. Or they can download the consent form from the website (in the Information page) and send the completed form to my email address. If an expert is severely sight impaired (blind), if they cannot sign, a signature by making a cross in the signature space will be sufficient.

I will provide all documents (participant information sheet, consent form and demographics questionnaire) in a digital accessible format to all participants.

I will arrange and agree a date and time for a remote interview with each participant. I will ask the visually impaired participant if they would be able to use an accessible video conferencing software, like Microsoft Teams, Zoom or Google Meet. I will ask participants to use their computer or tablet during the session. I will inform all participants the estimated duration of the app testing and interview.

As it will be a remote app testing, due to COVID-19 social distancing regulations, I would need to ask participants if they could invite someone in their social bubble to help with the technical part of the session.

If the invited person accepted this, they would be required to provide their own mobile phone for using the video conferencing software during the session. This is because it would be necessary that the invited person hold their own mobile phone or tablet to record the actions of the visually impaired participant while doing the app testing on their mobile phone. I would send a link to the video conference to visually impaired participant's email address. I will ask them to send this link to the invited person's email address to be online on the scheduled day and time. If they cannot find someone to help with this, we can proceed with the screen and audio recording of their screen's phone and the video conference using a computer, laptop, or tablet.

I will advise that participants can opt out of the study if they are no longer interested or do not have time to do the interview and testing. I will ask participants to send me an email informing me about their decision to withdraw from the study.

- Demographics survey

Young adults with visual impairment will be required to fill in the demographic's questionnaire before the arranged interview. This questionnaire has questions about gender, mental health, ethnic group, educational level, current living arrangement and household income. This is because there are different findings in the literature regarding these issues. According to Haegele et al. 2018, 'Limited and inconsistent evidence exists pertaining to the influence of demographic variables on the physical activity engagement of individuals with visual impairments.'

- Gender is necessary to investigate because some papers (Haegele et al. 2018, Haegele et al. 2017, Augestad & Jiang 2015) show inconsistent results about the influence of gender relating to participation in physical activity, e.g. no correlation between these variables, female were more engaged than male or vice-versa.

- Mental health needs to be included in the questionnaire because issues with cognitive, behavioural, and emotional wellbeing may affect the research results. Even though the researcher has requested that individuals with "good mental health" take part in the trial. There may be an occasion when this part of the criteria is missed. Therefore, if the researcher knows that an individual has omitted to perhaps say they have for instance bipolar disorder, any problems arising during the trial could be noted. Mental health conditions are included in the Universities and Colleges Admissions Service (UCAS) Disability Codes and the Equality Act 2010. Augestad (2017) in a review of papers that included data regarding the impact of visual impairments on mental health showed an increase in the number of emotional disorders compared to the typical population. Also, research found that 'depression may be more common at the beginning of the sight loss' (Hayman et al. 2007 cited in Papadopoulos 2014), so it is necessary to identify these issues. On the other hand,

other researchers have suggested that the maintenance of physical activity ‘may be predicted by the realisation of positive social, mental-wellbeing, and fitness goals.’ (Murray et al. 2017). A survey report in the UK identified that 50 per cent of active visually impaired adults consider better mental health as an outcome of participation in sport (Charity Today 2019).

- It is important to identify as many characteristics as possible about the population in this research, such as ethnic groups. This is because we cannot make a judgement that research applied to a group, for example, white and middle class can be applied to black with low income. According to Sallis & Owen (1999), it is relevant to identify groups of people through demographic characteristics (gender, income, age, ethnicity and location), as a way to find groups with high and low physical activity levels. In order to identify groups with low participation, researchers can tailor interventions to address the needs of these groups. 'This is important because activity levels vary widely in different populations groups, and different approaches are often needed to effectively intervene with various subgroups.' Qualitative studies on physical activity gather data on ethnic groups, such as studies of Allender, Cowburn and Foster (2006) and Weir et al (2010). Also, qualitative reporting guidelines recommends the use of demographics or cultural information of participants in qualitative research (APA 2020).
- Educational level is relevant because some papers identified a negative correlation on low level of education and poor fitness level (Augestad & Jiang 2015).
- Current living arrangement is also reported as one of the elements impacting the active lifestyle (Salminen & Karhula 2014).
- Household income is a variable that has not been explored as an influence on physical activity among VI people by researchers (Haegele et al. 2018).
- **App testing**

Visually impaired participants will be able to test the prototype through their own smartphone using an assistive technology (screen reader), such as VoiceOver for an iPhone/iPad or TalkBack for an Android mobile phone/tablet. I will take note of the time spent of each participant to complete the testing.

Participants will use their own mobile phone to install and test the app prototype. Participants will be given the instructions and the link to install the app prototype at least two days before the scheduled remote app testing and interview. Also, I will send an email to participants a list of tasks to do before testing the app prototype. The app prototype testing will be screen recorded. I will send instructions in an accessible word document to each visually impaired participant about: how to install the app

prototype; how to enable the built-in screen and audio recorder function on their mobile phone, which allows the recording of participant's interactions on their mobile phone and their voice. I will ask them to save this recording file on their mobile phone and send this file to my email address. I will let all participants to know that I will ask them to think aloud while testing the app prototype. Thinking aloud during user testing is a way to observe their interaction with the product. After the app testing, I will send an email to participants and ask them to fill in a standard usability scale, in an online accessible format on iSurvey. I will provide them the usability scale in an accessible Word format if they prefer this rather than an online form.

- **Interviews**

Prior to start the interview, I will inform participants that the interview will be recorded, using a video conferencing software. Also, I will give the definitions of terms used in the research, such as physical activity, sport and exercise, to make sure that participants are aware of these meanings. Also, I will inform the estimated duration of the interview and let them know that they can stop the interview at any time, if they want to.

All participants will be asked about their perceptions about the app prototype's concept and relevance, how easy it is to use, issues and problems that might be identified by the participant.

In addition, I will ask visually impaired participants about their experiences and needs of engaging in physical activity and sport as well as experts about their working experience with visually impaired people.

Identify how, when, where, and what kind of data will be recorded (not just the formal research data, but including all other study data such as e-mail addresses and signed consent forms)

I will have the name, email address, phone number (if they are willing to provide it) of those who will reply to my study advert accepting to participate in this study. Participants can provide this information by directly contacting me via email or by filling in the form titled 'Interested to take part?' available in the website's home page. This data will be recorded in my university email inbox. Other type of data will be registered during the interview, such as:

For young participants with visual impairment:

- Demographics (age, gender, occupation, salary, education, name of participants).
- Also, data related to their lifestyle (being physically active or not), experiences of physical activity or sport and the use of fitness trackers or apps.

For experts:

- Demographics (occupation, years of work experience, name of participants).
- Perceptions about the participation of young adults with visual impairment.

The answers given in the interviews will be analysed in order to identify missed responses, meaningful results, coding and data analysis. Responses will be anonymised. I will not include the name of participants during the interview and user testing notes and recordings. I will use a key-code to identify each participant to their answers and digital recording, for example, P1, P2, P3 and so on. All the data will be stored safely, anonymised and stored electronically in my computer at the University of Southampton. In the hard drive, the data will be password protected. I will transcribe the interviews and user testing recordings using a transcriber software, such as Otter.ai which is password-protected using my university email to have access to the data. I will be the only person to have access to the collected and transcribed data. At the end of the interview and user testing, participants can request me to send the transcripts of their interviews.

References

Participant questionnaire/data gathering methods (Appendix (ii))

As Appendix (ii), reproduce any and all **participant** questionnaires or data gathering instruments in the exact forms that they will be given to or experienced by **participants**. If conducting less formal data collection, or data collection that does not involve direct questioning or observation of participants (eg secondary data or “big data”), provide specific information concerning the methods that will be used to obtain the data of the study.

Post-study

Identify how, when, and where data will be stored, processed, and destroyed

If the Study Characteristic M.1 applies, provide this information in the DPA Plan as Appendix (iv) instead and do not provide explanation or information on this matter here.

Study characteristics

(L.1) The study is funded by a commercial organisation: **No** (delete one)

If ‘Yes’, provide details of the funder or funding agency here.

(L.2) There are restrictions upon the study: **No** (delete one)

If ‘Yes’, explain the nature and necessity of the restrictions here.

(L.3) Access to participants is through a third party: **Yes** (delete one)

Appendix F

If 'Yes', provide evidence of your permission to contact them as (v) in the Checklist below. Do not provide explanation or information on this matter here.

(M.1) Personal data is or *may be collected or processed: **Yes** (delete one)

Data will be processed outside the UK: **No** (delete one)

If 'Yes' to either question, provide the DPA Plan as (iv) in the Checklist below. Do not provide information or explanation on this matter here. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be "Yes".

(* Secondary data / "big data" may be de-anonymised, or may contain personal data. If so, answer 'Yes'.)

(L.3) Access to participants is through a third party: **Yes** (delete one)

If 'Yes', provide evidence of your permission to contact them as (v) in the Checklist below. Do not provide explanation or information on this matter here.

(M.1) Personal data is or *may be collected or processed: **Yes** (delete one)

Data will be processed outside the UK: **No** (delete one)

If 'Yes' to either question, provide the DPA Plan as (iv) in the Checklist below. Do not provide information or explanation on this matter here. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be "Yes".

(* Secondary data / "big data" may be de-anonymised, or may contain personal data. If so, answer 'Yes'.)

(M.2) There is inducement to participants: **No** (delete one)

If 'Yes', explain the nature and necessity of the inducement here.

(M.3) The study is intrusive: **No** (delete one)

If 'Yes', provide the Risk Management Plan, the Debrief Plan, and Technical Details as (vi), (vii), and (ix) in the Checklist below, and explain here the nature and necessity of the intrusion(s).

(M.4) There is risk of harm during the study: **No** (delete one)

Appendix F

If 'Yes', provide the Risk Management Plan, the Contact Information, the Debrief Plan, and Technical Details as (vi), (vii), (viii), and (ix) in the Checklist below, and explain here the necessity of the risks.

M.5) The true purpose of the study will be hidden from participants: **No** (delete one)

The study involves deception of participants: **No** (delete one)

If 'Yes' to either question, provide the Debrief Plan and Technical Details as (vii) and (ix) in the Checklist below, and explain here the necessity of the deception.

(M.6) Participants may be minors or otherwise have diminished capacity: **No** (delete one)

If 'Yes', AND if one or more Study Characteristics in categories M or H applies, provide the Risk Management Plan, the Contact Information, and Technical Details as (vi), (vii), & (ix) in the Checklist below, and explain here the special arrangements that will ensure informed consent.

(M.7) Special category personal data is collected or processed: **Yes** (delete one)

If 'Yes', provide the DPA Plan and Technical Details as (iv) and (ix) in the Checklist below. Do not provide explanation or information on this matter here.

(H.1) The study involves: invasive equipment, material(s), or process(es); or participants who are not able to withdraw at any time and for any reason; or animals; or human tissue; or biological samples: **No** (delete one)

If 'Yes', provide Technical Details and further justifications as (ix) and (x) in the Checklist below. Do not provide explanation or information on these matters here. Note that the study will require separate approval by the Research Governance Office.

Technical details

If one or more Study Characteristics in categories M.3 to M.7 or H applies, provide the description of the technical details of the experimental or study design, the power calculation(s) which yield the required sample size(s), and how the data will be analysed, as separate appendices.

Checklist of Documents to upload

Please provide the following forms, *naming the files as explicitly as possible*, e.g., "Participant Information", "Questionnaire", "Consent Form", "DPA Plan", "Permission to contact", "Risk Management Plan", "Debrief Plan", "Contact Information", and/or "Technical details" as appropriate. Each document must specify the reference number in the form ERGO/FPSE/xxxx, the document version number, and its date of last edit.

- (i): **Participant Information** in the form that it will be given to **participants**.
- (ii): Data collection method (eg for secondary data or “big data”) / **Participant** Questionnaire in the form that it will be given to **participants**.
- (iii): **Consent Form** (or consent information if no **personal data** is collected) in the form that it will be given to **participants**.
- (iv): **DPA Plan**.
- (v): Evidence of permission to contact (prospective) **participants** through any third party.
- (vi): **Risk Management Plan**.
- (vii): **Debrief Plan**.
- (viii): **Contact Information**.
- (ix): Technical details of the experimental or study design, the power calculation(s) for the required sample size(s), and how the data will be analysed.
- (x): Further details and justifications in the case of: **invasive** equipment, material(s), or process(es); **participants** who are not able to withdraw at any time and for any reason; animals; human tissue; or biological samples.

Appendix G Interview protocol for user evaluations

User Evaluation Plan

Main objective: Test the design requirements/guidelines of the prototype app.

Test goals

The goal of this test is to answer the following questions regarding the specific tasks:

- Is the system relevant and useful for helping young adults with visual impairment to engage in sport and physical activity?
- Can participants use this system to plan their physical activity in advance according to specific preferences and travel options in an easy and fast way?
- Can participants find coaches profiles, select one to send a message?
- What problems do users find when trying to use the system to plan and to know about the physical activity?

Specific recruiting and diversity criteria

The participants for this test will be young adults (between 18 to 30 years old) with visual impairment, regardless of being physically active or not.

Also, professionals that work in the physical activity and sport for visually impaired people that have at least one of work experience in this field.

Test preparation

Young adults with visual impairment will receive an online demographics questionnaire available on iSurvey to submit their answers at least two days before the user testing and interview session.

All participants will be given instructions via email to install the app prototype and a list of tasks to do while testing the app at least two days before the scheduled user testing session. They will receive a link to install the Apple TestFlight app and app prototype or the link to download the Android app version in their mobile phone, as well as the link to the scheduled online video conferencing. I will ask the visually impaired participant if they would be able to use an accessible video conferencing software, like Microsoft Teams, Zoom or Google Meet.

Also, they will be required to invite a third person from their social bubble to help with the technical part of the session. If the invited person accepted this, they would be required to provide their own

mobile phone for using the video conferencing software during the session. This is because it would be necessary that the invited person hold their own mobile phone or tablet to record the actions of the visually impaired participant while doing the app testing on their mobile phone. Visually impaired participants will need to forward the link to the invited person's email address to be online on the scheduled day and time. If they cannot find someone to help with this, we can proceed with the built-in screen and audio recording of their screen's phone and the video conference using a computer, laptop, or tablet.

The app prototype testing will be screen recorded. I will send instructions in an accessible word document to each visually impaired participant about how to enable the built-in screen and audio recorder function on their mobile phone, which allows the recording of participant's interactions on their mobile phone and their voice. I will ask them to save this recording file on their mobile phone and send this file to my email address. I will let all participants to know that I will ask them to think aloud while testing the app prototype.

VI sport or exercise coaches and guides will do the tasks looking at the visually impaired participant session to give their opinion about the whole system.

Task instructions and success criteria

- Task Design

I am aiming to create between 5 to 7 tasks, which is the normal practice in the user experience design. Tasks are instructions that I will give to participants in order to have them to try to complete some goals using the app prototype, according to some of the test goals listed above.

- Choosing tasks

I am interested to brainstorm some specific actions that I would like to participants to perform within the scope of the task design goals.

- Relevant and useful system:

Specific actions: engagement (creating a profile and searching activities); building knowledge (video description of a particular sport/activity).

- Planning physical activity in advance:

Specific actions: finding activities in participants actual location and other location, events and transport options; adding the activities to participant's phone calendar.

- Communicating with coaches:

Appendix G

Specific actions: finding coaches profiles and select one to send a message.

Task 1

You are going to create your profile. If some issue occurs, the participant can use the account “betatester@gmail.com” and password “betatester”. In the profile, you will add some preferences and interests.

Success criteria: (profile created and the recommended activities showing in the home screen).

Task 2

Afterwards, you want to know what blind tennis looks like. You want to understand how to play it.

Success criteria: (The screen informs the description of that activity).

Task 3

Search for a video explaining about blind tennis.

Success criteria: (At the bottom of the screen’s activity description has a button to open a video on YouTube).

Task 4

You are looking for the Football Training in London in February, on Friday 25th of February 2022.

You want to know how to get to the venue, which transport options are available?

After that, you want to book a place to this training. (by calling the organiser to book).

Success criteria: (The screen shows the activity details and by selecting transport button, it will open Google Maps; after closing it the user can find a call button at the bottom of the screen and call the organiser to book a place).

Task 5

You are interested to take part in a VI Rugby event in London in February, and you are planning a trip to London in the day the event is available. You want to add this event to your calendar to remind you about this.

Success criteria: (The screen is Vision Impaired Rugby in West London. The user should be able to add the event on his phone’s calendar).

Task 6

Also, you want to know who is the coach of this event (VI Rugby) and you want to message him via chat to ask few questions.

Success criteria: (At the bottom of the screen there is a chat bottom, the user should be able to open the chat window and text/dictate to the coach).

Task 7

You are interested in doing Martial Arts in London and you want to find a coach to have more information about the session. Select one of the coaches to message him by email.

Success criteria: (The screen – Coach information - will show first the email address and redirect the user to their email).

Post-test questionnaire

I will ask participants to access the link sent to their email address to access and fill in a standard usability scale (SUS), in an online accessible format on iSurvey. I will provide them the usability scale in an accessible Word format if they prefer this rather than an online form.

Debrief guide

The focus is to identify any problems that happened during the tasks and other aspects such as preferences, changes, understanding and use.

- Parts where user found difficult to accomplish.
- Preferences: What do you think about this app? Which parts are most or least important?
- Changes: What would you change in this app to make it better for you? Why?
- Understanding: How would you describe this app to a friend?
- Use: Under what situation would you use this app? Why?

After user testing, these questions may be asked:

1. What is your opinion about this app?
2. Would you recommend this app to other young visually impaired adults?
3. In your view, how different is this app to other type of information on the Web? (e.g., information on websites and social media)

Appendix H Codebook: Interview with VI young adults

Table H.1 Themes and sub-themes from the interview with VI young adults

Themes	Description
Theme 1: Challenges with participation in physical activity and sport	Issues that may affect the participation of VI young adults in physical activity or sport.
Sub-theme 1: Lack of knowledge and awareness of visual impairment and inclusive physical activity and sport	Need of more awareness about visual impairment and VI physical activity and sport.
Code: Lack of awareness of VI people's needs at the gym	Need to have professionals more aware of VI people's needs at the gym.
Code: Lot of information on online exercise	Mainstream workout exercise may have lots of information for a VI young adult.
Code: Lack of understanding of VI sport at venues	Perception that there is not much understanding of inclusive sport.
Code: Lack of understanding of visual impairment from professionals	VI young adults' perception of coaches and other professionals not understanding visual impairment.
Code: No awareness of visual impairment among other active members	Concerns about others in the running group not aware and not understanding visual impairment.
Code: Not enough guidance on online workouts	Online workout does not provide enough guidance to visually impaired people.
Code: Need someone to describe the online workout videos	Workout's videos need to be described.
Code: Very fast paced online workouts	Not being able to follow a fast-paced workout video.
Code: Hard to see the graphs on Nike Run Club app	Difficult to see the running graphs on the running app.
Code: VoiceOver cannot read graphs on Nike Run Club app	Not able to use VoiceOver to understand the running graph.

Table H.1 Continued

Themes	Description
Code: Not able to use magnifier on Nike Run Club app	Magnifier seems not to work on running tracker.
Code: Some inaccessible workouts on Aaptiv app	Recorded video of workouts not accessible.
Code: Need to have the app to input data on Strong app	User wants the app to input data.
Code: Too difficult manual input on Strong app	Not easy to manually add information about the exercise.
Code: Need of professional training	Need of more professional training in VI or inclusive sport and physical activity.
Code: Lack of support	Need of support to do physical activity or sport.
Code: Lack of local council support	Not having support to go to the gym from local council.
Code: Lack of accessible gyms	Issues around accessibility at the gym.
Code: Bad lighting	Not having enough lighting to be able to read or see objects at the gym.
Code: Inaccessible screens	Cardio machines having small buttons.
Code: Not able to read weights and instructions	Weights having small text or no contract colours.
Code: Lack of gym staff support	Gym not providing staff to support VI people.
Code: Lack of mobility support in the gym	Need help to move around the gym.
Code: Lack of own support	Having no one to bring along to the gym.
Code: Need help to operate gym machines	Need someone to help with gym machines.
Code: Not much support from organisations or professionals	Perception that some organisations or professionals do not provide much support.
Code: Non-sporting opportunities from charities	Some charities are sport focused only.
Code: Tricky to find a variety of guide runners	Difficult to find guide runners available to run more frequently a week.

Table H.1 Continued

Themes	Description
Code: Aiming to run more	Wishing to run more during the week.
Code: Depending on availability	VI young adult depends on available time of guide runner.
Code: No commitment for running regularly	Some guide runners may want to guide for a park run or race.
Code: Not fair to ask the same guide runner	Not asking to do more runs a week.
Code: Lack of information	Not having information on the local sessions and how to get support to do it.
Code: Lack of information for getting financial support	Financial support on getting someone to help at the gym.
Code: Not knowing much of local sport and physical activity opportunities	Not much information of local physical activity or sport sessions.
Code: Not knowing about online databases of guide runners	Available database of guide runners is not well known.
Code: VI sessions not well known	Existing VI physical activities sessions seems to be not well known.
Code: Need to know how to get started	The need of detailed information and insights for starting to do a physical activity.
Sub-theme 1.2: VI people feeling different	Perception of being treated differently because of visual impairment.
Code: Being treated differently	Perception that exercises and sport professionals treat VI young adults differently.
Code: Feeling pressure to be normal	Feeling pressure to perform as others sighted people in a running group.
Code: Intimidating running clubs	Running clubs is perceived as intimidating. Perception that running clubs are not welcoming to new runners.
Code: Having to explain visual impairment	Explaining visual impairment every time starting a physical activity.
Code: Disabled people exclusive activity	Some physical activity may have only disabled people taking part in.
Code: Not feeling part of VI community	VI young adults' perceptions of the VI community.

Table H.1 Continued

Themes	Description
Code: Physical activity and sport are not for everyone	Inactive VI young adult believes that physical activity is not for everyone.
Sub-theme 1.3: Concerns and insecurities to do physical activity and sport	Feelings that may interfere in taking part in physical activity and sport.
Code: Concern on accessibility of sessions	There is a concern on whether the physical activity or sport would be accessible.
Code: Social anxiety at the gym	There may be social anxiety being around other people at the gym.
Code: Not trusting a guide runner to start running	Both active and inactive VI young adults not able to trust and feel safe with a guide runner to start running.
Code: Inability to know the environment	Inactive adult's view of not being able to understand the surroundings clearly due to visual impairment.
Code: No sense of distance	Inactive VI young adult not knowing the surroundings and distance between themselves and an object or person.
Code: Running risk of accident	Risk of accident while running.
Code: Muscle pain	Inactive VI young adult believes exercises and sports can cause muscle pain.
Code: Risk of accident	Inactive VI young adult perceive a risk of crashing someone or things due to visual impairment while doing an exercise.
Code: Eyes conditions restricting physical activities	Not be allowed to do certain physical activities due to the eye health conditions.
Code: Sensory overload	Loud environment may prevent a VI young adult with sensory overload in physical activity participation.
Sub-theme 1.4: Belief that physical activity and sport is difficult and not for everyone	Perception that physical activity and sport is hard and not for everyone.
Code: Very difficult to run	Inactive young adult's view of running is difficult due to not being able to see.
Code: Running fast perception	Inactive VI young adult's perception of just running to get to the finish line and not having time to see and run around stuff.

Table H.1 Continued

Themes	Description
Code: Past experience competition focus	Inactive and active VI young adults' perceptions of competitive focus in past physical activity or sport experience.
Sub-theme 1.5: External factors discourage physical activity and sport participation	Perceived experiences from the physical activity service provision that prevented physical activity participation of VI young adults.
Code: Cost of physical activity and sport sessions	Physical activity or sport sessions related cost are expensive.
Code: Impeded to take part due to cost of physical activity and sport sessions	Expensive cost of sessions may deter VI young adults from participation in physical activity or sport.
Code: Not finding cost-effective way	Not able to find a good value for the amount of a session and potential travel costs.
Code: Paying someone to help with exercises	VI young adult making necessary payments to other university student to help in using the gym facilities.
Code: Financially feasible to get active	Having enough money to do physical activity may help to have intention to do more.
Code: Need of making cheaper sessions	The need of cheaper physical activity and sport sessions.
Code: Limited or lack of local VI physical activity or sport opportunities	There are few opportunities of VI physical activity and sport.
Code: Few opportunities for adults	Perception of more physical activity and sport for kids.
Code: Lack of local physical activity or sport sessions	There are no local or nearby opportunities of VI sport or physical activity.
Code: Relying on someone	Need to get help from others and its concerns or importance.
Code: Dependent on others availability	Being dependent from others availability to do physical activity or sport.
Code: Hard to find guide runner available	It's hard to find more availability from a guide runner.
Code: Not a long term wish to rely on others	Regarding to dependence of family members to take part in physical activity or sport.
Code: Not fair on others to be dependent on them	Relying on friends or family members all the time to take part in physical activity or sport.
Code: Chance to get wrong techniques from online content	Getting physical activity content online may lead to do wrong exercises.

Table H.1 Continued

Themes	Description
Theme 2: Facilitators for doing physical activity or sport	Factors that may make it easier to do physical activity or sport for VI young adults.
Sub-theme 2.1: Support to get active from others	Knowing that other VI young adults take part in physical activity and sport. Seeing similar peers doing physical activity or playing sport may be a motivation to do the same.
Code: One to one support	Inactive VI young adult perceive the need of one-to-one support.
Code: Socialising	Being motivated to take part in physical activity or sport with friends.
Code: Support from family members	Support from family members.
Code: Getting motivation from others	Others giving motivation helps VI young adults.
Code: Gym buddy	Doing workouts with friends.
Code: Openness and accepting behaviour from physical activity and sport providers	More openness and accepting behaviour from sport and gym providers.
Code: Peaceful environment	Inactive VI young adult may prefer a peaceful environment for taking part in exercises.
Code: More fun to have a gym buddy	To have fun with friends at the gym.
Sub-theme 2.2: Informational support	Necessary support for VI young adults to know about relevant information about physical activity
Code: Learning how to exercise by being guided by others	The need of getting someone's help to do exercise or play sport.
Code: Learning how to exercise by getting online content	Finding related physical activity content online.
Code: Being influenced by others on social media and YouTube	Perception that everyone is easily influenced by others exercising on social media and YouTube.
Code: How to prepare for exercising by using equipment and warming up	More videos on equipment and warming up.
Code: Enjoying notifications to remind exercising	Positive use of notifications like reminders of doing exercises.
Code: Finding the right and accessible resources	By finding good resources users can be able to do physical activity.

Table H.1 Continued

Themes	Description
Sub-theme 2.3: More VI physical activity and sport opportunities and promotion	The need of having more physical activity opportunities and adverts about physical activities sessions for VI young adults.
Code: More choice of VI sports	Having more opportunities may lead to more choice of VI sports.
Code: Online boot camps	Experience involved in online workouts for VI people during the pandemic.
Code: Knowing how to start	Getting support on how to start playing a sport.
Code: Knowing what accessible sports are	Getting a list of accessible sports.
Code: Inclusive physical activity and sport	Need of more inclusive sport opportunities for disabled and non-disabled people.
Code: More inclusive physical activity and sport	The need of inclusive physical activity and sport sessions for VI and sighted people.
Sub-theme 2.4: More inclusive physical activity and sport	Participants' wishes to take part in inclusive physical activity and sport sessions for VI and sighted people and to get into inclusive gyms.
Code: Inclusive gym claiming	Some gyms claiming inclusive practice and not doing it.
Code: Getting active with sighted and VI people	The wish of doing physical activity or play sport with sighted people and visually impaired as well.
Code: Getting help from sighted people	Opportunity to get help from sighted people doing workout next to VI young adult.
Code: Meet people	Getting to know other gym goers.
Sub-theme 2.5: Feeling independent and safe to get active	VI young adults want to feel independent and safe to do physical activity and sport
Code: Self-monitoring of exercises and building habits	Management of exercises to build habits.
Code: Health and exercise tracking	Tracking health and exercise helps to keep motivation.
Code: Staying consistent on physical activity or sport	Tracking activity and health helps to stay consistent.
Code: Setting goals	Having aims to achieve while doing physical activity or sport.
Code: Quickly and safely moving	Moving to and from places in a quick and safe way.
Code: Wayfinding apps	Use of wayfinding apps to assist moving around.

Table H.1 Continued

Themes	Description
Code: Slow paced and simple exercises	Need of slow paced and simple workouts. By doing simple and slow-paced workouts may give an independence feeling.
Code: Fitness app may help to feel independent	Perception that fitness apps help people who want to do exercise independently.
Theme 3: Motivations for doing physical activity or sport	To start doing physical activity or sport require lots of self-motivation and health consciousness
Code: Reminding health importance	Need of reminding themselves that health is important.
Code: Valid reason of helping others	Inactive VI young adult's views of doing physical activity for a useful and needed action of helping others.
Sub-theme 3.1: Lack of belief regarding the benefits of doing physical activity and sport	Poor motivation as VIP2 does not see the benefits, there is a lack of belief on any benefits of physical activity
Code: Tiring, risky and overwhelming activities	Inactive VI young adult believes physical activity is tiring, risky and overwhelming.
Code: Not good for mental health	Inactive VI young adult beliefs that physical activity or sport is not beneficial for mental health.
Code: Pressure on doing physical activity or sport	Inactive VI young adult believes physical activity or sport put us a lot of pressure.
Code: Taking up time	Inactive VI young adult perception of physical activity or sport take a lot of time.

Appendix I Protocol interview with coaches

Interview Guide – Expert Participant

Study Title: Interview Study-VI young adults and physical activity and sport experiences

Researcher: Geane de Almeida Fontinele Zadra

ERGO number: ERGO/FEPS/53732

Interview questions for coaches

I will ask participants to answer the questions based on their experiences before the COVID-19 pandemic.

The following questions are divided in topics:

Demographics

1. How long have you worked with VI physical activity and sport?
2. What is your current occupation?
3. How long have you been in this position?
4. Which type of physical activity do you work with?
- 4.5. What types of VI people (clients) you worked with? Which type of these VI people is the majority of your clients?

Work experience of VI physical activity and sport

- 5.6. What do you do as a coach in a non-pandemic situation?
- 6.7. What are the tasks that you would like to do more and focus on in a non-pandemic situation?
- 7.8. What are the tasks that you would like to do less often in a non-pandemic situation?
- 8.9. What are the simple or small tasks of coaching in a non-pandemic situation?
- 9.10. Is Are there any professional collaborations between coaches in a non-pandemic situation?
- 10.11. Describe your work experience with VI young adults aged between 18-30 years old in physical activity and sport before the pandemic.
- 11.12. Describe how was your interactions and communications with them before the pandemic.

12.13. Do you have strategies to engage VI young adults in physical activity or sport in a non-pandemic situation?

If answer is yes: Can you give some examples of these strategies? What improvements or modifications, if necessary, would you like to make to these strategies?

If answer is no: Why not?

Opinion

13.14. What do you know about the participation/What is your opinion of the participation (previous part of the question) of VI young adults in sport and physical activity in a non-pandemic situation?

14.15. What do you think is the most important need for VI young adults to do physical activity or sport in a non-pandemic situation?

15.16. In your view, who do you feel need more support to do physical activity or sport among VI young adults in a non-pandemic situation?

16.17. What do you think that could help or improve your work in a non-pandemic situation?

17.18. What is the impact of the pandemic in the activities for coaches and VI young adults? How has your work changed during the pandemic? (Previous question)

Questions for the demonstration session of the app

1. What do you think about this app?
2. How do feel using this app from the VI young adult perspective?
3. In your view, who would most need to use this app among the young visually impaired group?
4. Which parts of the app are most important for VI young adults?
5. Which parts of the app are least important for VI young adults?
6. Do you have any suggestion to add for this app that could help the VI young adult to engage in physical activity?
7. As a coach, what you would like to do as part of your work using this app? For example, looking at the profile of VI users that contacted you in the chat and wanted to take part in your activity. (I'm unsure if it's ok to give any example, will it be something like a leading question?)
8. Would you recommend this app to young visually impaired adults?

Appendix I

- a. If answer is yes or no: why?
- 9. Would you recommend this app to and other coaches if it had services for them?
- a. If answer is yes or no: why?

Appendix J Codebook: Interview with coaches

Table J.1 Themes and sub-themes of interviews with coaches

Themes	Description
Theme 1: Challenges for VI young adults to participate in physical activity or sport	Coaches' perspectives of challenges faced by VI young adults in taking part in physical activity or sport.
Sub-theme 1.1: Lack of knowledge about opportunities and how to take part	Some VI people may not know how to take part in physical activity or sport.
Code: Not aware about opportunities of accessible physical activity and sport sessions	There may be a lack of awareness of accessible exercise or sport opportunities among VI people.
Code: Not many sport opportunities for women	Organisation may not provide many sport opportunities to VI women.
Code: Transport for VI people	Coaches' perceived mobility issues for VI people.
Code: Cannot get a transport	Transport can be a barrier to some VI people.
Code: Dependency on family members	VI young people rely on family members for transport.
Code: Poor transport links	Transport links can be limited in some areas and times of the day.
Sub-theme 1.2: Limited opportunities of inclusive physical activity and sport sessions	Lack of accessible physical activity and sport sessions for VI people.
Code: Need more sporting opportunities	There is a need of more exercise or sport opportunities available for VI people in their local area.
Code: Difficult to find a guide	Some type of sport may require finding the right guide with ability to guide at recreational or performance level.
Code: VI children and teens' activities in VI charities	VI charities very focused on activities for VI children and teenagers and their families.

Table J.1 Continued

Themes	Description
Sub-theme 1.3: Perceived VI people's fears and concerns to get active	Coaches' perspective that VI young adults are afraid to take part in physical activity.
Code: VI people' fears to start doing physical activity or sport	Coaches perceive fear of doing physical activity or sport among some VI people.
Code: Environmental impact	Coaches need to understand some impacts of the environment on VI people while taking part in physical activity or sport.
Code: Building impact on produced sound indoors	Coaches need to consider the impact of the type of building and sound produced indoor during a session.
Code: Sensory impact	Colours and sound are important for VI players.
Sub-theme 1.4: Accessibility barriers in VI physical activity and sport	Accessibility barriers in physical activity.
Code: Inaccessible physical activity and sport social media posts	VI people complain about inaccessible image of physical activity event on social media.
Code: Lack of accessible system	Coaches identifies lack of accessibility in their sport online entry portal and their perceived view of other technologies.
Code: Preventing independence to use digital systems	VI people are not independent while using VI sport system.
Code: Social media not accessible for some VI people	Some (minority) VI people say they cannot access social media, or it is not accessible.
Code: Perceived VI people poor experience	Coaches' perception of previous poor experiences of VI people in physical activity or sport.
Code: Physical activity or sport not accessible	VI people tried many inaccessible activities.
Sub-theme 1.5: Lack of social support	Perceived lack of support to VI young adults from others
Code: Been told can't do it	VI young adults hear that they cannot do physical activity or play sport.

Table J.1 Continued

Themes	Description
Code: Difficult to be the younger in a VI session	It may be difficult to VI young adults to be a physical activity or sport with older adults.
Code: Family of VI young adults	Coaches perceive family as a challenge for VI young adults to get active.
Code: Biggest challenge	Coaches hear VI young adults say that their biggest challenge is their own families.
Code: Holding back from doing things	Some families seem to have a negative attitude towards physical activity that put their VI young adult away from any activity.
Code: Need of right attitude	Perceived need of change in the attitude of families of VI young adults towards their participation in physical activity or sport.
Code: Protective circle	Some families of VI young adults seem to form a protective circle around them.
Code: Reluctant and concerned	Some family members of VI young adults show reluctance or do not understand what the session is or how it works.
Code: Taking independence away from VI young adult	Coaches perceive that some families want to do everything for their VI young adult and take their independence away.
Code: Lack of a buddy to exercise with	Some VI young adults may not have someone to go out to exercise.
Theme 2: Challenges for coaches' work that impact the service in VI physical activity and sport	Coaches' work experience with VI young adults.
Sub-theme 2.1: Coaches' views on what knowledge is needed	The need of more knowledge about visual impairment and barriers faced by visually impaired people.
Code: Coach's views on needed training	Coaches' views about more needed training around inclusive coaching.
Code: Need of awareness of environment impact for VI people	Be aware of how things change for VI people due to some aspects of the environment and the sessions.
Code: Continuous professional development	Continuous professional development in the qualification system for coaches.
Code: Enable a bigger workforce	To train more coaches about VI sport.
Code: Being confident to work with VI people	Confident to work with VI people in sport or physical activity.

Table J.1 Continued

Themes	Description
Code: Facilitate VI people play more locally	Training coaches may enable VI people to play locally.
Code: Need of knowledge about VI players	Coaches need to understand that there are different types of sight loss and people have different needs and aspirations.
Code: Asking about past and current physical activity level	Coaches need to know about past and current physical activity level of VI people.
Code: Build sense of trust	Coaches can be able to know more about participants as soon the VI person can trust the coach.
Code: Need to know if bring a company to the session	Need to know if someone would be with a VI participant.
Code: Need to know how participants get to the venue	Asking how a VI participant would get to the venue.
Code: Need to know that is important to adapt the communication and coaching	By knowing about VI participants, coaches can adapt their way to communicate and teach the sport or physical activity.
Code: Need to know the preferred way to be guided	Some VI people may prefer to be guide in a certain way, especially, in running with a tether or holding a harm.
Code: Need to know visual impairment level and health conditions	Coaches' need to know the visual impairment level and health conditions of participants.
Code: Lack of knowledge of visual feedback	For coaches it may be difficult to give detailed information of the game for partially sighted players, especially in VI tennis.
Code: Not knowing about other impairment	VI players may not tell coaches about other impairment they may have.
Sub-theme 2.2: Coaches' apprehensions and fears	Coaches do not feel confident in coaching, especially VI tennis.
Code: Difficult to engage VI young adults in physical activity or sport	It's difficult to get VI young adults committed to take part in physical activity or sport.
Code: Sighted guide can't really understand sight loss	Understanding sight loss and its impact on taking part in the physical activity may not be fully understood by sighted guide.

Table J.1 Continued

Themes	Description
Code: VI people's preference for VI coaches	VI coaches perceive that VI players prefer to be guided by them.
Sub-theme 2.3: Administration difficulties	Making administrative tasks more efficient for coaches.
Code: All administration on sessions	Getting information and all administration on running sessions.
Code: Making players registration accessible	VI players cannot access an online portal to register themselves.
Code: Enabling more time for coaching	Efficient work may enable coaches to spend more time on coaching and other related tasks.
Code: Unknown participants confirmation	Lack of knowledge on participants' numbers can impact the viability of the session.
Sub-theme 2.4: Getting VI people in physical activity	Coaches' issues on getting VI young adults to take part in sessions.
Code: Difficult to find VI young adults	Coaches find it difficult to find VI people to take part in the exercise or sport.
Code: Do more to promote accessible sport	Need of more effort to promote accessible sport.
Code: Need more reach	The need to get more VI people involved in physical activity or sport.
Code: Spending a lot of time to get VI people in	Coaches spending a lot of time to get VI people to take part in exercises or sport.
Code: Hard to engage with some VI young adults until they feel comfortable	Some VI people may start to become more communicative with coaches when they feel comfortable.
Theme 3: Facilitators to engage VI young adults	Coaches' perspectives of facilitators or recommendations for engaging VI young adults.
Sub-theme 3.1: Coaches need to know about VI players	Coaches need to understand everyone with VI, as the impairment varies from levels and its impact on people's lives.
Code: Different level of support	Each person with visual impairment needs appropriate support according to their needs.

Table J.1 Continued

Themes	Description
Code: Just to play	One of the reasons VI people for getting into sport is they just want to play and no more input from the coach.
Code: Multiple impairments support	Different support for those with multiple impairments.
Code: One to one for beginners	
Code: Providing more input	One of the reasons VI people take part in sports is they want more input from coaches.
Code: Let VI people know about available support for VI people	Getting VI people to understand there is support for taking part in physical activity and sport.
Code: Make VI people understand they can do physical activity	Make VI people understand they can do physical activity.
Sub-theme 3.2: Improvements to accessibility and usability	Coaches' perceived meaning of accessibility on approaches for delivering VI physical activity or sport.
Code: Everything audio described	Coaches have to describe everything.
Code: Gym and sport venue staff awareness	Gym and sport venue staff need to be aware of sight loss.
Code: Make accessible physical activity and sport sessions	Sight loss charities and gym and sport venues need to focus more on making physical activity and sport sessions accessible.
Code: Make things efficient	Make systems efficient for VI people as they cannot easily register themselves on an online system.
Code: Accessible registration system	Need of a registration app working for VI people as it is already working for sighted participants.
Code: No need of two systems	Avoid creating extra work with two systems to make one accessible.
Code: Providing online booking sessions	
Sub-theme 3.3: Inclusive coaching	The need of an inclusive approach for coaching.
Code: Become inclusive coaches	The need of coaches to become more inclusive.
Code: Help VI young adult to take part independently and safely	Providing the right support to VI people be able to take part independently and safely in the physical activity or sport session.
Code: Make VI people feeling comfortable and welcome	Coaches need to make sure VI people feel comfortable and welcome.
Code: Backup plans	For those getting anxious or concerned during the sessions.

Table J.1 Continued

Themes	Description
Code: Being supportive and open	Coaches need to show they are really supportive to help VI young adults feel welcomed.
Code: All ready and everyone is aware	The sessions are set up for VI people and everyone knows what is going on.
Code: No pressure to progress in physical activity or sport	No need to make pressure for VI young adults to make progress in physical activity or sport.
Code: Offering a have a go session	Coaches see that have a go session may help VI people to decide to take part in the exercise or sport.
Code: Start with an individual physical activity or sport session	If the person is brand new to physical activity or sport, a separate session from the group may help VI young adult feel less apprehensive.
Code: Be around sighted friends	Coach's perspective that VI young adults may want to play or exercise with their sighted friends.
Code: Be around similar peers	Coaches' perspective that VI young adults may want to play or exercise with similar peers.
Code: Meet everyone's needs	Run the sessions to meet the needs of VI people.
Code: Providing accessible tools	Provide the right equipment to make physical activity or sport more accessible.
Code: Providing assistance	Coaches and staff helping VI people to move around the venue and other assistance.
Code: Online coaching for VI people	As a result of the pandemic, coaches were doing online coaching of physical activity or sport skills.
Code: All joining in together	Opportunity to run sessions that everyone, all disabilities could take part in.
Code: Lots of creativity	By running VI tennis skills online, participants had been creative to adapt to the sessions.
Code: Start activity at home	VI people can start playing tennis/exercise at home.
Code: VI coaching is a practical challenge	Coaching seems to be challenging as coaches are still learning how to approach VI people.
Sub-theme 3.4: Promoting sessions	Exercise and sport promotion approaches and challenges.
Code: Clear target audience	VI people need to know what to expect and what target group is promoted in the adverts.
Code: Find better way to promote sessions	More effort and efficient promotion of exercise and sport sessions.
Code: Physical activity or sport session adverts	Adverts promoting physical activity or sport sessions for VI young adults.
Code: Need to communicate the adverts really well	Need of good communication to start promoting about exercises or sports.

Table J.1 Continued

Themes	Description
Code: Adverts seems to be not appealing	Physical activity or sport session adverts seem to be not appealing for VI young adults.
Code: Not easy to make attractive adverts	Coaches perceive that advertising exercises or sport activities is not an easy task.
Code: Provide quick information about the session	Make VI people aware about details of the sessions.
Code: Teaming up with local charity to promote sessions	Promoting VI sessions via local charities.
Code: Promote sessions as very much inclusive focus	Promote sessions as being very much inclusive.
Sub-theme 3.5: Support for VI young adults to engage in physical activity or sport	Different types of support that is necessary to help VI people to take part in exercise or sport.
Code: Communication between coaches and VI young adults	Communication between coaches and VI young adults is important in sport and physical activity before, during and after the sessions.
Code: Perceptions of information needs of VI young adults	Coaches' perceived information needs of VI young adults about coaches and physical activities and sport sessions.
Code: Need to inform how to get to places safely	Coaches need to provide information on how to get to the physical activity session safely.
Code: Need to inform somebody can help at the venue	Need to inform VI young adults that there is someone to welcome and help them at the venue.
Code: Need to inform what sessions coaches provide	The need of informing VI young adults about what coaches are doing or sessions provided.
Code: Use of Facebook and WhatsApp	Coaches' experiences of using social media to share information about their sessions.
Code: Building community via social media	Communication between coaches and players throughout the week is part of building the community.
Code: Mechanism of sharing via WhatsApp	Coach's perspective of WhatsApp as a mechanism of sharing information between players.

Table J.1 Continued

Themes	Description
Code: Word of mouth within the VI community	Some people in the VI community rely on other people telling them about sport or physical activity sessions.
Code: Support network	Coaches and guides point out the links and collaboration between professionals, organisations and support from volunteers and peers as an impact on VI young adult experience in PA and sport.
Code: Bigger link between recreational providers and sight loss charities	Need of better link between local leisure centres and sight loss charities.
Code: Coaches collaboration	Coaches' collaboration to improve the service provided to VI people.
Code: Fragmented	Coaches' perception of not having enough collaboration between them.
Code: More professional collaboration	The need of more collaboration between coaches.
Code: More collaboration between clubs	The need of more collaboration between sport clubs.
Code: Share learnings	Collaboration between coaches to share ideas and practices.
Code: Influence other coaches	To influence other coaches who are doing some or none in VI sport.
Code: Swap people over	Coaches may need to contact other coaches to swap participants of their sessions.
Code: Peer support	Coaches see that support from existing members is important to new participants.
Code: Getting VI people involved	Important to involve VI people into a group.
Code: Make VI young adult feel welcome	VI people feel welcome by coaches and peers in the sport or physical activity sessions.
Code: Volunteers' collaboration	Importance of volunteers' participation for coaches and VI people.
Code: Volunteers being careful about safety reasons	To consider the needs of VI people for safety reasons.
Code: Volunteers as Buddy coaches	Work with volunteers to give the opportunity to them to play and give feedback to VI players.
Code: Easy and fun playing with Volunteers	VI people may find easy and fun playing with sighted volunteers.
Code: Volunteers help to give more information during the game	Volunteers can help VI people by giving more information about the ball, net, etc. during the game.

Table J.1 Continued

Themes	Description
Code: Make volunteering Inclusive and extended out across the country	Make volunteering more inclusive and extended out across the country.
Code: Need right amount of volunteers	There is a need of a number of volunteers to support VI people.
Code: Preventing risk of exclusion	Volunteers may be a type of support to reduce the risk of exclusion that VI people may feel in sport or exercise sessions.
Code: Preventing struggle	Having right amount of volunteers may help VI people and coaches will not struggle to provide their service.
Code: Need of wider awareness	Need of making everyone including VI people aware of inclusive physical activity and sport.
Code: Producing audio described VI sports	Producing and promoting audio described videos about VI sports for both VI and sighted community awareness.
Code: Reach VI people out in the community	Promoting VI sport in its widest sense, which includes those people that are not connected to disabled groups as well.
Code: Need of everyone understanding VI people can do	Everyone needs to understand that VI people can take part in physical activity or sport.
Code: Enhanced by interactive talks in organisations	By making interactive talks sighted people in organisations can better understand sight loss.
Code: Need of wider encouragement	Coaches and guides need to encourage VI young adults and the VI sport community to be involved and make sport more inclusive.
Code: Encouraging VI people	Coaches' perspectives in encouraging VI people.
Code: Being independent	Encouraging VI young adults be independent and control their life.
Code: Believe in themselves	VI people need to be encouraged to believe in themselves.
Code: Establish VI young people mindset	Starting to build the active lifestyle among the VI young people under 18 years old.
Code: Help facing fears	Help VI young adults to overcome their fears.
Code: Need of push and encouragement	Some VI people may need to be encouraged to overcome their fears.

Table J.1 Continued

Themes	Description
Code: Show examples of other VI people taking part in physical activity or sport	Coaches perceive that VI young adult may need to know about other examples.
Code: Show others having good time doing physical activity or sport	Showing VI young adults enjoying taking part in physical activity or sport.
Code: Knowing that VI friends do physical activity	VI people may be more motivated to get active if they know their VI friends are enjoying the physical activity or sport.
Code: Show similar age doing physical activity or sport	By seeing similar peers may influence VI young adults to engage in physical activity or sport.
Code: Encouraging VI sport community	Perceived need of encouragement of sport community to become more inclusive.
Code: Who need more support	Identifying who need more support among VI young adults.
Code: Blind young adults first time doing physical activity need more support	Blind young adults starting to get active may need more support.
Code: VI young adults dependent on others need more support	The least independent people are those in need of more support.

Appendix K Accessible online survey

Participant Questionnaire

Online survey Reference Number ERGO/FEPS/ 51707

Age group

How old are you?

If you are under 18 years old or above 30 years old, I'm afraid you are not eligible to take part in this study. Thank you for your interest and you can close this document.

How has your physical activity changed during the COVID-19 pandemic?

Now please answer the following questions based on your experiences before the COVID-19 pandemic.

Physical Activity

I am going to ask you about the time you spend doing different types of physical activity in a typical week in a non-pandemic situation. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, housework, gardening, seeking employment. In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

Questions

Activity at work

1. Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads for at least 10 minutes continuously? Place an X for your answer.

☐ Yes

☐ No if No, go to Question 4

2. In a typical week, on how many days do you do vigorous-intensity activities as part of your work?

Number of days:

3. How much time do you spend doing vigorous-intensity activities at work on a typical day?

Hours:

Minutes:

4. Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking or carrying light loads for at least 10 minutes continuously?

☐ Yes

☐ No if No, go to Question 7

5. In a typical week, on how many days do you do moderate- intensity activities as part of your work?

Number of days:

6. How much time do you spend doing moderate-intensity activities at work on a typical day?

Hours:

Minutes:

Travel to and from places

The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example, to work, for shopping, to market, to place of worship.

7. Do you walk or use a tandem bicycle for at least 10 minutes continuously to get to and from places?

☐ Yes

☐ No if No, go to Question 10

8. In a typical week, on how many days do you walk or use a tandem bicycle for at least 10 minutes continuously to get to and from places?

Number of days:

9. How much time do you spend walking or using tandem bicycle for travel on a typical day?

Hours:

Minutes:

Recreational activities

The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure).

10. Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like running or football for at least 10 minutes continuously?

☐ Yes

☐ No if No, go to Question 13

11. In a typical week, on how many days do you do vigorous- intensity sports, fitness or recreational (leisure) activities?

Number of days:

12. How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?

Hours:

Minutes:

13. Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that causes a small increase in breathing or heart rate such as brisk walking, cycling, swimming, goalball for at least 10 minutes continuously?

☐ Yes

☐ No if No, go to Question 16

14. In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities?

Number of days:

15. How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?

Hours:

Minutes:

Sedentary behaviour

The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping.

16. How much time do you usually spend sitting or reclining on a typical day?

Hours:

Minutes:

Capability, opportunity and motivation

When it comes to you personally doing or not doing physical activity or sport, what do you think it would take for you to do it? (Tick any of the items on the list that you think apply; you can tick as many or as few as you think appropriate, some of the items may look strange, but that is just because we need to include anything that might possibly apply for some people.)

In each case please would you say why you think it might be important for you.

Capability

☐17. I would have to know more about why it was important. e.g. have a better understanding of the benefits of physical activity and sport.

☐18. I would have to know more about how to do it. e.g. have a better understanding of how to do physical activity or play sport.

☐19. I would have to have better physical skills. e.g. learn how to develop balance.

☐20. I would have to have better mental skills. e.g. learn how to reason more effectively.

☐21. I would have to have more physical strength. e.g. build up muscles for demanding physical work.

☐22. I would have to have more mental strength. e.g. develop stronger resilience against cravings.

☐23. I would have to overcome physical limitations. e.g. get around problems of disability.

☐24. I would have to overcome mental obstacles. e.g. reduce unwanted urges or feelings.

☐25. I would have to have more physical stamina. e.g. develop greater capacity to maintain physical effort.

Appendix K

☐26. I would have to have more mental stamina. e.g. develop greater capacity to maintain mental effort.

Opportunity

☐27. I would have to have more time to do it. e.g. create dedicated time during the day.

☐28. I would have to have more money. e.g. be given or earn funds to support the behaviour.

☐29. I would have to have the necessary materials. e.g. acquire better technology assistance.

☐30. I would have to have it more easily accessible. e.g. provide easier access to facilities and equipment.

☐31. I would have to have more people around you doing it. e.g. be part of a group who are doing physical activity or playing sport.

☐32. I would have to have more triggers to prompt you. e.g. have more reminders at strategic times.

☐33. I would have to have more support from others. e.g. have family or friends to take you to a leisure centre.

Motivation

☐34. I would have to feel that you want to do it enough. e.g. feel more of a sense of pleasure or satisfaction from doing physical activity or playing sport.

☐35. I would have to feel that you need to do it enough. e.g. care more about the negative consequences of not doing it.

☐36. I would have to believe that it would be a good thing to do. e.g. have a stronger sense that one should do it.

☐37. I would have to develop better plans for doing it. e.g. have clearer and better developed plans for doing physical activity or playing sport.

☐38. I would have to develop a habit of doing it. e.g. get into a pattern of doing physical activity or playing sport without having to think.

☐39. Something else (please specify).

Experiences and personal details

Existing preferences

40. What type of physical activity or sport you usually take part in a non-pandemic situation?

☐ Individual

☐ Team

☐ Both

☐ None

41. Which activities you have usually done in a non-pandemic situation? Please tick as many as apply.

☐ Fitness

☐ Aerobics

☐ Weighting

☐ Lifting

☐ Walking

☐ Running

☐ Cycling

☐ Goalball

☐ Visually impaired tennis

☐ Netball

☐ Blind football

☐ Blind cricket

☐ None

☐ Other (please specify):

36. Do you have a membership of a gym or sport club?

☐ Just gym

☐ Just sport club

☐ Both

☐ Neither

37. Where do you prefer to do physical activity?

☐ Outdoor

☐ Gym

☐ Sport clubs

☐ Home

☐ None

Future preferences

38. How interested are you in doing more physical activity or sport?

☐ Not very interested

☐ Not interested

☐ Neutral

☐ Interested

☐ Very interested

39. Which activities you would like to do more of? Please tick as many as apply.

☐ Fitness

☐ Aerobics

☐ Weighting lifting

☐ Walking

☐ Running

☐ Tandem cycling

☐Cycling at the gym

☐Goalball

☐Visually impaired tennis

☐Netball, blind football

☐Blind cricket

☐Parkrun

☐None, (please specify):

Awareness

40. Are you aware how much physical activity you should be doing according to the UK Government Physical Activity Recommendations?

☐Not at all aware

☐Slightly aware

☐Somewhat aware

☐Moderately aware

☐Extremely aware

41. Are you aware of what facilities are available near to you in a non-pandemic situation?

☐Not at all aware

☐Slightly aware

☐Somewhat aware

☐Moderately aware

☐Extremely aware

42. If yes, how do you find them?

☐Through Internet

☐Through friends or family

☐News

☐Other (please specify):

43. How often do you get information about fitness, sport and physical activity on the Web?

☐Never

☐Rarely

☐Sometimes

☐Often

☐Always

Technologies

44. Which of these technologies have you used (please tick all that apply):

☐Fitness or physical activity app (now answer Question 51)

☐Wearable physical activity tracker, e.g. Fitbit, Apple Watch, Samsung Gear (now answer Question 51)

☐Neither (now answer Question 52)

45. If you are using these technologies, how long you have used them?

☐Between 1 to 6 months

☐Between 7 to 12 months

☐Less than 1 year

☐Not using them for nearly one year or more.

46. If you are not using these technologies, how interested are you in using these types of technologies?

☐Not very interested

☐Not interested

☐Neutral

☐Interested

☐Very interested

Please explain why you gave the answer above:

47. Which social media account you have (tick all that apply)?

☐Facebook

☐Instagram

☐Twitter

☐None

☐Other (please specify):

Personal details

48. What is your level of visual impairment?

☐Severely sight impaired (blind)

☐Sight impaired (partially sighted)

49. What is the cause of your impairment?

☐Congenital (impairment exists from birth)

☐Acquired (acquired vision loss after birth)

50. What sex were you assigned at birth, on your original birth certificate?

☐Female

☐Male

51. What best describes your gender?

☐Female

☐Male

☐ Prefer not to say

☐ Prefer to self-describe (please specify):

52. What are you doing at the moment?

☐ Full-time employee (30 or more hours a week)

☐ Part-time employee (under 30 hours)

☐ Full-time self-employed

☐ Part-time self-employed

☐ In unpaid or voluntary work

☐ Full-time Studying – School/College/University

☐ Part-time Studying – School/College/University

☐ Unemployed and seeking work

☐ Apprenticeship

☐ Looking after your home or family

☐ Other (please specify):

Do you want to receive the results of this survey? Would you like to be contacted for interviews in this research?

☐ Yes

☐ No

If yes, you can contact the researcher Geane Fontinele directly on gdaz1e17@soton.ac.uk

Is there anything not covered in this survey and you want to make any comment? Please feel free to give your opinion here!

Feedback

How long did you take to complete it? How easy or hard it was to complete? Was it easy to understand the questions? Is there any wording that caused misunderstanding? Is there any problem you identified in this questionnaire?

This is the end of the questionnaire, thank you for participating.

Appendix L Ethics application for accessible online survey

FEPS Ethics Committee

FEPS Ethics Application Form Ver 3

Refer to the *Instructions* and to the *Guide* documents for a glossary of the key phrases in **bold** and for an explanation of the information required in each section. The *Templates* document provides some text that may be helpful in preparing some of the required appendices.

Replace the highlighted text with the appropriate information.

Note that the size of the text entry boxes provided on this form does **not** indicate the expected amount of information; instead, refer to the *Instructions* and to the *Guide* documents in providing the complete information required in each section. Do **not** duplicate information from one text box to another. Do not otherwise edit this form.

Reference number: ERGO/FEPS/51707

Submission version: 3 Date: 2019-07-18

Name of investigator(s): Geane de Almeida Fontinele Zadra

Name of supervisor(s) (if student investigator(s)): Mike Wald

Title of study: Towards an online physical activity intervention for young adults with visual impairment

Note that failure to follow the University's policy on Ethics may lead to disciplinary action concerning Misconduct or a breach of Academic Integrity.

By submitting this application, the investigator(s) undertake to:

- Conduct the study in accordance with University policies governing:

Ethics (<http://www.southampton.ac.uk/ris/policies/ethics.html>);

Data management (<http://www.southampton.ac.uk/library/research/researchdata/>);

Health and Safety (<http://www.southampton.ac.uk/healthandsafety>);

Academic Integrity (<http://www.calendar.soton.ac.uk/sectionIV/academic-integrity-statement.html>).

- Ensure the study Reference number ERGO/FEPS/xxxx is prominently displayed on all advertising and study materials, and is reported on all media and in all publications;

- Conduct the study in accordance with the information provided in the application, its appendices, and any other documents submitted;
- Submit the study for re-review (as an amendment through ERGO) or seek FEPS EC advice if any changes, circumstances, or outcomes materially affect the study or the information given;
- Promptly advise an appropriate authority (Research Integrity and Governance team) of any adverse study outcomes;
- Submit an end-of-study form if required to do so.

Refer to the [Instructions](#) and [Guide](#) documents when completing this form and the [Templates](#) document when preparing the required appendices.

Study details

What are the aims and objectives of this study?

This study aims to understand the experiences and behaviours that impact the active lifestyle of visually impaired young adults, and the current online technologies aimed to improve physical activity engagement. The first part of this study is to conduct a pilot study of an online questionnaire on iSurvey, followed by an interview, in order to evaluate if the online survey is easy to understand and complete prior to make it available to a wider number of participants.

Background of the study (a brief rationale for conducting the study)

There are few studies about factors that determine the engagement and participation of visually impaired adults in physical activity and sport through a theory-based perspective (Haegele et al. 2018), as well as their sedentary behaviour (Haegele et al. 2017). Some current research findings have been inconsistent on demographics, personal, environmental and social factors; also, some of these studies have not reported accurate results based on a wide age range.

Key research question (Specify hypothesis if applicable)

How can we design an online physical activity intervention for young adults with visual impairment in the UK?

What are the experiences and needs of young adults with visual impairment with regard to engaging in physical activity or sport in the UK?

Study design (Give a brief outline of the study design and why it is being used)

Firstly, I will conduct a pilot study on few people that represents the definitive sample. I will interview the participants of the pilot study to obtain their feedback about the survey. For this pilot study, 6 participants will be invited to test the online survey.

Pre-study

Characterise the proposed participants

Participants are young adults from 18 to 30 years old with visual impairment (partially sighted or blind).

Describe how participants will be approached

If any e-mail lists are used, including FEPS distribution lists, justify their use here

I will use my university e-mail to contact local visual impairment charities. I will identify the e-mail address of these charities through its website. I will approach each charity by email with a request to share my invitation to their members with visual impairment to participate in this pilot study. A short description of the pilot study will be provided by email. Prospective participants will be able to contact me by email to participate.

Describe how inclusion / exclusion criteria will be applied (if any)

The inclusion criteria: participants aged 18 to 30 with visual impairment (partially sighted or blind) only. The exclusion criteria: No other type of impairment.

Describe how participants will decide whether or not to take part

Participant and consent information will be provided on the landing page of iSurvey. The following wording will be available in the participant information, 'Simply read the participant information and the consent will be confirmed when you place a tick (check) in the iSurvey box where it says, 'Please tick (check) this box to indicate that you consent to taking part in this survey', prior to test the questionnaire. This will indicate that you have read and agree to the participant information. Please then select 'Start the survey''. There is no time limit for doing this. If the participant does not place a tick (check) in the iSurvey box, they will be prevented from proceeding. Participants can choose to not accept to participate in this study, and they can withdraw at any time.

Participant Information (Appendix (i))

Provide the **Participant Information** in the form that it will be given to **participants** as Appendix (i). All studies must provide **participant information**.

Consent Form/Information (Appendix (iii))

Provide the **Consent Form** (or the request for consent) in the form that it will be given to **participants** as Appendix (iii). All studies must obtain **participant** consent. Some studies may obtain verbal consent (and only present consent information), other studies will require written consent, as explained in the *Instructions*, *Guide*, and *Templates* documents.

During the study**Participant questionnaire/data gathering methods (Appendix (ii))**

As Appendix (ii), reproduce any and all **participant** questionnaires or data gathering instruments in the exact forms that they will be given to or experienced by **participants**. If conducting less formal data collection, or data collection that does not involve direct questioning or observation of participants (eg secondary data or “big data”), provide specific information concerning the methods that will be used to obtain the data of the study.

Post-study**Describe the study procedures as they will be experienced by the participants**

Participants will be advised how to test the online survey. They can use their own mobile phone or a computer at the University of Southampton and use an assistive technology (screen reader), such as VoiceOver for an iPhone or TalkBack for an Android mobile phone or NVDA to be able to use the computer. They will be informed that they will not be recorded at any time. I will observe the time spent of each participant to complete the survey. Once the questionnaire is completed, I will ask few questions on what they think about the questionnaire if it is easy to understand and complete, if the order and meaning of words make sense and about their interest and attention.

Identify how, when, where, and what kind of data will be recorded (not just the formal research data, but including all other study data such as e-mail addresses and signed consent forms)

I will have only the name and email address of those who will reply to my invitation email accepting to participate in the pilot study. This data will be recorded in my university email inbox. The test will be conducted at the University of Southampton. The online survey test will be done only once, the answers given in the questionnaire will be analysed in order to identify missed responses, meaningful results, to test the data entry, coding of the items, descriptive statistics and to test preliminary data for the first outcome measure. Responses will be anonymous. I will interview the participants to ask about the questionnaire and I will make notes of their opinions in order to improve the survey. All the data will be stored safely, anonymised and stored electronically in my computer at the University

of Southampton, in the hard drive, the data will be password protected. At the end of the questionnaire, participants can request the results and say they are interested in taking part in the study by contacting me by email, this is the message in the questionnaire: 'Do you want to receive the results of this survey? Would you like to participate in interviews further on about your experience of physical activity or sport? Please contact me Geane Fontinele gdaz1e17@soton.ac.uk.'

Identify how, when, and where data will be stored, processed, and destroyed

If the Study Characteristic M.1 applies, provide this information in the DPA Plan as Appendix (iv) instead and do not provide explanation or information on this matter here

Study characteristics

(L.1) The study is funded by a commercial organisation: **No** (delete one)

If 'Yes', provide details of the funder or funding agency here.

(L.2) There are restrictions upon the study: **No** (delete one)

If 'Yes', explain the nature and necessity of the restrictions here.

(L.3) Access to participants is through a third party: **Yes** (delete one)

If 'Yes', provide evidence of your permission to contact them as (v) in the Checklist below. Do not provide explanation or information on this matter here.

(M.1) Personal data is or *may be collected or processed: **Yes** (delete one)

Data will be processed outside the UK: **No** (delete one)

If 'Yes' to either question, provide the DPA Plan as (iv) in the Checklist below. Do not provide information or explanation on this matter here. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be "Yes".

(L.3) Access to participants is through a third party: **Yes** (delete one)

If 'Yes', provide evidence of your permission to contact them as (v) in the Checklist below. Do not provide explanation or information on this matter here.

(M.1) Personal data is or *may be collected or processed: **Yes** (delete one)

Data will be processed outside the UK: **No** (delete one)

Appendix L

If 'Yes' to either question, provide the DPA Plan as (iv) in the Checklist below. Do not provide information or explanation on this matter here. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be "Yes".

(* Secondary data / "big data" may be de-anonymised, or may contain personal data. If so, answer 'Yes'.)

(M.2) There is inducement to participants: **No** (delete one)

If 'Yes', explain the nature and necessity of the inducement here.

(M.3) The study is intrusive: **No** (delete one)

If 'Yes', provide the Risk Management Plan, the Debrief Plan, and Technical Details as (vi), (vii), and (ix) in the Checklist below, and explain here the nature and necessity of the intrusion(s).

(M.4) There is risk of harm during the study: **No** (delete one)

If 'Yes', provide the Risk Management Plan, the Contact Information, the Debrief Plan, and Technical Details as (vi), (vii), (viii), and (ix) in the Checklist below, and explain here the necessity of the risks.

(M.5) The true purpose of the study will be hidden from participants: **No** (delete one)

The study involves deception of participants: **No** (delete one)

If 'Yes' to either question, provide the Debrief Plan and Technical Details as (vii) and (ix) in the Checklist below, and explain here the necessity of the deception.

(M.6) Participants may be minors or otherwise have diminished capacity: **No** (delete one)

If 'Yes', AND if one or more Study Characteristics in categories M or H applies, provide the Risk Management Plan, the Contact Information, and Technical Details as (vi), (vii), & (ix) in the Checklist below, and explain here the special arrangements that will ensure informed consent.

(M.7) Special category personal data is collected or processed: **No** (delete one)

If 'Yes', provide the DPA Plan and Technical Details as (iv) and (ix) in the Checklist below. Do not provide explanation or information on this matter here.

(H.1) The study involves: invasive equipment, material(s), or process(es); or participants who are not able to withdraw at any time and for any reason; or animals; or human tissue; or biological samples: **No** (delete one)

If 'Yes', provide Technical Details and further justifications as (ix) and (x) in the Checklist below. Do not provide explanation or information on these matters here. Note that the study will require separate approval by the Research Governance Office.

Technical details

If one or more Study Characteristics in categories M.3 to M.7 or H applies, provide the description of the technical details of the experimental or study design, the power calculation(s) which yield the required sample size(s), and how the data will be analysed, as separate appendices.

Checklist of Documents to upload

Please provide the following forms, *naming the files as explicitly as possible*, e.g., "Participant Information", "Questionnaire", "Consent Form", "DPA Plan", "Permission to contact", "Risk Management Plan", "Debrief Plan", "Contact Information", and/or "Technical details" as appropriate. Each document must specify the reference number in the form ERGO/FPSE/xxxx, the document version number, and its date of last edit.

- (i): **Participant Information** in the form that it will be given to **participants**.
- (ii): Data collection method (e.g. for secondary data or "big data") / **Participant** Questionnaire in the form that it will be given to **participants**.
- (iii): **Consent Form** (or consent information if no **personal data** is collected) in the form that it will be given to **participants**.
- (iv): **DPA Plan**.
- (v): Evidence of permission to contact (prospective) **participants** through any third party.
- (vi): **Risk Management Plan**.
- (vii): **Debrief Plan**.
- (viii): **Contact Information**.
- (ix): Technical details of the experimental or study design, the power calculation(s) for the required sample size(s), and how the data will be analysed.
- (x): Further details and justifications in the case of: **invasive** equipment, material(s), or process(es); **participants** who are not able to withdraw at any time and for any reason; animals; human tissue; or biological samples.

Appendix M First version of Guidance A

The design process was based on the design thinking and agile design process. It provides additional steps, such as relevant recommendations to implement accessibility and usability from the beginning of the design process of mobile applications. (See Design Process of Guidance A Diagram).

[User Research](#)

[Problem definition](#)

[Initial design concept and Minimum Viable Product requirements](#)

[Accessible Mid-Fidelity Prototype](#)

[Accessibility and usability check of Accessible Mid-Fidelity Prototype](#)

[User testing and interview of Accessible Mid-Fidelity Prototype](#)

[User testing and interview analysis of Accessible Mid-Fidelity Prototype](#)

[Review design requirements](#)

[Accessible High-Fidelity Prototype](#)

[Accessibility and usability check of Accessible High-Fidelity Prototype](#)

[Preparation of app release for testing \(Android, iOS\)](#)

[Usability testing and interview of Accessible High-Fidelity Prototype](#)

[Usability testing and interview analysis of Accessible High-Fidelity Prototype](#)

[Update the design requirements](#)

1 User Research

Conduct a literature review for the related design problem to be addressed as it is usually done in the design process. The interviews or surveys can also be conducted as usual with research participants, if necessary and whenever possible.

2 Problem definition

Categorisation of the target audience of the mobile application, for instance, visually impaired young adults' needs and experience in physical activity and sport. In interdisciplinary projects, ensure approaches from fields, such as behavioural science, can be applied into the study.

Create personas to help the design team to comprehend the needs of visually impaired people.

3 Initial design concept and Minimum Viable Product requirements

Define the design system features to be tested out at the user evaluation stage, based on the literature review, interviews or surveys.

Implement accessibility and usability guidelines, such as Web Content Accessibility Guidelines (WCAG) 2.1 Conformance levels A and AA, Jakob Nielsen's Ten Usability Heuristics, and BBC accessibility guidelines.

Consider implementing responsive design for applications suitable for smartphones and desktops. The interface should adapt to different screen sizes. There is a need to ensure that visually impaired people, not using touchscreen devices, are able to use the application via a desktop and keyboard.

Prioritise design requirements according to feasibility and most relevant features to build.

Ensure there will always be developer(s) working throughout the entire process.

4 Accessible Mid-Fidelity Prototype

Use a digital platform to create an Accessible Mid-Fidelity Prototype, such as MS PowerPoint. Avoid use of paper prototyping as this can prevent visually impaired people from participation in the design process. By using MS PowerPoint and setting the screen size to match a potential user's device screen size, it is possible to simulate user's actions when testing interface adaptations.

Set a sequential reading order for all screen components and slides on MS PowerPoint. This allows the screen reader user to hear the contents in correct order.

Add unique titles to slides and make sure that slides as part of a consecutive process do not have the same title. In this case the title can have additional information, such as title's name part 1, title's name part 2 so screen reader users know where they are in the prototype.

Apply good levels of background and text colour contrast. It is recommended to use the colours and font, for instance, black for background and yellow for text, a sans serif font, and bold fonts. Font size: 18 or 22.

5 Accessibility and usability check of Accessible Mid-Fidelity Prototype

Use automatic and manual checks and if available use the application's accessibility checker (e.g., Microsoft Office including PowerPoint). Make sure screen content and font sizes work with appropriate levels of magnification and in particular without loss of functionality on mobile devices. Ensure screen readers built into the operating systems of all devices, including iPhone and Android are compatible with the application. Also check the mobile application with an external Bluetooth keyboard.

6 User testing and interview of Accessible Mid-Fidelity Prototype

First interview and then run the user testing with a few participants, consider recruiting 5 participants to test the Accessible Mid-Fidelity Prototype. If possible, run individual face-to-face session with each participant. Ask participants to think aloud. Having gained consent, record the session. Participants do test on their own device.

7 User testing and interview analysis of Accessible Mid-Fidelity Prototype

Choose a qualitative method such as thematic analysis or affinity diagram to analyse the interview's transcripts.

8 Review design requirements

Prioritise the design requirements.

Adjust accessibility and usability needs based on feedback received.

9 Accessible High-Fidelity Prototype

Use cross-platform software, for instance, React Native, to build a mobile app and web app.

10 Accessibility and usability check of Accessible High-Fidelity Prototype

Automatic check of accessibility on Xcode Accessibility Inspector, Android Accessibility Scanner and accessibility checker for web apps. Ensure to check the accessibility of the mobile application with an external Bluetooth keyboard. Manual check of accessibility and usability on an iOS and Android mobile phone.

Record both manual and automatic check results on an Excel spreadsheet. The record can be saved in a format based on the Web Content Accessibility Guidelines Evaluation Methodology (WCAG-EM) Report Tool, in which includes selecting a sample of screens, the WCAG 2.1 Success Criteria, tools, analysed functions or elements, comments and expected. The record can be saved in a format based on the Web Content Accessibility Guidelines Evaluation Methodology (WCAG-EM) Report Tool, in

which includes screens sample, the WCAG 2.1 Success Criteria, used tools, analysed functions or elements, result, comments and expected outcomes.

11 Preparation of app release for testing (Android, iOS)

Process to be conducted by a software engineer with experience in mobile application releases.

Make sure an Apple developer account is available.

Be aware of TestFlight and the certification process.

Prepare an APK (Android Package Kit) file for Android release.

12 Usability testing and interview of Accessible High-Fidelity Prototype

First interview and then run the usability testing with participants. Ask participants to think aloud.

Record the session. This process can be completed remotely via a video call, but may need some adaptations and different strategies, such as connecting via accessible video conferencing software and asking participants to enable the built-in screen recorder. It also possible for the tester to have their interactions filmed using another mobile device connected to the accessible video conferencing software. By using the built-in screen recorder, ask participants to enable the assistive touch in iOS to show the finger taps. When using the latest version of iOS, be aware of the red recording sign on the top of screen during usability testing – make sure the test application can be seen in the recording.

There may be the need to rearrange the setting or readjust the size of elements on the screen to be accessible during the testing. Android also has a red recording sign which can be moved around the screen, but it cannot be moved while using TalkBack. By the end of the usability testing, participants can be asked to fill in an accessible usability questionnaire, such as the System Usability Scale (SUS).

Make an accessible Word version of the SUS, in the case some participants prefer to use an accessible Word document.

13 Usability testing and interview analysis of Accessible High-Fidelity Prototype

Choose a qualitative method, such as thematic analysis or affinity diagram to analyse the interview's transcripts.

14 Update the design requirements.

Give priority to improve and add new requirements that are the most important features and aspects identified by participants that can address their needs and enhance their user experience.

Appendix N First version of Guidance B

This guidance has two parts:

General categories and guidance information for accessible mobile applications.

Specific guidance for accessible mobile applications related to physical activity and sport for young adults with visual impairment and physical activity and sport coaches.

General categories and guidance information for accessible mobile applications.

Categories and its respective guidance. The guidance that contains existing WCAG 2.1 accessibility guidelines are informed with its respective Success Criteria – SC.

Notification

- a. Make a search button inactive when information is not available for searching. (For examples, see [Appendix A](#)).
- b. Ensure colour is not the only way to convey information of inactive button. Note: A disabled button does not need to meet the ([WCAG 2.1 SC 1.4.3 Contrast \(minimum\)](#)). However, applying colour only is not acceptable ([WCAG 2.1 SC 1.4.1 Use of colour](#)).

Text

- a. Provide adequate word spacing. Avoid big spaces between text. Avoid full justification of a block of text. ([WCAG 2.1 SC 1.4.8 Visual presentation](#)).
- b. Provide clear format for a list of items:
 - (1) Show list of items by one item per line. Avoid multiple columns or items separated by hyphen.
 - (2) Avoid full justification of a block of text. ([WCAG 2.1 SC 1.4.8 Visual presentation](#)).
 - (3) Show list of items in ascending or alphabetic order. ([WCAG 2.1 Technique T2: 1.3.1 Info and relationships](#)).
- c. Provide bold and large text size (e.g., 18 or 22) for both mid-fidelity and high-fidelity prototype.
- d. Provide adequate contrast between background and text, including for buttons with text and text fields. ([WCAG 2.1 SC 1.4.3 Contrast \(minimum\)](#)).

Customisation

- a. Provide custom control on the screen for:
 - (1) Background and fonts contrast. ([WCAG 2.1 SC 1.4.3 Contrast \(minimum\)](#)).
 - (2) Font size. ([WCAG 2.1 AA, SC 1.4.4 Resize text](#)).
- b. Ensure the app is interoperable, adapts and displays the pre-defined settings on iOS and Android devices. (For more details, see [Appendix A](#)).
- c. Provide voice assistant as optional. (For more details, see [Appendix A](#)).

- d. Provide built-in speech as optional. (For more details, see [Appendix A](#)).

Compatibility

- a. Provide full compatibility with assistive technologies, braille displays and specialist mobile phones for visually impaired people (For more details, see [Appendix A](#)).

Reminders

- a. Allow users to add reminders in their phone's calendar app or on braille notetakers directly from the mobile application's screen.
- b. Allow users to choose whether calendar or note app to save information.

Visual

- a. Provide accessible visual content (images, videos) of a provided service.
- b. Ensure video can open and be made inside the app with subtitles and transcripts.

Buttons, tabs and icons size

- a. Provide consistent large tabs, buttons.
- b. Ensure large touch target around 60 pixels (at least 1cm wide and 1cm wide).

Elements attributes

- a. Provide roles/traits to all functional elements to support screen readers and operational system of mobile devices. ([WCAG 2.1 A, SC 4.1.2 Name, role, value](#)).

Labels

- a. Provide clear and short labels. Avoid redundancy in describing the labels. (For more details, see [Appendix A](#)).
- b. Provide labels to all icons and buttons. ([WCAG 2.1 AA, SC 2.4.6 Headings and Labels](#)).
- c. Place labels above text fields, not beside. The same is for combo boxes and similar widgets.
- d. Always maintain labels visible below icons.

Focus organisation of opening screen

- a. Provide consistent focus order when screen opens, from top to bottom starting from back button and following a logical and sequential navigation.
- b. Make sure the braille display and screen reader focus are synchronised.
- c. Inform the user the back button goes to previous screen.

Focus on forms and buttons

- a. Always show or highlight visually the focus on text fields and buttons, including when using assistive technology. ([WCAG 2.1 A, SC 2.4.7 Focus Visible](#), [WCAG 2.1 A, SC 1.4.1 Use of colour](#)).

Localisation

- a. Provide clear localisation of elements. Important information at the top of the screen.
- b. Provide static main navigation tabs/bar on all screens.
- c. Provide tutorial for navigation.
- d. Place all elements by one element per line.
- e. Ensure elements are not visually interfered by the horizontal home bar at the bottom of latest versions of iOS screen devices.

List view

- a. Keep minimum information for each item in the list view, if possible, at least two lines and use headers, if necessary, to split the list by potential categories.

Feedback

- a. Provide feedback of user actions. ([WCAG 2.1 AA, SC 4.1.3 Status messages](#)).

Help

- a. Provide a search feature to help user to find content. ([Jakob Nielsen's Usability Heuristics, Help and documentation](#)).
- b. Provide a help documentation in the mobile application. ([BBC guideline, Feedback and assistance](#)).

Registration form

- a. Give instructions for data input above each text field. ([WCAG 2.1 A, SC 3.3.2 Labels or instructions](#))
- b. Avoid use of placeholders inside text fields as instructions or visible labels.
- c. Ensure password is hidden by default.

Keyboard

- a. Provide fully accessible on-screen keyboard compatible with text fields. ([WCAG 2.1 AA, SC 1.3.5 Identify Input Purpose](#)).
- b. Make sure each character deleted is read out by the screen reader.
- c. Ensure autocomplete is available for use in text fields.
- d. Allow user to scroll along to the end of autocomplete text.
- e. Provide accessible show or hide password toggle button, with its attribute as 'button' to avoid unexpected form submission.
- f. Ensure screen reader reads out the input.

Similarity

- a. Group together similar features. ([BBC guidelines, Grouped elements](#)).
- b. Provide succinct, related information and functions for a specific service/activity on the same screen. Less than 30 items.
- c. Use common design patterns to create interfaces.
- d. Provide simple and consistent interfaces design.

Copy and paste

- a. Provide copy and paste function for email address and phone number.

Meaning

- a. Provide icons that communicate meaning.
- b. Provide clear meaning and simple terms for buttons.

Modal selector window for single or multiple choices

- a. Trigger element to open options must show the word “select” as default.
- b. Provide accessible full screen of a modal selector window for single and multiple choices. (For more details, see [Appendix A](#)).
- c. Ensure the focus is moved to the first element inside the window. ([WCAG 2.1 A, SC 2.1.2 No Keyboard Trap](#))
- d. Always show confirm and cancel buttons for multiple choices. (For more details, see [Appendix A](#)).
- e. Make confirm button on modal selector window to update selected options.

Terms and conditions, policy notice and accessibility statement

- a. Provide an accessible hyperlink with a short name to access the long text of terms and conditions, policy notice and accessibility statement.

Quick information and actions

- a. Make an accessible link to open a third-party app directly from the mobile application’s screen. (For examples, see [Appendix A](#)).
- b. Provide options for third-party apps to select and open directly from the mobile application’s screen. (For examples, see [Appendix A](#)).
- c. Reduce amount of required text input, instead offer options to select from.

Specific guidance for accessible mobile application regarding to physical activity and sport for young adults with visual impairment, and physical activity and sport coaches.

Guidance for visually impaired young adults’ account

1. Young adults with visual impairment can create their own registration and user profile.
2. Allow the user to add details in their user profile, such as visual impairment level, physical activity level, requirements for support.
3. Make user profile details, including visual impairment level, physical activity level, requirements for support, visible for coaches if users consented.

4. Provide diverse physical activity and sport types according to the user's visual impairment level and physical activity level.
5. 'Find a coach' feature can be used for organising activities.
6. Allow user to make a direct call to organisers from the event's details screen.
7. Allow user to email and chat with coaches.
8. Provide clear instruction for booking a place in sessions or events.
9. Ask users to add information in their booking, for example, ask if they need to bring along a guide dog, a carer.
10. Provide a booking button and payment link.
11. Provide clear questions for user profile creation and statements.
12. Allow participants to share their current profile of physical activity or sport activities.
13. Allow participants to share their stories of physical activity or sport activities.
14. Search participants with similar interest in physical activity or sport activities.
15. Search participants to do physical activity or play sport together.
16. Provide information for financial support.
17. Provide a search for inclusive mainstream and specialist sessions or venues (e.g., gym, leisure and sport centres, clubs, etc.).
18. Provide reminders of exercises or sport sessions.
19. Offer a 'have a go' session for inactive young adults with visual impairment.
20. Provide number and age of participants in a session.
21. Provide extra information resources, for instance organisations' website, accessible fitness, tracking apps.
22. Provide pictures and videos of venues, coaches, and members.
23. Provide link to walking or guide runner database.
24. Provide options of inclusive mainstream and specialist sessions or venues for active young adults with visual impairment.
25. Provide a sport teams' league table.
26. Provide transport options by opening navigation apps or transport services directly from the event's details screen. For example, Google Maps, Apple Maps, Soundscape, Citymapper and Uber.
27. Inform the level and frequency of physical activity and sport session.
28. Show physical activity or sport by level of the session (beginner, intermediate, advanced).
29. Search for nearest physical activity or sport.
30. Provide upcoming events based on user's location.
31. Provide use of filtering by categories: age group, team, and individual sport, outdoors and indoors sports, ability level.

32. Provide push notifications of new physical activity or sport.
33. Provide notifications of updates about the sessions and events.
34. Generate FAQ for young adults with visual impairment.
35. Ensure recorded running or walk map is accessible for screen reader and magnifier users.

Guidance for physical activity and sport coaches' account

1. Coaches can create their own registration and profile.
2. Provide video maker for coaches to create their own introductory video.
3. Provide resource information for coaches training about inclusive coaching.
4. Make coach profile, including background checks and licenses, work experience, qualifications and reviews, visible for coaches and young adults with visual impairment.
5. Make coaches have access to a booking confirmation list.
6. Provide information about coaches and guides.
7. Add details about the session and provided support for attendees.
8. Allow coaches to send reminders.
9. Allow coaches to provide live or recorded online exercise sessions for young adults with visual impairment.
10. Allow coaches to contact via chat young adults with visual impairment, if they have given authorisation.
11. Allow coaches to contact each other via chat and share files.
12. Coaching volunteers can create their own registration for coaches' approval.
13. Allow coaches to promote accessible adverts of online sessions or events.
14. Allow coaches to promote accessible adverts of sport, fitness and walking sessions.
15. Allow coaches to upload videos of their offered activities, such as warming up, workouts and equipment.
16. Provide reminders to produce slow-paced and described videos of workouts.

Appendix 1

Notification

- a. For example: A button aimed to find an address on Google Maps app or other GPS navigation app cannot have focus visible available when the address of an event is to be confirmed.

(Go back to [page 1](#))

Customisation

- b. For example:

Zoom (iOS), Font size (Android).

Dark mode (iOS), Dark theme (Android).

Smart invert (iOS), Colour correction (Android).

Classic invert (iOS), Colour inversion (Android, does not invert background colour).

Dynamic Type (iOS), Display size (Android).

Ensure enabled bold text (iOS) can make changes in edit text fields.

(Go back to [page 1](#))

- c. Consider that some blind people may use more often voice assistant such as Siri and Alexa than screen readers. Although, some other visually impaired people perceive that noise environment can disturb the interaction with voice assistant. It may be possible to offer the voice assistant as an optional feature.

(Go back to [page 1](#))

- d. The built-in speech can be offered as a feature to turn on and off. It can benefit partially sighted people to better understand the content of the screen such as the layout, components, and functions for user actions. It is not ideal to be used by screen reader users, as the user will get two voices at the same time while listening the screen reader and the built-in voice.

(Go back to [page 2](#))

Compatibility

- a. Specialist mobile phone for visually impaired people, such as SmartVision by Kapsys, which uses physical keypad on the mobile phone.

(Go back to [page 2](#))

Labels

- a. Short and descriptive label need to be announced by screen readers. Do not add the word “button” in the programmatic name to avoid redundancy, e.g., “button” cycling, button. Screen readers will announce the trait/role – button. It is especially necessary for a list of items, in which has items to select and/or make actions, such as opening a new screen. Screen reader users, such as blind people, can hear the first letter of each item in the list, while moving the screen reader focus until listening the entire label of the desired item to select from the list.

(Go back to [page 2](#))

Modal selector window for single and multiple-choice options

- b. Triggered element must be keyboard and screen reader accessible. Once the window opens, focus must move to the top element of the window. Provide title and list items in alphabetic/numerical order. Make the modal

window scrollable if it contains many items. Provide cancel and confirm buttons only for multiple choice window. Whereas single choice can present only the cancel button, as the single choice is selected, and the modal window closes and focus return to the triggered element (e.g., button). Allow selected items to be highlighted. Single choice: background changes colour. Multiple choice: background changes colour, and a tick symbol and 'selected' text appear. For both single and multiple choice, screen reader must inform it as selected.

(Go back to [page 4](#))

- d. Place cancel button on the top left side of the modal window and the confirm button on the bottom.

(Go back to [page 4](#))

Quick information and actions

- a. For example: By clicking on an email address or phone number link it opens user's email or phone call app directly from the mobile application's screen.

(Go back to [page 4](#))

- b. For example: Button for finding transport options can open a dialog window with navigational apps installed in the user's mobile phone. By selecting the app, the current user's location and the destination are open in the selected third-party app.

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Appendix O Expert review questionnaire

Study Title: Expert review of design guidance

Researcher: Geane de Almeida Fontinele Zadra

ERGO number: ERGO/FEPS/79406

This questionnaire regards to both Guidance “A” and “B”:

Guidance A refers to the design process.

Guidance B refers to designing an accessible and usable mobile application for general and specific contents related to physical activity and sport information retrieval and support for visually impaired young adults.

1. How long have you worked with digital accessibility and/or software development, user experience design?

Answer:

2. What is your current occupation?

Answer:

3. How would you rate your familiarity with discount usability methods?
(1) Low; (2) Medium; (3) High; (4) Very high.

Answer:

4. I believe I could easily understand the guidance “A” for the design process to develop an accessible mobile application for visually impaired people.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

Answer:

5. I believe I could easily understand the guidance “B” for designing an accessible and usable mobile application for generic and specific contents related to physical activity and sport for visually impaired users.
(2) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

Answer:

6. Is there any difficulty in understanding any guidance components? Please, explain which part is not clear and how it can be improved.

Answer:

7. I believe the guidance "A" is structured in a clear and easy way to use and apply.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

Answer:

8. I believe the guidance "B" is structured in a clear and easy way to use and apply.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

Answer:

9. I believe I could easily use both guidance "A" and "B" to design accessible and usable mobile applications.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

Answer:

10. I think there are specific guidelines or accessibility aspects missing.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

If agree or strongly agree, please specify.

Answer:

11. I would like to recommend the guidance "A" and "B" to designers and software engineers to work with.
(1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree.

If disagree or strongly disagree, please explain why.

Answer:

Would you like to add any comments or suggestions to improve the guidance A and B?

Thank you.

Appendix P Ethics application for expert review questionnaire

FEPS Ethics Committee

FEPS Ethics Application Form Ver 1

Refer to the *Instructions* and to the *Guide* documents for a glossary of the key phrases in **bold** and for an explanation of the information required in each section. The *Templates* document provides some text that may be helpful in preparing some of the required appendices.

Replace the highlighted text with the appropriate information.

Note that the size of the text entry boxes provided on this form does **not** indicate the expected amount of information; instead, refer to the *Instructions* and to the *Guide* documents in providing the complete information required in each section. Do **not** duplicate information from one text box to another. Do not otherwise edit this form.

Reference number: ERGO/FEPS/79406 Submission version: 1 Date: 2022-12-28

Name of investigator(s): Geane de Almeida Fontinele Zadra

Name of supervisor(s) (if student investigator(s)): Mike Wald

Title of study: Expert review of design guidance

Note that failure to follow the University's policy on Ethics may lead to disciplinary action concerning Misconduct or a breach of Academic Integrity.

By submitting this application, the investigator(s) undertake to:

- Conduct the study in accordance with University policies governing:

Ethics (<http://www.southampton.ac.uk/ris/policies/ethics.html>);

Data management (<http://www.southampton.ac.uk/library/research/researchdata/>);

Health and Safety (<http://www.southampton.ac.uk/healthandsafety>);

Academic Integrity (<http://www.calendar.soton.ac.uk/sectionIV/academic-integrity-statement.html>).

- Ensure the study Reference number ERGO/FEPS/xxxx is prominently displayed on all advertising and study materials, and is reported on all media and in all publications;

- Conduct the study in accordance with the information provided in the application, its appendices, and any other documents submitted;
- Submit the study for re-review (as an amendment through ERGO) or seek FEPS EC advice if any changes, circumstances, or outcomes materially affect the study or the information given;
- Promptly advise an appropriate authority (Research Integrity and Governance team) of any adverse study outcomes;
- Submit an end-of-study form if required to do so.

Refer to the Instructions and Guide documents when completing this form and the Templates document when preparing the required appendices.

Study details

What are the aims and objectives of this study?

Aim: Professionals in digital accessibility, user experience design and/or software development would be able to evaluate whether the proposed guidance for accessible mobile app development (design process and accessibility and usability recommendations) would be easy to understand and be useful for designers and software developers to work with.

Objective: Each expert will review the guidance independently and can offer feedback, suggestions for improvements and add missing accessibility guidelines.

Background of the study (*a brief rationale for conducting the study*)

There is a need to implement accessibility and usability aspects from the beginning of mobile applications design process (Sierra & De Togores 2012). Furthermore, designers and software engineers could benefit from a better design process to develop accessible mobile apps for visually impaired people to aid the development of an accessible mobile app to help visually impaired adults to overcome barriers such as difficult in finding information regarding accessible sporting opportunities and related support for doing physical activity or sport (British Blind Sport 2014).

Key research question (*Specify hypothesis if applicable*)

1. Is the guidance relevant to design physical activity and sport related mobile applications for VI young adults?
2. Is the guidance relevant for the design of any accessible and usable mobile applications design?
3. Is the guidance relevant to help designers and software developers in the design process?

Are the components of the guidance clear?

Study design (*Give a **brief** outline of the study design and why it is being used*)

Two experts who are professionals with at least 2 years of work experience in digital accessibility, user experience design and/or software development will be recruited by convenience sampling. Experts with knowledge about different guidelines regarding to UX design and digital accessibility.

Experts will obtain via email the consent form, participant information and the objective of conducting the evaluation.

Each expert will review the guidance independently and can offer feedback, suggestions for improvements and add missing design guidance. They will receive an email with the guidance and the questionnaire on accessible Word document. The questionnaire has demographic, open-ended and 5-point Likert scale questions. These questions are regarding to length of work experience, current job role, self-report of familiarity with discount usability methods as well as understanding of the guidance, guidance structure, effectiveness in helping designers/developers to design accessible mobile app for VI users in physical activity and sport context, missing guidelines, interest to use the guidance in future design or evaluation and recommend to designers/software developers.

Pre-study

Characterise the proposed participants

Participants are experts who are professionals with at least 2 years of work experience in digital accessibility, user experience design and/or software development.

Describe how participants will be approached

If any e-mail lists are used, including FEPS distribution lists, justify their use *here*

I will use my university e-mail to contact professionals at organisations in the field of design and computer science. I will identify their e-mail address through the internet and send an invitation email to each professional to take part in this study. A short description of the study and the Participant Information Sheet will be provided by email. They will be informed that it is a volunteer participation, and they can withdraw at any time.

Describe how inclusion / exclusion criteria will be applied (if any)

Inclusion criteria: Professionals with at least 2 years of work experience in digital accessibility, user experience design and/or software development.

Describe how participants will decide whether or not to take part

Participants can decide to participate once they will be invited to this research project via an invitation email and by reading the Participant Information Sheet. After getting access to the

Participant Information Sheet, participants can choose to accept or not accept to participate in this study, and they can withdraw at any time. They can confirm their participation by emailing to me.

Participant Information (Appendix (i))

Provide the **Participant Information** in the form that it will be given to **participants** as Appendix (i). All studies must provide **participant information**.

Consent Form/Information (Appendix (iii))

Provide the **Consent Form** (or the request for consent) in the form that it will be given to **participants** as Appendix (iii). All studies must obtain **participant** consent. Some studies may obtain verbal consent (and only present consent information), other studies will require written consent, as explained in the *Instructions, Guide, and Templates* documents.

During the study

Describe the study procedures as they will be experienced by the participants

Two participants will be invited to take part in this study via email and will be able to confirm their participation by replying to my email and completing the consent form. I will send to participants an accessible digital copy of the participant information sheet, in case, they have not had access to it through the study invitation that will have been shared in organisations' social media, newsletters, website, etc. Participants will also be informed about the procedures of this study by email. They will receive the consent form, the proposed guidance, and the questionnaire on accessible Word document. They will provide the signed consent form and the answered questionnaire and send them back to my email address. I will advise that participants can opt out of the study if they are no longer interested or do not have time to complete the questionnaire. I will ask participants to send me an email informing me about their decision to withdraw from the study.

Identify how, when, where, and what kind of data will be recorded (not just the formal research data, but including all other study data such as e-mail addresses and signed consent forms)

I will have the name and email address of participants. This data will be recorded in my university email inbox. Other type of data will be registered during the interview, such as:

Demographics (occupation, years of work experience, name of participants).

The answers given in the questionnaire will be analysed to identify missed responses, meaningful results. Responses will be anonymous. I will not include the name of participants during the data analysis and writing up the results. I will use a key-code to identify each participant to their answers,

for example, P1, P2. All the data will be stored safely, anonymised and stored electronically in my computer at the University of Southampton. In the hard drive, the data will be password protected.

Participant questionnaire/data gathering methods (Appendix (ii))

As Appendix (ii), reproduce any and all **participant** questionnaires or data gathering instruments in the exact forms that they will be given to or experienced by **participants**. If conducting less formal data collection, or data collection that does not involve direct questioning or observation of participants (e.g. secondary data or “big data”), provide specific information concerning the methods that will be used to obtain the data of the study.

Post-study

Identify how, when, and where data will be stored, processed, and destroyed

If the Study Characteristic M.1 applies, provide this information in the DPA Plan as Appendix (iv) instead and do not provide explanation or information on this matter here.

Study characteristics

(L.1) The study is funded by a commercial organisation: **No** (delete one)

If ‘Yes’, provide details of the funder or funding agency here.

(L.2) There are restrictions upon the study: **No** (delete one)

If ‘Yes’, explain the nature and necessity of the restrictions here.

(L.3) Access to participants is through a third party: **No** (delete one)

If ‘Yes’, provide evidence of your permission to contact them as (v) in the Checklist below. Do not provide explanation or information on this matter here.

(M.1) Personal data is or *may be collected or processed: **Yes** (delete one)

Data will be processed outside the UK: **No** (delete one)

If ‘Yes’ to either question, provide the DPA Plan as (iv) in the Checklist below. Do not provide information or explanation on this matter here. Note that using or recording e-mail addresses, telephone numbers, signed consent forms, or similar study-related personal data requires M.1 to be “Yes”.

(* Secondary data / “big data” may be de-anonymised, or may contain personal data. If so, answer ‘Yes’.)

(M.2) There is inducement to participants: **No** (delete one)

If ‘Yes’, explain the nature and necessity of the inducement here.

(M.3) The study is intrusive: **No** (delete one)

If ‘Yes’, provide the Risk Management Plan, the Debrief Plan, and Technical Details as (vi), (vii), and (ix) in the Checklist below, and explain here the nature and necessity of the intrusion(s).

(M.4) There is risk of harm during the study: **No** (delete one)

If ‘Yes’, provide the Risk Management Plan, the Contact Information, the Debrief Plan, and Technical Details as (vi), (vii), (viii), and (ix) in the Checklist below, and explain here the necessity of the risks.

(M.5) The true purpose of the study will be hidden from participants: **No** (delete one)

The study involves deception of participants: **No** (delete one)

If ‘Yes’ to either question, provide the Debrief Plan and Technical Details as (vii) and (ix) in the Checklist below, and explain here the necessity of the deception.

(M.6) Participants may be minors or otherwise have diminished capacity: **No** (delete one)

If ‘Yes’, AND if one or more Study Characteristics in categories M or H applies, provide the Risk Management Plan, the Contact Information, and Technical Details as (vi), (vii), & (ix) in the Checklist below, and explain here the special arrangements that will ensure informed consent.

(M.7) Special category personal data is collected or processed: **No** (delete one)

If ‘Yes’, provide the DPA Plan and Technical Details as (iv) and (ix) in the Checklist below. Do not provide explanation or information on this matter here.

(H.1) The study involves: invasive equipment, material(s), or process(es); or participants who are not able to withdraw at any time and for any reason; or animals; or human tissue; or biological samples: **No** (delete one)

If ‘Yes’, provide Technical Details and further justifications as (ix) and (x) in the Checklist below. Do not provide explanation or information on these matters here. Note that the study will require separate approval by the Research Governance Office.

Technical details

If one or more Study Characteristics in categories M.3 to M.7 or H applies, provide the description of the technical details of the experimental or study design, the power calculation(s) which yield the required sample size(s), and how the data will be analysed, as separate appendices.

Checklist of Documents to upload

Please provide the following forms, *naming the files as explicitly as possible*, e.g., “Participant Information”, “Questionnaire”, “Consent Form”, “DPA Plan”, “Permission to contact”, “Risk Management Plan”, “Debrief Plan”, “Contact Information”, and/or “Technical details” as appropriate. Each document must specify the reference number in the form ERGO/FPSE/xxxx, the document version number, and its date of last edit.

- (i): **Participant Information** in the form that it will be given to **participants**.
- (ii): Data collection method (e.g. for secondary data or “big data”) / **Participant Questionnaire** in the form that it will be given to **participants**.
- (iii): **Consent Form** (or consent information if no **personal data** is collected) in the form that it will be given to **participants**.
- (iv): **DPA Plan**.
- (v): Evidence of permission to contact (prospective) **participants** through any third party.
- (vi): **Risk Management Plan**.
- (vii): **Debrief Plan**.
- (viii): **Contact Information**.
- (ix): Technical details of the experimental or study design, the power calculation(s) for the required sample size(s), and how the data will be analysed.
- (x): Further details and justifications in the case of: **invasive** equipment, material(s), or process(es); **participants** who are not able to withdraw at any time and for any reason; animals; human tissue; or biological samples.

Appendix Q Guidance A and diagram

Version: 02

Date: June 2023

Introduction

The design process was based on the design thinking and agile design process. It provides additional steps, such as relevant recommendations to implement accessibility, usability and user experience from the beginning of the design process of mobile applications.

Important: Consider gaining more up-to-date knowledge about digital accessibility to enhance your project by taking part in training courses continuously.

Important: Consider ask yourself throughout development of the prototype if the UI elements proposed can be accessible in the interface.

Table Q.1 Design Process of Guidance A 1

Phase	Design Thinking and Agile	Actions	Step's recommendations
1	Empathise, Analysis	User research	Conduct a literature review for the related design problem to be addressed as it is usually done in the design process. The interviews or surveys can also be conducted as usual with research participants, if necessary and whenever possible.
2	Define, Design	Problem definition	Categorisation of the target audience of the mobile application, for instance, visually impaired young adults' needs and experience in physical activity and sport. In interdisciplinary projects, ensure approaches from fields, such as behavioural science, can be applied into the study. Create personas to help the design team to comprehend the needs of visually impaired people.

Table Q.1 Continued

Phase	Design Thinking and Agile	Actions	Step's recommendations
3	Ideate	Initial design concept and Minimum Viable Product requirements	Define the design system features to be tested out at the user evaluation stage, based on the literature review, interviews or surveys. Implement accessibility and usability guidelines, such as Web Content Accessibility Guidelines (WCAG) 2.1 Conformance levels A and AA, Jakob Nielsen's Ten Usability Heuristics, and BBC accessibility guidelines. Consider implementing responsive design for applications suitable for smartphones and desktops. The interface should adapt to different screen sizes. There is a need to ensure that visually impaired people, not using touchscreen devices, are able to use the application via a desktop and keyboard. Prioritise design requirements according to feasibility and most relevant features to build. Ensure there will always be developer(s) working throughout the entire process.
4	Prototype	Accessible Mid-Fidelity Prototype	Use a digital platform to create an Accessible Mid-Fidelity Prototype, such as MS PowerPoint. Avoid use of paper prototyping as this can prevent visually impaired people from participation in the design process. By using MS PowerPoint and setting the screen size to match a potential user's device screen size, it is possible to simulate user's actions when testing interface adaptations. Set a sequential reading order for all screen components and slides on MS PowerPoint. This allows the screen reader user to hear the contents in correct order. Add unique titles to slides and make sure that slides as part of a consecutive process do not have the same title. In this case the title can have additional information, such as title's name part 1, title's name part 2 so screen reader users know where they are in the prototype. Apply good levels of background and text colour contrast. It is recommended to use the colours and font, for instance, black for background and yellow for text, a sans serif font, and bold fonts.

Table Q.1 Continued

Phase	Design Thinking and Agile	Actions	Step's recommendations
5	Prototype	Accessibility and usability check of Accessible Mid-Fidelity Prototype	Use automatic and manual checks and if available use the application's accessibility checker (e.g., Microsoft Office including PowerPoint). Make sure screen content and font sizes work with appropriate levels of magnification and without loss of functionality on mobile devices. Ensure screen readers built into the operating systems of all devices, including iPhone and Android are compatible with the application. Also check the mobile application with an external Bluetooth keyboard.
6	Test	User testing and interview of Accessible Mid-Fidelity Prototype	First interview and then run the user testing with a few participants, consider recruiting 5 participants to test the Accessible Mid-Fidelity Prototype. If possible, run individual face-to-face session with each participant. Ask participants to think aloud. Having gained consent, record the session. Participants do test on their own device.
7	Test	User testing and interview analysis of Accessible Mid-Fidelity Prototype	Choose a qualitative method such as thematic analysis or affinity diagram to analyse the interview's transcripts.
8	Test	Review design requirements	Prioritise the design requirements. Adjust accessibility and usability needs based on feedback received.

Expected milestones: Initial validation of the concept, feasibility, and changes of the design requirements to progress to the next phase.

Table Q.1 Design Process of Guidance A 2

Phase	Design Thinking and Agile	Actions	Step's recommendations
9	Prototype, Implementation	Accessible High-Fidelity Prototype	Consider use cross-platform software, for instance, React Native, to build a mobile app and web app. However, Swift for iOS or Kotlin for Android are preferred to achieve a fully accessible app as they offer highly customisable UI components. Provide multiple ways to navigate back to the top of the page, which is often neglected for screen reader users. If using electronic documentation, e.g., pdf, check accessibility for using it within the app or opening it on a web browser. The title of the PDF itself should be the same for any link or information in-app that points to that document. Provide information about how to navigate back to the application from a web browser should be mentioned in the accessibility statement. Set permissions regarding personal identifiable information to overcome issues with the General Data Protection Regulation. Apply the new WCAG 2.2 success criteria (SC.3.3.8) Accessible Authentication, especially if payment would be a feature. Apply one single sign-in to mobile applications with not many functions.
10	Prototype, Implementation	Accessibility and usability check of Accessible High-Fidelity Prototype	Automatic check of accessibility in Xcode Accessibility Inspector, Android Accessibility Scanner and accessibility checker for web apps. Ensure to check the accessibility of the mobile application with an external Bluetooth keyboard. Manual check of accessibility and usability on an iOS and Android mobile phone. Record both manual and automatic check results on an Excel spreadsheet. The record can be saved in a format based on the Web Content Accessibility Guidelines Evaluation Methodology (WCAG-EM) Report Tool, in which includes selecting a sample of screens, the WCAG 2.1 Success Criteria, tools, analysed functions or elements, comments and expected. The record can be saved in a format based on the Web Content Accessibility Guidelines Evaluation Methodology (WCAG-EM) Report Tool, in which includes screens sample, the WCAG 2.1 Success Criteria, used tools, analysed functions or elements, result, comments and expected outcomes.

Table Q.1 Continued

Phase	Design Thinking and Agile	Actions	Step's recommendations
11	Prototype, Implementation	Preparation of app release for testing (Android, iOS)	Process to be conducted by a software engineer with experience in mobile application releases. Make sure an Apple developer account is available. Be aware of TestFlight and the certification process. Prepare an APK (Android Package Kit) file for Android release.
12	Test	Usability testing and interview of Accessible High-Fidelity Prototype	First interview and then run the usability testing with participants. Ask participants to think aloud. Record the session. This process can be completed remotely via a video call, but may need some adaptations and different strategies, such as connecting via accessible video conferencing software and asking participants to enable the built-in screen recorder. It is also possible for the tester to have their interactions filmed using another mobile device connected to the accessible video conferencing software. By using the built-in screen recorder, ask participants to enable the assistive touch in iOS to show the finger taps. When using the latest version of iOS, be aware of the red recording sign on the top of screen during usability testing – make sure the test application can be seen in the recording. There may be the need to rearrange the setting or readjust the size of elements on the screen to be accessible during the testing. Android also has a red recording sign which can be moved around the screen, but it cannot be moved while using TalkBack. By the end of the usability testing, participants can be asked to fill in an online accessible usability questionnaire, such as the System Usability Scale (SUS). Make an accessible Word version of the SUS, in the case some participants prefer to use an accessible Word document.
13	Test	Usability testing and interview analysis of Accessible High-Fidelity Prototype	Choose a qualitative method, such as thematic analysis or affinity diagram to analyse the interview's transcripts.
14	Define, Design	Update the design requirements	Give priority to improve and add new requirements that are the most important features and aspects identified by participants that can address their needs and enhance their user experience.

Expected milestones: Validation of the design requirements to progress the project to iteration/release.

Design Process of Guidance A

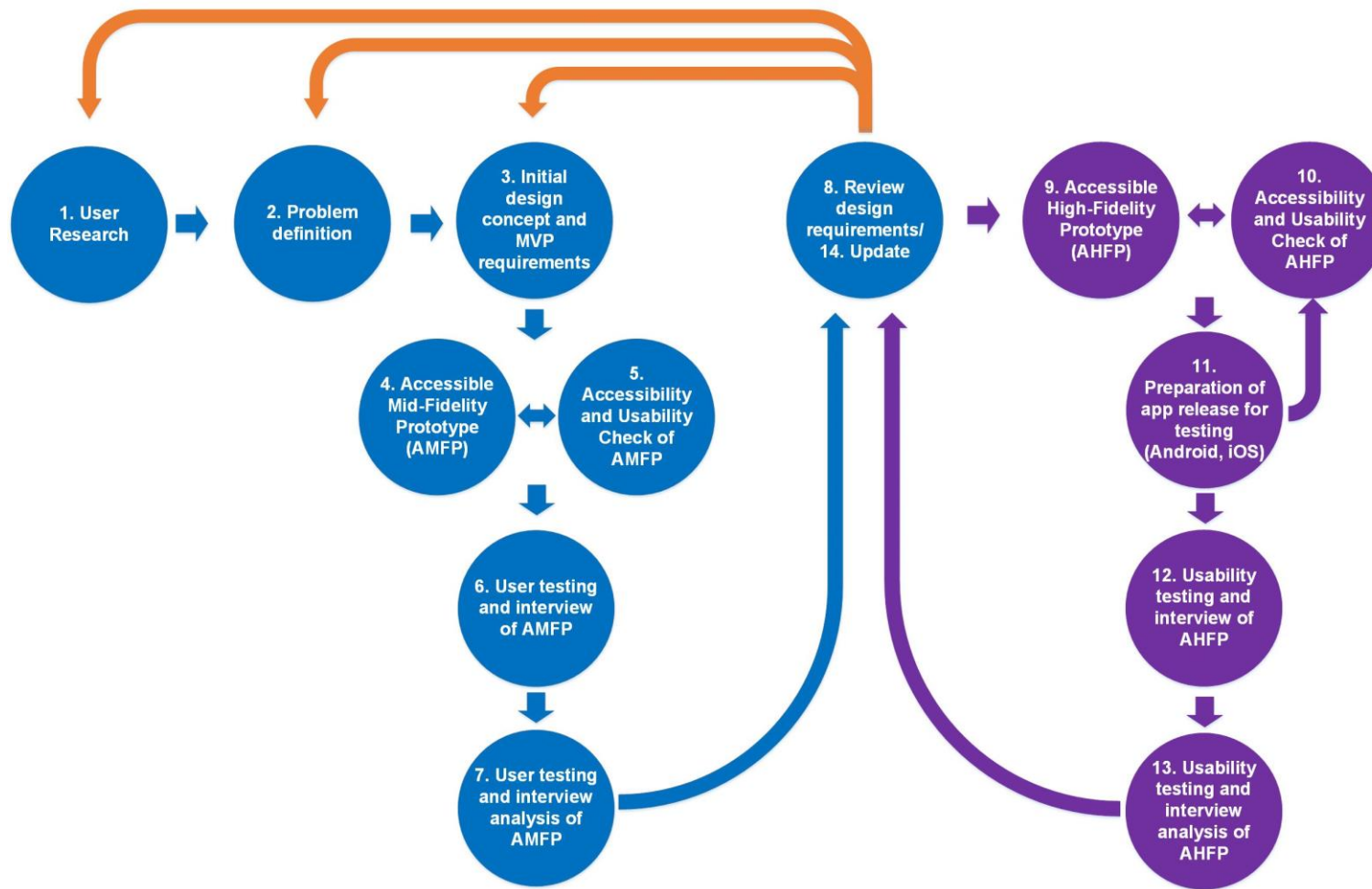


Figure Q.1 Design process of Guidance A

Appendix R Guidance B

Version: 02

Date: June 2023

Introduction

Specific recommendations for accessible and usable mobile applications to provide services for inclusive physical activity and sport.

These recommendations are addressing the development of two distinct mobile applications based on user's type: (User 1) young adults with visual impairment and (User 2) coaches or volunteers. Each user type requires one mobile application, in which includes the following main services:

User 1: Young adults with visual impairment

- Search of nearest or distant inclusive physical activity and sport sessions and events.
- Booking and payment for inclusive physical activity and sport sessions and events.
- Communication with coaches.
- Knowledge about coaches' work experience, licenses, organisation.
- Search for transport by opening navigational apps to select from.

User 2: Coaches or volunteers

- Enable coaches or volunteers to advertise services of inclusive physical activity and sport.
- Search other coaches or volunteers.

- Communication with other coaches or volunteers and young adults with visual impairment.
- Information resources for inclusive physical activity and sport training courses.

Table R.2 Guidance B for visually impaired users

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	Text	Provide clear format for a list of physical activities and sports sessions	Show list of physical activities and sports by one item per line. Avoid multiple columns or items separated by hyphen.	Correia et al. (2019)
4, 9, 10	Text	List physical activities and sports sessions in alphabetic order to select from.	This makes easier navigation for screen reader users as they tend to listen the first letters to select the desired item or jump to the next items in a list.	User evaluation
4, 9, 10	Text	Apply bold and large text size on both mid-fidelity and high-fidelity prototype.	Size 18 or 22.	Kulpa et al. (2013), user evaluation
4, 9, 10	Accessible registration	Users can create their own registration.	Accessible registration form is essential to enable users with VI to register themselves independently.	User evaluation
4, 9, 10	User profile	Users can create their own user profile. Consider allowing sighted people to sign in to have those interested to take part in inclusive physical activity and sport.	Accessible creation of user profile allows users with VI to inform their details independently. By having sighted people interested and registered in the app can help VI young adults become more engaged in inclusive physical activity and sport. This may allow parents be members and know more about opportunities.	User evaluation
4, 9, 10	User profile	Provide clear questions for user profile creation.	Users can be able to inform their visual impairment level, physical activity level, requirements for support, physical activity or sport interests.	User evaluation

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	User profile	Ask users to consent profile details visible for coaches.	visual impairment level, physical activity level, requirements for support	User evaluation
4, 9, 10	User profile	Ask users to consent profile details visible for other VI users.	physical activity or sport interests, age, visual impairment level, physical activity level.	User evaluation
4, 9, 10	Sharing information	Allow participants to make visible their current profile of physical activity or sport activities.	Visible current physical activities or sports in their user's profile.	User evaluation
4, 9, 10	Sharing information	Allow participants to share their stories of physical activity or sport activities.	By sharing their stories within the mobile applications.	User evaluation, interview
4, 9, 10	Sharing information	Allow VI users to write reviews about coaches.	VI users may build confidence from knowing more about coaches from other VI users.	User evaluation, interview
9, 10	Voice assistant	Offer the voice assistant as an optional feature to search for physical activity and sport sessions.	Consider that some blind people may use more often voice assistant such as Siri and Alexa to speed searching than screen readers. Although, some other VI people perceive that noise environment can disturb the interaction with voice assistant.	Interview
4, 9, 10	Personalised search of inclusive physical activity and sport	Filtering by inclusive mainstream and specialist physical activity and sport	Provide a search for diverse types of inclusive mainstream and specialist sessions or venues (e.g., gym, leisure and sport centres, clubs, etc.).	User evaluation

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	Personalised search of inclusive physical activity and sport	Filtering by user's visual impairment level	Provide diverse types of inclusive physical activity and sport according to the user's visual impairment level.	User evaluation
4, 9, 10	Personalised search of inclusive physical activity and sport	Filtering by level of physical activity and sport	Show physical activity or sport by level of the session (beginner, intermediate, advanced).	User evaluation
4, 9, 10	Personalised search of inclusive physical activity and sport	Filtering by location	Search for nearest physical activity or sport.	User evaluation
4, 9, 10	Personalised search of inclusive physical activity and sport	Filtering by categories	Provide use of filtering by categories: age group, team, and individual sport, outdoors and indoors sports, online sessions.	User evaluation
4, 9, 10	Searching for transport	Make a search button inactive when information is not available for searching transport when the location is not confirmed yet.	A button aimed to find an address on Google Maps app or other GPS navigation app cannot have focus visible available or have the same colour as active buttons, when the address of a sport session or event is to be confirmed.	User evaluation

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	Searching other users	Search participants with similar interest in physical activity or sport activities.	Users can search other users by interest in physical activity or sport activities.	Interview
4, 9, 10	Searching other users	Search participants to do physical activity or play sport together.	Users may need to find company to do physical activity or play sport together.	User evaluation, online survey
4, 9, 10	Information about inclusive physical activity and sport sessions	Provide number and age of participants in a session.	VI users may be interested to know the number of attendees and their age group, as young adults with VI may prefer to do physical activities or play sport with similar peers.	User evaluation
4, 9, 10	Information about inclusive physical activity and sport sessions	Provide pictures and videos of venues, coaches, and members.	VI users, especially partially sighted young adults, may need to know how the venue, coaches and members look like when going first time to the session.	User evaluation
4, 9, 10	Information about inclusive physical activity and sport sessions	Inform the level and frequency of physical activity and sport session.	VI users need to know the level of physical activity required in the advertised physical activity or sport sessions.	User evaluation, interview

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	Information about inclusive physical activity and sport sessions	Provide upcoming events based on user's location and interests.	VI users may be interested to know the physical activities and sport sessions happening in the next month in their local area.	User evaluation
4, 9, 10	List view	Keep minimum information for each item in the list view of upcoming sessions.	List by potential categories, such as sessions, events as headers. Keep at least two lines of information.	User evaluation
4, 9, 10	Grouped information and functions	Provide succinct information and functions for a specific physical activity or sport session on the same screen.	Less than 30 items.	Park et al. (2014)
4, 9, 10	Grouped information and functions	Group together features to contact coaches or organisers.	Chat, phone number and email links to contact coaches or organisers on the sessions' details screen and coaches' profile.	User evaluation
9, 10	Chat	Make accessible chat with coaches and VI users.	'Send' button always visible and focusable for screen readers and braille display. Inform screen reader and braille display users that a message is sent.	User evaluation
9, 10	Copy and paste	Provide copy and paste function for email address and phone number of coaches or organisers of physical activity and sport sessions.	Copy and paste the email address and phone number of coaches or organisers can be easier for partially sighted users than memorising them to type in another place.	User evaluation
9, 10	Link to call organisers or coaches	Allow user to make a direct call to organisers from the event or session's details screen	By clicking on phone number link, it opens user's phone call app directly from the physical activity and sport details' screen.	User evaluation

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
9, 10	Link to email organisers or coaches	Allow user to email and chat with coaches.	By clicking on an email address or phone number link it opens user's email or phone call app directly from the physical activity and sport details' screen.	User evaluation
9, 10	Link to open navigation apps	Provide transport options by opening navigation apps or transport services directly from the event's details screen.	Button for finding transport options can open a dialog window with navigational apps installed in the user's mobile phone. By selecting the app, the current user's location and the destination are open in the selected third-party app: Google Maps, Apple Maps, Soundscape, Citymapper and Uber.	User evaluation
9, 10	Link to open calendar	Allow users to automatically add reminders in their phone's calendar app or on braille notetakers directly from the session's details' screen.	VI users can choose whether calendar or note app to save information about the booked session. This can help them to manage and remind their agenda.	User evaluation
9, 10	Booking physical activity and sport sessions	Provide clear instruction for booking a place in sessions or events.	Provide booking and payment buttons.	User evaluation
9, 10	Booking physical activity and sport sessions	Ask users to add information in their booking.	If VI users need to bring along a guide dog or a carer.	User evaluation, interview
9, 10	Reminders	Provide reminders of exercises or sport sessions	The mobile app can send reminders of booked sessions.	User evaluation, interview

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
9, 10	Provide push notifications of physical activity or sport.	Provide link to existing physical activities or sports database.	VI users may need to receive some notifications of available databases for walking or guide runner.	User evaluation, online survey
9, 10	Provide push notifications of physical activity or sport.	Provide options of inclusive mainstream and specialist sessions or venues.	VI users may feel nudged to do physical activity and sport with notifications of new sessions.	User evaluation
9, 10	Provide push notifications of physical activity or sport.	Offer a 'have a go' session	Physically inactive young adults with visual impairment can start with a 'have a go' physical activity or sport session.	User evaluation
9, 10	Update notifications	Provide notifications of updates about the sessions and events.	VI users can be informed quickly of cancelled or changes in the details of the sessions or events.	User evaluation
9, 10	Running and walking map	Ensure recorded running or walk map is accessible if the app supports this feature.	VI users need to have access to running or walk map by screen reader and magnifier.	Interview
4, 9, 10	Providing additional information	Provide information for financial support.	VI users may need to know about financial support, if it exists for paying carer to help the VI user to do physical activity or sport.	Interview

Table R.1 Continued

Phase	Categories	Specific for users 1	Example/explanations	Originated from
4, 9, 10	Providing additional information	Provide information on external resources.	Open organisations' website, information about resources of accessible fitness, tracking apps, within the mobile application, whenever possible or externally.	User evaluation
4, 9, 10	Providing additional information	Provide VI sport teams' league table.	VI users may be interested to know about the competition between VI sports' teams.	User evaluation
4, 9, 10	Frequent asked questions list (FAQ)	Generate FAQ for young adults with visual impairment.	VI users, especially physically inactive, may need more knowledge about physical activity and sport through the most asked and answered questions.	User evaluation

Table R.3 Guidance B for coach users

Phase	Categories	Specific for users 2	Example/explanation	Originated from
4, 9, 10	Text	Apply bold and large text size on both mid-fidelity and high-fidelity prototype.	Size 18 or 22.	Kulpa et al. (2013), user evaluation
4, 9, 10	Accessible registration	Coaches and volunteers can create their own registration.	Accessible registration form is essential to enable coaches and volunteers with VI to register themselves independently.	User evaluation
4, 9, 10	User profile	Coaches and volunteers can create their own user profile.	Accessible creation of user profile allows users with VI to inform their details independently.	User evaluation
4, 9, 10	User profile	Provide clear questions for user profile creation.	Users can be able to inform inclusive physical activities or sports, background checks and licenses, work experience, qualifications, upload user profile photo.	User evaluation
4, 9, 10	User profile	Ask users to consent profile details visible for VI users.	Inclusive physical activities or sports, background checks and licenses, work experience, qualifications, reviews from VI clients, profile photo.	User evaluation
4, 9, 10	User profile	Ask users to consent profile details visible for other coaches or volunteers.	Background checks and licenses, work experience, qualifications, reviews from VI clients, profile photo.	User evaluation
4, 9, 10	Sharing information	Allow coaches to make visible their current profile of physical activity or sport activities.	Visible current physical activities or sports in their user's profile.	User evaluation
9, 10	Making introductory video	Provide video maker for coaches to create their own introductory video.	Coaches or volunteers may want to make a video to introduce themselves to help promote their work in the mobile application.	User evaluation
4, 9, 10	Inclusive coaching training	Provide resource information for coaches training about inclusive coaching.	Information about existing training courses in inclusive physical activity and sport.	(Haeghele and Porretta 2015; Wrzesińska et al. 2018; Johnson 2019) User evaluation, interview, online survey

Table R.3 Continued

Phase	Categories	Specific for users 2	Example/explanation	Originated from
4, 9, 10	Access to booking attendance list	Make coaches have access to a booking confirmation list.	Coaches need to know the number of attendees to their sessions and the requirements or needs of attendees. This is important to know due to feasibility of the session and how coaches can be prepared to support the attendees.	User evaluation, interview
4, 9, 10	Searching other coaches	Allow coaches to search other coaches or volunteers.	Coaches may need to find other coaches or volunteers to see their activities.	User evaluation
4, 9, 10	Providing information to attendees	Add details about the session and provided support for attendees.	Information can provide what is expected in the session and what type of support is provided for VI attendees.	User evaluation
9, 10	Sending reminders	Allow app to send reminders to attendees.	Sessions or events can be automatically sent on behalf of coaches to VI users.	User evaluation
9, 10	Online sessions	Allow coaches to provide live or recorded online exercise sessions for young adults with visual impairment.	Coaches or volunteers may choose to make live, or upload recorded physical activity or sport skill sessions in the app.	User evaluation, interview
9, 10	Online sessions	Allow coaches to upload videos of their offered activities.	Coaches can upload videos of warming up, workouts and equipment used in their sessions.	User evaluation
9, 10	Online sessions	Provide reminders to produce slow-paced and described videos of workouts.	Coaches need to be reminded of making workout or sport skills' videos well described and slow-paced.	User evaluation, interview
9, 10	Contacting other VI users and coaches	Allow coaches to contact via chat young adults with visual impairment if they have given authorisation.	Coaches may want to send a chat to VI users that access their profile to promote their physical activity or sport session.	User evaluation, interview
9, 10	Contacting other VI users and coaches	Allow coaches to contact each other via chat.	Coaches or volunteers may need to ask other coaches for sharing information, swapping clients and replacement.	User evaluation, interview

Table R.3 Continued

Phase	Categories	Specific for users 2	Example/explanation	Originated from
9, 10	Sharing files with coaches	Allow coaches to contact each other to share files.	Coaches may need to share information, photos, or videos of their sessions with other coaches.	Interview
9, 10	Accessible advertising	Allow coaches to promote accessible adverts of online sessions or events.	Coaches may need to make quick and accessible adverts to promote their online sessions or events in the mobile application.	Interview
9, 10	Accessible advertising	Allow coaches to promote accessible adverts of their local sessions.	Coaches may need to make quick and accessible adverts to promote their sport, fitness, and walking sessions or events in the mobile application.	Jaarsma et al. (2019; Smith and Wightman 2021) Interview
4, 9, 10	Visual	Provide accessible visual content (images, videos) of the inclusive physical activity and sport sessions and venues.	It is necessary to make available images and videos of the inclusive physical activity or sport sessions and the venues, staff.	User evaluation
4, 9, 10	Visual	Ensure video can open and be made accessible inside the mobile application.	If possible, coaches can make and open videos inside the mobile application with captions and transcripts.	User evaluation

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