University of Southampton

Faculty of Medicine

MRC Lifecourse Epidemiology Centre

Human Development and Health

Physical activity: benefits, barriers, and modification in adults in their eighth and ninth decades

by

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Thesis for the degree of Doctor of Philosophy

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Abstract

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Participation in regular physical activity has long been linked to improved cardiovascular health, reduced risk of developing metabolic syndrome and improved mental well-being. More recently, the musculoskeletal benefits derived from weight bearing physical activity (WBPA) have been acknowledged in the latest update of the UK Chief Medical Officers' PA Guidelines. However, few studies have considered a lifecourse approach to relationships between WBPA and musculoskeletal health. Furthermore, the percentage of community dwelling older adults remaining sufficiently active remains low, with few studies considering how this figure may be improved.

In this thesis, previously collected data from the Hertfordshire Cohort Study (HCS) were used to analyse the relationship between lifetime participation of WBPA and its relationship with bone mineral density, fat and lean mass and grip strength outcomes in later life. This was followed by a thematic analysis of previously collected qualitative data from a focus group study sited in HCS to understand the barriers and facilitators influencing community dwelling older adults in physical activity participation. These findings informed the construction of a pilot study trialling a participant-led behavioural approach, Healthy Conversation Skills, to improve WBPA, in HCS.

The findings from this thesis add to our current understanding of factors affecting older adults' participation in physical activity, in the UK. Positive relationships between WBPA and BMD are reported in women in later life; in qualitative work two key modifiable elements are highlighted: psychological and social engagement as influential factors in affecting the outcome of physical activity level. A pilot study that trialled Healthy Conversation Skills in older adults supports the feasibility of using such an approach in an older adult cohort. A larger trial is now warranted to investigate the efficacy of Healthy Conversation Skills in promoting physical activity in community dwelling older adults.

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Research Thesis: Declaration of Authorship

Print name:	Jean Jing Zhang

Title of thesis:	Physical activity: benefits, barriers, and modification in adults in their eighth and ninth decades

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:

- This work was done wholly or mainly while in candidature for a research degree at this University;
- 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;
- Where I have consulted the published work of others, this is always clearly attributed;
- 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;
- I have acknowledged all main sources of help;
- 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;
- Parts of this work have been published as: shown in the Author's contributions section.

Signature:		Date:	12/01/2023

Author's contributions

The hypotheses, analysis ideas, interpretations and writing of this thesis are my own, with the support of my supervisors and statisticians. The HCS study had been previously established before I started my doctoral studies at the Medical Research Council Lifecourse Epidemiology Centre. The data used for Chapter 3 have been previously collected by the HCS research team. The data for Chapter 4 had been previously collected by Ilse Bloom and Wendy Lawrence. Working alongside Ilse Bloom, we established a new cohort from the existing HCS database for the NAPA study. Jointly with Ilse Bloom, I wrote the protocol, developed, and submitted the ethics application substantial amendment for the NAPA study. The baseline home visits, and Healthy Conversation Skills follow up telephone calls (the intervention for the NAPA study) were equally shared between me, and Ilse Bloom. I assisted in the ethics amendment for the 1-year follow up for NAPA which was led by Ilse Bloom. The ethics amendment application took place in April-May 2020, and I was seconded to the Acute Medical Unit at University Hospital Southampton as a full-time doctor due to COVID-19. I returned to research in end of May 2020, Jointly, with Ilse Bloom, I organised the logistical procedure for the 1-year follow up which was due to start in November 2020. The pre-emptive logistic management was to allow for a smooth postal questionnaire collection process while I was away on maternity leave (December 2020-September 2021). The 1-year follow up data collection was shared between Gregorio Bevilacqua and Ilse Bloom.

I participated in the data analysis for Chapter 3 alongside with Karen Jameson, who was the statistician for this section of the project. I constructed the coding framework, Appendix B, and performed the thematic analysis for the qualitative study, Chapter 4, alongside Ilse Bloom with the support of Wendy Lawrence. The data collected for the NAPA study was inputted into the computer system by the Computing team led by Ken Cox. I was involved with the data cleaning process at both baseline and the 1-year follow up. Under the guidance of statistical support from Leo Westbury, I was able to perform some of the statistical calculations and tables in this results chapter. The planning for process evaluation was led by me and working with Ilse Bloom, and under the guidance of Wendy Lawrence. One of the forms for assessing the intervention, Process Evaluation of Healthy Conversation Skills Intervention in NAPA study, Appendix H, was constructed by me with inputs from Ilse Bloom and Wendy Lawrence. Process evaluation was conducted by Julia Hammond and Karen McGill.

The two journal papers that (listed in Outputs from this PhD) have been previously published contributed to the results of Chapter 3 and 4, been primarily written by me. The journal paper related to Chapter 4, I drafted the introduction, methods, and discussion sections, with Ilse Bloom

drafting the results section and we carried out the analysis process jointly, therefore reflecting the joint first authorship.

Both the main study results and the results of process evaluation are being written up as journal papers, jointly by myself and Ilse Bloom. The NAPA study paper will include the results of diet and nutrition which was the other key aspect investigated in NAPA alongside PA. This aspect was led by Ilse Bloom. Process Evaluation is also being drafted as an original manuscript, which is being jointly led by myself with Ilse Bloom.

Outputs from this PhD

Publications

Chapters published as peer-reviewed articles:

Chapter 4: **Jean Zhang**, Camille Parsons, Nicholas Fuggle, Kate A Ward, Cyrus Cooper, Elaine Dennison. Is regular weight bearing physical activity throughout the lifecourse associated with better bone health in late adulthood? Calcif Tissue Int. 2022 Jun 17.doi: 10.1007/s00223-022-00995-9. Online ahead of print. (Appendix K)

Chapter 5: **Jean Zhang***, Ilse Bloom*, Elaine M Dennison, Kate A Ward, Sian M Robinson, Mary Barker, Cyrus Cooper, Wendy Lawrence. Understanding influences on physical activity participation by older adults: A qualitative study of community-dwelling older adults from the Hertfordshire Cohort Study, UK. PLoS One. 2022 Jan 25;17(1):e0263050. doi: 10.1371/journal.pone.0263050. eCollection 2022 (Appendix L)

Related published peer-reviewed articles:

Ilse Bloom, **Jean Zhang**, Camille Parsons, Gregorio Bevilacqua, Elaine M Dennison, Cyrus Cooper, Kate A Ward. Nutritional risk and its relationship with physical function in community-dwelling older adults. Aging Clin Exp Res. 2022 Jul 1. doi: 10.1007/s40520-022-02171-3. Online ahead of print.

Gregorio Bevilacqua, Stefania D'Angelo, Cathy Linaker, Alice Paul, Ilse Bloom, **Jean Zhang**, Faidra Laskou, Cyrus Cooper, Kate A Ward, Karen Walker-Bone, Elaine M Dennison. Physical Activity and Diet in a Global Pandemic: An Investigation of the Impact of COVID-19 on Factors Relevant for Musculoskeletal Health at Two Different Stages of the Lifecourse. Front Endocrinol (Lausanne). 2022 May 3;13:882399.doi: 10.3389/fendo.2022.882399. eCollection 2022.

Gregorio Bevilacqua*, **Jean Zhang***, Camille Parsons, Faidra Laskou, Nicholas Fuggle, Cyrus Cooper, Elaine Dennison. Medical history, medication use and physical activity in adults in their eighth and ninth decade of life in the Hertfordshire Cohort Study. EXCLI J. 2022 Apr 19;21:695-703.doi: 10.17179/excli2022-4874. eCollection 2022.

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Published abstracts

Conference abstract 'The benefits of regular weight bearing activity throughout the lifecourse: do men and women reap the same rewards?': British Society of Rheumatology Annual Conference, April 2019, British Journal of Rheumatology 58(Supplement_3), DOI:10.1093/rheumatology/kez108.075

Conference abstract 'The experiences of community-dwelling older adults during the COVID-19 pandemic: preliminary findings from a qualitative study with Hertfordshire cohort study participants': Society for Social Medicine Annual Conference, September 2021, Journal of Epidemiology and Community Health 75(Suppl 1):A65.2-A66, DOI:10.1136/jech-2021-SSMabstracts.140

Conference abstract 'Comparison of Physical Activity Derived from the LASA Physical Activity Questionnaire (LAPAQ) and accelerometers in older adults from the Hertfordshire cohort study' 17th Congress of the European Geriatric Medicine Society, October 2021, European Geriatric Medicine (2021) 12 (Suppl 1):S1–S387, https://doi.org/10.1007/s41999-021-00585-2

Conference abstract 'Does weight bearing physical activity track through the lifecourse? Findings from the Hertfordshire Cohort Study' British Society of Rheumatology Annual conference, April 2022, British Journal of Rheumatology Volume 61, Issue Supplement_1 May 2022

Conference abstract 'The UK Hertfordshire Cohort Study: Nutrition and Physical Activity (NAPA) study – A pilot study of Healthy Conversation Skills in older community-dwelling adults during the COVID-19 pandemic' WCO-IOF-ESCEO Congress, March 2022- due to be published. Abstract

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Definitions and Abbreviations

ADL: Activity of daily living

BMD: Bone mineral density

BMI: Body mass index

CI: Confidence Interval

CVD: Cardiovascular disease

DALY: Disability-adjusted life years

LTPA: Leisure time physical activity

LAPAQ: Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire

HCS: Hertfordshire Cohort Study

HIIT: High intensity interval training

HR: Hazard ratio

IQR: Interquartile range

MET: metabolic equivalent of task

MVPA: Moderate-vigorous physical activity

OR: Odds ratio

PA: Physical activity

POR: Prevalence odds ratio

r: Pearson's co-efficient correlation

SD: standard deviation

SMD: standardized mean difference

SPPB: Short Physical Performance Battery

U3A: University of the Third Age

WBPA: weight-bearing physical activity

Chapter 1 **Literature Review**

1.1 Physical Activity in older adults: background to the thesis

This thesis explores the benefits, associates, and potential modification of physical activity (PA) in a cohort of community dwelling older adults. Compelling evidence supporting the health benefits of regular PA has steadily emerged over the last decade (1-8). Specifically, studies have linked regular PA to a reduced risk of developing certain chronic health conditions such as coronary heart disease (1), obesity (9), type 2 diabetes mellitus (10), and mental health problems(11). In an aging population, we are increasingly likely to have a significant proportion of older adults living with multi-morbidities, so strategies to improve PA levels in older people might be beneficial to improve public health.

Over the last 2 decades the importance of PA has been highlighted in the World Health Organisation (WHO) public health agenda (12). In the 2015 World Report on Ageing and Health published by WHO, PA was highlighted as a key component to the concept of "Healthy Ageing" (13). Sadly, despite the multitude of beneficial effects from PA participation, the World Health Survey, which collected data from 70 countries between 2002 and 2004, showed that 18.8% (median prevalence) of 60-69 years old male and 24.5% of 60-69 years old female did not meet the minimum aerobic target (150 minutes/week) set by the WHO PA guidelines. This percentage increased to 42.1% for the ≥80 years old male age group, and 54.6% for females (14).

Both the WHO and the UK have released official guidelines in recommending the amount of PA that an older adult, ≥65 years old, should ideally participate in (see 0). However from the worldwide research literature the level of self-reported PA in older adults varies (15). Data from the Survey of Health, Ageing and Retirement in Europe (SHARE), a cohort of 10 European countries showed the prevalence of insufficient levels of PA (defined as engaged in vigorous PA ≤ once a week) in 65 to 75-year-olds range from 55.4% to 83.3% in women and from 46.6% to 73.7% in men (16). In a nationally representative cohort of Australian older adults, aged ≥60 years old, 25.8% were found to be sufficiently active, defined as 150 mins of activity per week over five or more times per week, of any walking or other moderate and vigorous PA (17). In the US, using the Behavioural Risk Factor Surveillance System (BRFSS), a national survey of health behaviours, 43% of older adults aged ≥ 50 years old were reported to have met the recommended level of PA, which also include travelling to work (walking or cycling), household activities as well as leisure time physical activity (LTPA) (18). The recommended level refers to ≥30mins per day of moderate-

intensity non-occupational PA ≥5 days per week or ≥20 minutes per day of vigorous intensity non-occupational PA ≥3 days per week (18).

Meyer and colleagues found 44.6% of older adults in Switzerland, aged ≥ 50 years old, participated in habitual PA (defined as 30 minutes of daily walking and or cycling at ≥5 times per week) (19). However, the percentage of older adults participating in exercise or sporting activities was much lower, only 9.1% of older adults performed moderate sports/exercise and 18.2% performed vigorous sports/exercise. The trend for both moderate and vigorous sports/exercise participation showed a downward trajectory as age increased (19). However, for habitual PA interestingly, the youngest age category 50-64 years were less likely to report regular habitual PA than their older counterparts, perhaps reflecting increased time pressures on the younger age group.

The proportion of older adults in the UK reported as being sufficiently active has been found to be lower than in the US and Australia. Utilising data from the Health Survey for England (HsfE), which draws an annual nationally representative sample of the general population living in households, researchers showed in 2003 that 20% of women aged 55-64 and 19.3% of men were meeting the UK PA guidelines, defined as ≥30 minutes of moderate or greater intensity activity on ≥ 5 days per week (20). For this study reported PA was a combination of housework, manual work, walking, and sporting activity; occupational PA was excluded(20). Like the Swiss data reported above, the percentage of older adults meeting the recommended level of PA decreased as age increased, for instance only 8.7% of ≥75 year old men and 4.3% of ≥75 years old women meet the UK PA guideline (20).

One key observation from these studies is that the definition for being active or inactive varies from study to study, thus resulting in difficulty directly comparing studies. A uniform approach such as using the WHO recommended level of weekly PA activities as the threshold of being active, could lead to the figures being more easily compared. Currently the definition of PA is broad. In 1985 Caspersen and colleagues defined PA as “any bodily movement produced by skeletal muscles that results in energy expenditure” (21) which has been widely adopted including by the WHO. Based on the Caspersen definition, PA comprises any activity requiring energy expenditure including exercise, occupational work, household work, and recreational activity. However often exercise is a term that has been used interchangeably with PA which is confusing as exercise has been strictly defined as “a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness” (21).

Whilst it is very difficult to compare the data discussed so far directly, it is clear that several studies have shown that the proportion of older adults been physically active declines as age increases. Certainly the temporal trend from the Spanish National Health Surveys showed there was a decrease in the prevalence of ≥80 year olds self-reporting LTPA in 2011 (40.5%, 29.7% ≥80 year old men and women respectively self-reported LTPA) compared to the prevalence in 2006 (65.3%, 46.0% ≥80 year old men and women respectively self-reported LTPA) (22). However, the bulk of PA data on older adults tend to report on findings at the younger end of the older adult age spectrum i.e., participants in their sixties or seventies. Therefore, more studies involving those aged 80 and above would be valuable.

This thesis will consider how PA at different stages of the lifecourse relate to each other and their relationship to body composition and musculoskeletal health in old age. It will also explore the determinants of PA levels in older adults, and describe a pilot study that aimed to modify PA.

1.1.1 Physical Activity Guidelines –WHO and UK

The WHO recommendations for PA in older adults ≥65 years old was updated in 2016, Table 1, and it made clear reference to various key components of PA including aerobic, muscle strengthening activities, and as well as falls prevention (23). The UK Physical Activity guideline was updated recently in 2019, see Table 1 (24).

The key change in the 2019 UK Chief Medical Officers' PA Guidelines from its previous iterations highlights the emergence of data supporting the observation that even relatively small increase in PA can contribute to better health (25, 26). It is now recognised that benefits can be derived from all levels of PA, and the emphasis on minimum level or amount of PA recommended is no longer as strong as previously. However, the guideline highlights that a minimum of 10 minutes of daily activity can be helpful towards behavioural modification to those with very low level of PA. Hupin and colleagues undertook a systematic review and meta-analysis of nine prospective cohorts of older adults, and found that even those performing low dose of MVPA (MVPA defined as 1–499 weekly dose of MET minutes) had a 22% reduction in mortality risk (4), and that the relationship between increasing PA and mortality risk reduction is linear (4).

WHO recommendations 2016 for adults ≥65 years	UK Physical activity guidelines 2019
Total volume of physical activity for older adults	
Older adults should do at least 150 minutes of moderate-intensity aerobic PA throughout the week or do at least 75 minutes of vigorous-intensity aerobic PA throughout the week or an equivalent combination of moderate- and vigorous-intensity activity.	Each week older adults should aim to accumulate at least 150 minutes of moderate intensity aerobic activity, building up gradually from current levels. Those who are already regularly active can achieve these benefits through 75 minutes of vigorous intensity activity, or a combination of moderate and vigorous activity, to achieve greater benefits. Weight-bearing activities which create an impact through the body help to maintain bone health
Minimum duration of activity	
Aerobic activity should be performed in bouts of at least 10 minutes duration.	No minimum Older adults should participate in daily PA to gain health benefits, including maintenance of good physical and mental health, wellbeing, and social functioning. Some PA is better than none: even light activity brings some health benefits compared to being sedentary, while more daily PA provides greater health and social benefits.
Falls prevention activity	
Older adults, with poor mobility, should perform PA to enhance balance and prevent falls on 3 or more days per week. Muscle-strengthening activities, involving major muscle groups, should be done on 2 or more days a week.	
Activity for frail older adults	
When older adults cannot do the recommended amounts of PA due to health conditions, they should be as physically active as their abilities and conditions allow	
Sedentary time	
	Older adults should break up prolonged periods of being sedentary with light activity when physically possible, or at least with standing, as this has distinct health benefits for older people.

Table 1 WHO and UK Physical Activity Guidelines.

The dedicated section for older adults ≥ 65 years old in the 2019 UK Chief Medical Officers' PA Guideline has re-iterated their earlier overall message "Some physical activity is better than none: even light activity brings some health benefits compared to being sedentary". Key points included the need for a range of activity that can strength muscle, improve balance and flexibility, 150 minutes (two and a half hours) of moderate intensity aerobic activity, and weight bearing activities for bone health maintenance. Comparing this to the WHO guidelines published in 2016, both guidelines echo the same key message that PA comprises of a wide range of activity including aerobic, muscle strengthening, and a focus on balance and falls prevention, important as falls are common in the older population.

Another emerging theme from the 2019 UK guideline is that sedentary time is now recognised as a potential separate contributory factor to all-cause and cardiovascular mortality (27), cancer risk (2, 28) and survivorship (29). Therefore, reduction in sedentary time poses another possible avenue for intervention, aiming to improve health outcomes.

In later life, where periods of sedentary time are likely to be higher than in younger individuals, early studies have illustrated behavioural changes however minor can have beneficial effects (25, 26). Physical inactivity has been found to be amongst the top 10 leading risk factors for global disease burden in the 2010 Global Burden of Disease Study (30). This considers the sedentary aspects of PA and estimates that physical inactivity alongside with dietary risk factors account for 10% of the global DALYs in 2010 (30). Regular PA has been associated with reduction in all-cause mortality in middle aged and older adults compared with those who reported no MVPA with a 34%, 54% reduction for those reporting 10 – 149 min/week, and 300 min/week or more of activity respectively (31). Similarly, in the PURE study, where a cohort of 130,000 participants from 17 high-income, middle-income, and low-income countries were recruited to study the effect of PA on mortality and cardiovascular disease, compared with low PA, being in a moderate and high PA group was associated with a graded reduction in mortality (HR: 0·80, 95% CI 0·74-0·87 and 0·65, 0·60-0·71; $p<0·0001$ for trend, respectively) (32).

1.1.2 Physical activity and body composition

A particular focus of this thesis is the relationship of PA to musculoskeletal health. I will address the current literature with regards to bone health first then moving onto muscle and fat mass.

Osteoporosis is a major public health problem through its association with fragility fracture, classically of the hip, wrist, and spine. Our bone is a living tissue that will undergo a continuous process of resorption via osteoclasts and formation by osteoblasts called remodelling. PA will generate mechanical force which can affect this delicately balanced process, in which the loading

pressure from PA of certain magnitudes (33) will be applied to bone. Then alongside the repetitive nature of this application (34) bone formation and enhancement of bone mass can be promoted hence reducing the risk of fragility fracture (35, 36).

PA in the form of exercise can be divided largely in to four categories: aerobic, weight bearing, resistance training, and high-velocity power training. Each type has a different strength of effect on bone health, with progressive resistance training and weight bearing exercise having the most effect on increasing and maintaining bone mineral density (BMD) (37, 38).

Weight bearing physical activity (WBPA) can be split into high or low impact and with or without an aerobic element and common examples include: running, stair climbing, jumping, Tai chi, dancing and tennis (37). Activity on the lower impact scale such as walking is associated with minimal benefits with regards to bone building (5). However, with the addition of higher impact activities such as stair climbing and jumping it has been shown to have an overall beneficial effect on BMD in both men and women (39-43). However, two of the reviews have noted the limitation of lack of well-constructed studies to draw strong conclusions, one review focussed on studies in men, and the other focussed on PA in older adults (39) and their compliance with current PA (15).

Previous work has suggested exercise interventions may be used to promote better bone health. For example, a position statement from Exercise and Sports Science Australia has recommended resistance training consist of sessions with 2–3 sets of 8 repetitions with moderate to high intensity (80-85% maximal muscle strength) to gain the maximal benefit for BMD (44). The intensity and frequency should be adjusted for the level of risk applicable to each individual (44). Common manoeuvres include movements such as lunges, arm lifts with weights and pelvic floor exercises (38). These recommendations are supported by a meta-analysis in 2015 which showed that overall resistance training was associated with significantly increased femoral neck BMD (SMD = 0.303, 95% CI (95% CI) = 0.127-0.479, p = 0.001) and lumbar spine BMD (SMD = 0.311, 95% CI = 0.115-0.507, p = 0.002) in postmenopausal women (7). In a subgroup analysis, combined resistance training was the most beneficial (7). A further meta-analysis in 2017 of combined exercise interventions provided further evidence of a beneficial effect on BMD in postmenopausal women at the lumbar spine, femoral neck, total hip, and total body (45).

The relationship between PA and body composition involving muscle and fat mass has been studied in the adult population (46-50). Some cross-sectional studies have focussed on exploring this relationship in older adult population cohorts (49, 51, 52), these studies investigated the relationship between general PA and body composition. In my first results chapter I have explored the relationship between previous WBPA participation across the younger years in the lifecourse and its effect on body composition.

In one study with 30 healthy older adult volunteers, mean age of 79.0 ± 3.6 years for men and 79.3 ± 3.4 years for women, the total sedentary time was significantly associated with percentage body fat (r = 0.548; P = 0.042), and lower limb fat mass (r = 0.765; P = 0.001) in men whereas no such association was seen for women (53). In a larger cross-sectional analysis of the population-based sub-sample of elderly enrolees of the Cardiovascular Health Study, n= 1404, based on questionnaire PA data and body composition measured by DXA scanners, in both men and women faster pace of walking was associated with lower body and fat mass ($p<0.01$), however lean muscle mass was not associated with PA (54). In another cohort of 293 community-dwelling sedentary or at most moderately active older men and women (42% men, mean age 74 ± 4 years), (55), researchers found time spent in sedentary activity was positively associated with fat percent, and time spent in both light and moderate-to-vigorous-intensity activities was negatively associated with fat percent, but appendicular lean mass was not associated with any PA intensity category. In Hertfordshire Cohort Study (HCS, higher PA measured by a hip worn accelerometer was associated with lower fat mass, regardless of the intensity of the PA (51). In these studies, accelerometers were used to measure the PA data, which mainly consider cardiovascular related activities (including elements of aerobic, and power resistance), whereas other types of PA such as weight bearing, or high velocity power training are not as well recorded, and they may exert a differential effect on body composition.

1.1.3 Physical activity and Physical Performance

Physical performance tests such as timed chair rises and gait speed are often used as an outcome in studies that study PA (56, 57). Such outcomes are important, as they link to reduced fall rate and improved balance (57).

An American study investigated the relationship between those meeting the 2008 PA guideline (US version) and physical performance outcomes compared with those who did not (58). They performed a cross-sectional study of 85 community-dwelling older adults (50 women, 35 men) with a mean (SD) age of 67.5 (5.6) years. Participants who performed muscle strengthening ≥2 days per week had significantly better measures of grip strength and stair climb test compared to those who did not meet the guideline. Those meeting the aerobic activity guideline performed significantly better on the 10-m walk test, five-time sit-to-stand test, and stair climb test compared to those who did not meet the guideline. Most encouraging of all, participants who met both the strengthening and aerobic activity guidelines performed significantly better on all physical performance measures than participants who met neither of the guidelines (58). This shows the positive association between being physically active and physical function as measured by physical performance tests.

The Lifestyle Interventions and Independence for Elders (LIFE) study recruited 1,635 men and women aged 70–89 years who had physical limitations, which was defined as a score of ≤ 9 using Short Physical Performance Battery (SPPB) but were able to walk 400 m (59). This trial compared the effectiveness of a long-term structured PA program against a health education program in risk reduction of major mobility disability as measured by the ability to walk 400m unaided. Over 2.6 years of follow-up, the PA intervention significantly reduced major mobility disability (HR=0.82, p=0.03), and persistent mobility disability (HR=0.72, p=0.006) compared with the health education intervention (59). De Vries and colleagues performed a meta-analysis assessing the effects of physical exercise on mobility, physical functioning, PA, and quality of life using studies that recruited older adults with reduced mobility and or multi-morbidity (30). The meta-analysis found physical exercise therapy has a positive effect on mobility and physical functioning compared with no exercise (56). Finally another meta-analysis has shown regular PA protects against future difficulties with performing activity of daily living (ADLs) in community dwelling older adults(60)

1.1.4 Physical activity and mental health

Engaging in regular PA has been linked to a reduced risk of depression (11), dementia, Alzheimer's (61, 62) and overall well-being (63, 64). This is important as the prevalence of depression is common in older adults ; it was estimated at 4.2%-10.6% in a Swedish study of 3353 individuals aged 60-104 years (65), and has been noted to increase with age (66). In addition low levels of PA have been associated with anxiety symptoms and/or depressive symptoms (67-69), and in a prospective study of an Irish cohort, depressive symptoms were significantly higher among people not meeting PA guidelines than those meeting PA guidelines (69). The overall global prevalence of anxiety was estimated at 11.4% across 47 countries using data collected from the World Health Survey (70). Noticeably, the prevalence of low PA was higher in those with anxiety compared with those without, 22.9% vs. 16.6% (p<0.001), respectively (70). In a cohort of COPD participants, those with higher levels of PA at baseline, which was defined as 2.5 points difference in the LAPAQ score, was found to have a reduced risk of depression and anxiety, the adjusted HRs were 0.85 (0.75–0.95; $p = 0.005$) and 0.89 (0.79–1.00; $p = 0.045$), respectively (71). Similarly, in a Dutch cohort of >60 years participants, depressed participants were less physically active in comparison with non-depressed participants (72).

The relationship between PA and depression could be affected by psychosocial factors and somatic conditions, in particular mastery and functional limitations (72). Mastery is defined as a sense of having control over the forces that affect one's life. McDowell and colleagues investigated whether there is a protective effect of meeting MVPA guidelines (defined as reporting ≥150 min weekly of MVPA, ≥75 min weekly of vigorous PA) in an Irish cohort of

community dwelling adults aged ≥ 50 years (69). There was significantly a lower risk of depressive symptoms in those meeting the guideline compared with those did not, odds ratio (OR): 0.60, p<0.001 (adjusted for age, sex, waist circumference, social class, smoking status, and number of comorbidities) (69). This protective effect was observed more keenly in 80+ years group, OR: 0.27, compared with younger age group of 50-59 years, OR: 0.86, although the ORs did not reach statistical significance for these 2 groups (69). This illustrates the benefits of been physically active and its positive relationship with mental health.

1.2 Factors influencing physical activity in older adults

At the heart of this research, it is important to understand and explore older adults' attitudes towards PA. This can be explored through numerous avenues; at an individual/personal level, environmental/surrounding level, or regarding the type of PA participated.

The type of PA participated in by the public has evolved over the years; from the early 1990s compared to early 2000s the PA levels performed at work have declined. Also the intention to keep active may not be present as suggested in a cross-sectional Australian wide telephone survey that investigated older adults' (≥65 years old) PA intentions and found 60% of older adults had no intentions of engaging in regular PA within the next 6 months compared to 25% younger adults (< 45 years old) (73). This highlights the need for us to understand the factors that can influence the likelihood of PA participation. A discrepancy between how older adults perceive their own lifestyle behaviour e.g.: believed reasons for breaking sedentary behaviours and actual reasons, has been shown when 30 older adults, mean (SD) age of 74.0 (±5.3) years old, were asked about believed reasons for breaking sedentary behaviour (74). The participants were also monitored with accelerometers and time-lapsed cameras objectively to document what happened when the breaking of sedentary behaviour occurred. 17.2% of the participants self-reported food/tea preparation was a reason to break up sitting, however based on the objective measures food/tea preparation actually accounted for 82.8% of the participants for breaking up sitting time (74). This highlights the need for qualitative studies to understand the causes for low PA, before effective intervention can be achieved.

As discussed previously, higher impact activities are associated with improved bone mass, however falling/safety concerns and damage to joints have been identified as barriers to participate in high impact PA in the older adult population (75). However encouragingly, the ability to understand the benefits and incorporation of activity into activities of daily living (ADLS) has been shown to increase the likelihood of participation in more activity (75, 76). Studies have identified older adults are also more likely to have aversion towards structured exercise/sports

(77), and would prefer PA to be enjoyable, sociable, accessible, flexible and seasonal (76). Factors such as a lack of transportation (78), time commitments (78, 79) and preference for activities that can done alone (79) have been found as reasons for lack of adherence for exercise interventions. However once older adults are engaged in an exercise programme/intervention, systematic reviews and meta-analysis have found older adults are less likely to drop out of an exercise programme compared with their younger counterpart (80, 81).

1.2.1 Comorbidities

Our pilot study features a group of older adults where comorbidities are common. The presence of comorbidities might be expected affect the level of PA, either because individuals with multimorbidity may be less active as a consequence of their conditions, or because their medical health is worsened by the lack of activity. The definition of multi-morbidities has been largely adopted as the presence of ≥2 chronic conditions in research (82). In Scotland, Barnett and colleagues studied 1.7 million patients registered with medical practices reported that the prevalence of multi-morbidity increased substantially with age (83). This cross-sectional study found 81.5% of those aged ≥85 years reported ≥2 chronic conditions (83). Data from the Italian InCHIANTI Study, a nine-year longitudinal study of 1018 participants aged ≥60 years old, suggests the increase in number of chronic diseases accelerates significantly as people age (84). Data from the English Longitudinal Study of Ageing showed similar trends (85). Of note in this study, the authors reported an inverse dose-response relationship between levels of PA and multi-morbidity, whereby the odds of multimorbidity were reduced in those engaged in vigorous (running or jogging, swimming, cycling, and tennis), moderate (gardening, cleaning the car, and moderate pace walking) and mild (laundry and home repairs) PA at least once a week by 55%, 39% and 16% respectively, compared to physically inactive people (85). However, the direction of association cannot be determined from this observational study across several time points.

Another factor that could impact on PA levels is becoming frail or prefrail. A Spanish population-based prospective cohort study of 3,896 older adults aged 60 and older, found those who were frail were older and less physically active than robust participants (all $p<0.05$) (86). Based on these cohort studies we may predict, being frail or pre-frail, and reporting several comorbidities, can be associated with lower levels of PA. While the sequence of events cannot be disentangled from these cross-sectional studies, this highlights that to promote PA in older adults will require more than prescribing exercise regimens. The type of PA might be modified for maximum benefit according to medical history; for instance, those with bone health issue may benefit from WBPA, and those with cardiac conditions may benefit from cardiovascular type of activity.

1.2.2 Environmental factors

Franco and colleagues found in their systematic review that environmental barriers were more important in the context of non-structured PA than structured exercise programme interventions (87). Positive influences from environmental factors and general accessibility have been linked to higher chances of PA participation in an older person; in an meta-analysis consisting of 72 studies, with the mean sample age of ≥65 years, the researchers reported a positive association between walkability ($p = 0.01$) and land-use mix access ($p = 0.02$), and very strong evidence of a positive association between walking and aesthetically pleasing scenery ($p < 0.001$) (88). Walkability was a composite index of residential density, street connectivity, and land-use mix (88). In an observational study of older adults, aged >65 years old, living in Massachusetts, USA, researchers found the three most commonly cited locations for PA away from home were streets or pavements, shopping malls, and membership-only facilities (e.g., YMCA/YWCA, gym, yoga, martial arts) (89). Similarly, older adults living in Hong Kong were likely to walk around their own neighbourhood (75%) and reported the use of parks (42% of all trips) and streets (32% of all trips) as frequently destined places (90, 91).

Hence these data highlight there are important differences between factors that may influence an older person's decision with regards to participate in structured or non-structured PA. There are other factors that may influence on older adults' reliance on utilising their surrounding environment for PA participation such as being limited by their physical capabilities, reduced income, or ability to travel (e.g.: lack of local transport or unable to drive). This emphasises the importance of access or proximity of resources for healthy ageing of older adults. Whereas for structured PA programmes, factors involving "dependence on professional instructions, pain or discomfort, affordability and self-confidence" were reported as influential factors for PA participation (87).

1.2.3 Lifetime habitual activity

One of the research questions addressed in this thesis is whether participation in regular PA tends to track throughout the lifecourse i.e., does someone who is sporty as a teenager and young adult maintain those habits through to later life. Mixed results have been observed in studies that have considered this issue; in one example, a cohort of 220 boys and 205 girls completed questionnaires at the ages of 16 (in 1974) and then again at 34 (in 1992). Interestingly the gender differences in the rate of participation noted at 16 years (more boys, 69%, participated in sporting activities in leisure time than girls, 51%) had disappeared at adulthood (92). The overall rate of participating in MVPA declined but there were indications those individuals who had participated

in PA during their early years remained more active during their adulthood (92). In another Finnish study of 1338 boys and 1596 girls, the participants were followed up for 3 years from the age of 16, researchers noted substantial changes over time among individuals from one PA group to another. Only 19.1% of boys and 11.2% of girls remained as persistent exercisers (i.e., very active on all three years) (93). The type of PA participated in has been observed as one potential factor that could influence the likelihood of sustained PA over adulthood (93, 94). Other suggested influencing factors include competency in sports, playing sport outside school and having an active parent, all of which have been observed as positive factors in sustained PA from childhood to adulthood (95).

1.2.4 Gender differences

Gender differences in participation of PA have been noted in previous work. In an observational study of older adults, aged >65 years old, in Massachusetts, USA, researchers found men were more likely than women to participate in golfing, heavy housework (e.g., washing windows, cleaning gutters), heavy gardening (e.g., shovelling, raking), and moderate-heavy strength training whereas women were more likely to choose light housework (e.g., dusting, sweeping), yoga/tai-chi, and aerobic dance (89).

Qualitative studies have shown there is an intrinsic variation in PA motivators and context preferences between men and women (96, 97). Women aged 60-67 years old were found to be nearly 3 times more likely than men (OR 2.93, 95%CI: 2.07-4.15) to be motivated by improving appearance, just over 1.5 times more likely to be motivated by spending time with others (1.76, 1.31-2.37) and losing weight (1.74, 1.12-2.71) to participate in PA. This link between desire for weight loss or improving appearance and likelihood of PA is not unique to older females, it has also been noted in younger females (98). In a study of 1,360 Malaysian participants (703 males, 657 females) aged 20-64 years who undertook regular PA (at least 150 minutes of MVPA per week) over six months, researchers showed there were noticeable differences between the motives for PA participations in men and women including competition/ego, appearance, physical condition and mastery, where females reported higher motivation for appearance and physical condition than males, and males were more motivated by competition/ego and mastery than females (99).

A qualitative analysis of a small group of French adults with type 2 diabetes mellitus (T2DM), n=23, showed women indicated the importance of the sense of well-being and the positive body image related to regular participation of PA, and men were more likely to be prompted by health benefit and health promoting behaviour in relation to PA (97). This particular cohort may not be

representative of the general population as all participants had a medical condition, T2DM, however parallels can be tentatively drawn with the older adults' population cohort as they are likely to have a co-existing medical condition. Another consideration in differences between men and women could be cultural factors. In a cohort of a South Asian population living in Canada (100), there were clear differences between men and women; women reported barriers include lack of time due to work and family, and a lack of motivation as main reasons for not been able to participate in PA, whereas for men the main barrier was weather-related. In terms of motivators, for men they were more likely to be influenced by health benefits, watching others perform (social remodelling), whereas the motivators for women in this cohort were weight loss and looking like others. The drivers and barriers for different age groups will also likely differ, and this is addressed later in the thesis.

1.3 Ways of assessing physical activity level in older adults

PA is a broad term, and in much of the literature discussed in this thesis, it can refer to exercise, LTPA and or household related activities. There are several ways to measure the level of PA. Two of the most common methods of measuring amount of PA is the use of self-reporting through a questionnaire, and objective measurement using an accelerometer.

Questionnaires are the most common way of collecting data with regards to PA (101). The advantages of using questionnaires include cost-effectiveness, ease of administration (102), ability to determine amount of PA into discrete groups (low, medium, high) in particular high intensity activity (103), and ability to show change from baseline (104, 105). However, limitations include reduced robustness in measuring light/medium intensity activity (104) , recall bias (105), and influence of cultural on response or dependency on the language of the questionnaire (105). There are several frequently used PA questionnaires as summarised in Table 2.

Questionnaire	Target Age Group (years)
Previous Week Modifiable Activity Questionnaire (PWMAQ) (106)	40-60
Recent Physical Activity Questionnaire (RPAQ) (102),	21–55
International Physical Activity Questionnaires (IPAQ) (107)	18-65
Global Physical Activity Questionnaire (GPAQ) (108, 109)	18-75
7-Day Physical Activity Recall (7-Day PAR) (110)	20-74
Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) (111, 112).	≥65

Table 2 Characteristics of different physical activity questionnaires

The Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) was developed by the Longitudinal Aging Study Amsterdam Study (LASA) in the early 1990s as a response to a lack of robust PA questionnaires for older adults (112). LAPAQ is a face-to-face questionnaire that is administered by a researcher (see Appendix D for the questionnaire). There are questions covering the frequency and duration of walking outside, bicycling, gardening, light and heavy household activities, and a maximum of two sport activities during the previous two weeks. At the end, the questionnaire asks the participant if the level of activities in the past 2 weeks is normal for them. This allows for unpredicted/unavoidable circumstances that may affect the level of activities such as illness, weather, and holidays. LAPAQ has been measured against a 7-day diary, the total activity of the LAPAQ and 7-day diary correlated reasonably ($r=0.68$, $p<0.001$) (112). In the same study, the repeatability of LAPAQ was found to be reasonably good, the weighted kappa of the total number of activities of the LAPAQ over 1 year for all subjects ($n=348$) was 0.65 ($p<0.01$), which increased to 0.75 ($p<0.01$) if the participants were retested in the same month ($n=40$) (112).

The use of accelerometers has gained popularity since the 1990s (113), see Figure 1. In a systematic review published in 2018, in 2004 4.4% of studies included in this systematic review had used objective measurements and this figure grew to 70.6% in 2016 (114). The systematic review focused on PA outcomes in lifestyle interventions among adults, and the authors included

other methods of objective measurements such as pedometer. Of the 103 studies employed a form of objective measurement, 42% used accelerometers solely (114).

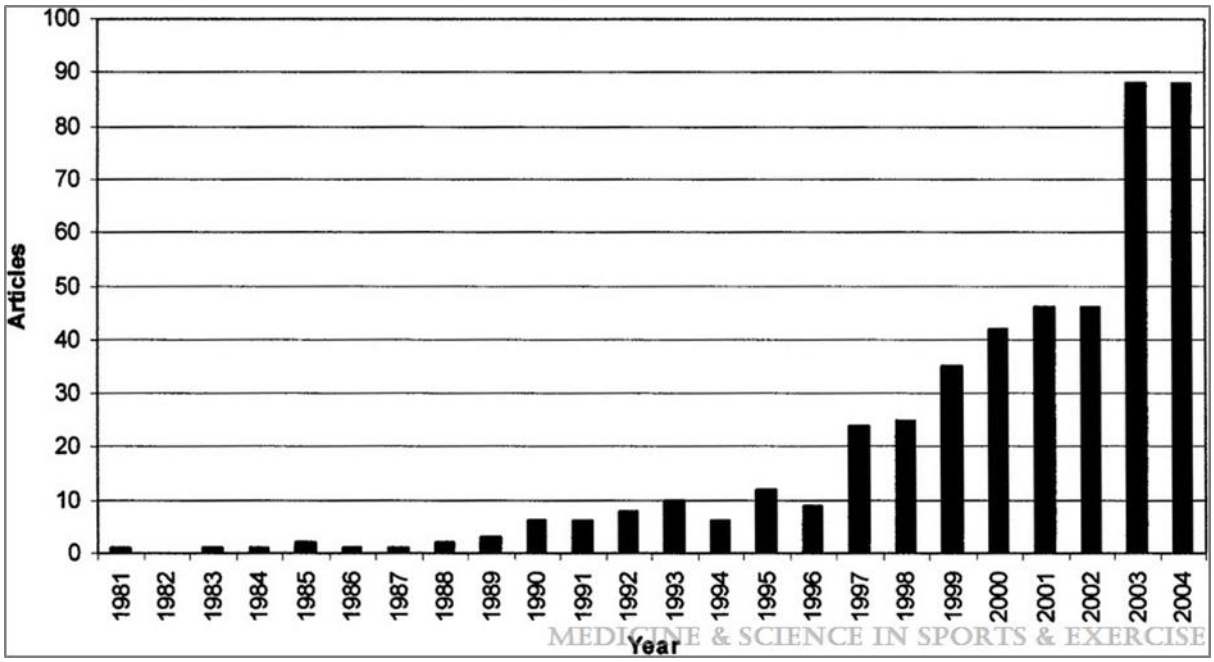


Figure 1 Trend in research publications involving the use of accelerometer in the study design (reproduced with permission(113))

A number of studies have compared the use of accelerometer against self-reported outcomes from PA questionnaires (111, 112, 115, 116). There has been a mixed response with some studies showing good agreement between accelerometer and questionnaires, and others less so. For LAPAQ, there were good correlations between the questionnaire and a 7-day diary (r=0.68, P<.001) and a pedometer (r=0.56, P<.001) (112), The authors found reasonable correlation, Pearson's *r*=0.25 (95% CI 0.07–0.44) between LPAQ and accelerometery data for total PA (≥2 METs), (111). Sabia and colleagues used a modified version of the Minnesota Leisure Time Physical Activity Questionnaire and validated it against a wrist worn accelerometer worn for 9 days, finding a correlation between questionnaire and accelerometer assessed PA (Spearman's *r*=0.33, 95% CI: 0.30, 0.36) (117).

A systematic review performed in 2016 investigated the correlation between accelerometery and PA questionnaires and found the correlation between the two measures for total PA (questionnaire versus accelerometer) ranged from *r*=0.14 to *r*=0.58 (all p<0.001) (118). The correlation range differs for the ≥65 years' group, from *r* = 0.16 (p=0.02) to *r*=0.53 (p< 0.01(118). The disparity between the correlations found may not be unsurprising as the studies included in the review used a variety of PA questionnaires, different models of accelerometers, and varying length of wear time of the accelerometers. Of the 57 studies included in this systematic review, the majority, 17 studies, used hip worn accelerometers, 6 studies used waist worn devices and

one each for chest, iliac crest, wrist, and triceps attachment sites. Herbolsheimer and colleagues explored if cognitive function may play a part in the discrepancy between self-reported PA via questionnaires and objectively measured accelerometery noted above (119). In this study cross-sectional data from the ActiFe Study (Activity and Function in the Elderly in Ulm study) were used. A total of 1172 community-dwelling older adults (aged 65–90 years) wore a uniaxial accelerometer (activPAL unit) for a week, self-reported PA data were collected using the LAPAQ and cognitive function as assessed by a battery of tests: the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) score. In men they found cognitive function was associated with the mean differences of self-reported and accelerometer assessed PA, those men with lower cognitive function were more likely to self-report higher levels of PA than that of accelerometers in comparison to men with higher cognitive function. This association was not noted in women. In light of this study's findings, it poses the consideration should PA questionnaires completed by older adults include an assessment on their cognitive function, and if so, how should the PA questionnaire score be interpreted.

1.4 Types of intervention

There is much heterogeneity in the types of interventions that have been implemented in various studies and trials with the aim of either improving the level of PA or reducing sedentary behaviour in older adults. However, the interventions trialled can be largely divided into 4 groups: structured, multicomponent, integrated, and pure behavioural, as described below.

1.4.1 Structured intervention

Structured interventions usually include a prescribed exercise component set at regular intervals in a designated centre but can also occur at home (120), and often will be delivered by a physiotherapist or equivalent (59, 121). The prescribed exercise/PA intervention often will include elements of aerobic, resistance, balance, and flexibility training. Some of the structured interventions also include education, discussion, and counselling elements (122, 123). This type of intervention has been discussed in detail in the literature (122-124) therefore I will not address it further in my thesis. However, I will discuss in some detail with regards to the effect of using everyday exercise methods such as Pilates, and yoga in older adults. This provides an interesting avenue, as the availability of such exercise classes tend to be prevalent in the community, therefore may increase the likelihood of accessibility for older adults and this can also reduce the need for specialist intervention which can be costly to provide at a population level. Additionally utilising existing facilities and promoting commonly encountered community based PA, both are in keeping with the ethos of Healthy Ageing (13)

Pilates is an adaptable form of exercise which means the intensity and level of difficulty can be altered to suit older adults' needs. Systematic reviews and meta-analysis have shown Pilates can decrease the risk of falls and improve physical function (compared to usual practice), and have shown positive effects on psychological health parameters such as quality of life, fear of falling, and health perception (125). However, heterogeneity remains an issue in meta-analysis.

Josephs and colleagues compared Pilates group exercises directly to traditional strength and balance group exercise for improving balance, reducing falls and improving balance confidence in community dwelling older adults (≥65 years old) with fall risk (126). This study had 24 participants who fully completed the study with an average age of 75.6 in the Pilates group and 74.5 in the traditional group. Both groups showed significant improvement in balance (Pilates group $p<0.05$, and traditional group $p=0.01$), and those in the Pilates were found to have significant improvement in balance confidence (Activities-Specific Balance Confidence Scale mean difference = 10.57, $p =0.008$). Data on falls from this study remain to be published.

Many of the studies mentioned above have small study cohorts, therefore much larger trials are required to see if the beneficial effects are maintained. Barker and colleagues investigated the feasibility and acceptability of a randomised control trial utilising group based Pilates exercise program (one hour, twice weekly) versus usual care via their health practitioners (127) in a pilot study. They recruited 53 older adults aged ≥60 years (mean age of 69.3 year) from the community in Melbourne, Australia with risk factors for falls. Of the recruited 18 (82%) intervention participants and 22 (71%) control participants completed the protocol, the average attendance rate for the intervention group was 21 of 24 sessions (range, 14–24), and 14 participants (82%) said they would like to continue with Pilates exercise.

Similarly, yoga has been linked to improving mobility and balance in older adults ≥60 years of age, when compared to usual care or no intervention(128). In this meta-analysis it included 6 RCTs (n=307) that fulfilled the criteria and it excluded yoga interventions that involved mediation or breathing only. They found a small but significant effect on balance of yoga versus control with no indication of heterogeneity in the estimate of the effect of the intervention (I^2 = 0%, P = 0.615). There was also a significant medium sized effect of yoga on mobility, here there was a trend showing heterogeneity in the estimate of the effect of the intervention (I^2 = 51.8%, P = 0.126). No serious adverse events were reported in the 6 studies. Yoga has also been found to positively associate with health-related quality of life (HRQoL) in depression, perceived mental health, perceived physical health and sleep quality compared to inactive controls in older adults not recruited on the basis of any specific disease or condition (mean age ranging from 61.0 years to 83.8 years) (129).

1.4.2 Integrated intervention

Integrated interventions will normally involve alterations to parts of the participant's daily routine to instil a new habitual routine within an everyday context with the aim to improve overall PA level. One such example is the Lifestyle integrated Functional Exercise (LiFE) programme (130), where everyday activities are used to improve balance or increase strength and the movements can be done multiple times during the day. The strategies to improve balance include "shift weight from foot to foot", "step over objects", and "turning and changing direction". For muscle strengthening approaches included "bend your knees", "on your toes", "up the stairs", and "sit to stand". Weber and colleagues performed a systematic review and reported that in randomised studies integrated training resulted in improved overall function and disability in daily life tasks compared to structured training, which reflects how closely inline the intervention is with daily tasks can increase its natural transferability to everyday life (57). In addition, integrated training reduced falls by 31% compared with 21% reported in structured regime, and the drop-out rate was lower (5-18%) than that of structured training (7.5-21%), combination programmes, 13.7-29% (57). Weber and colleagues noted not all trials reported adherence, and threshold for adherence is variable from trial to trial, however it does appear that the integrated programme had slightly better adherence rates than the structured one, but adherence rates levelled out at 4 months (57). This is slightly disappointing as adherence to the intervention is key to the sustainability of these measures.

1.4.3 Behavioural Intervention

Pure behavioural intervention in older adults have previously been explored; in 2013 a systematic review looked at 284 studies to establish the key features of health coaching in the context of behavioural intervention for improved health (131). This systematic review looked at a variety of studies including chronic disease management, PA, nutrition, smoking, general lifestyle, and health education, and it was evident there was much heterogeneity in the behavioural intervention component. However, the common theme was that this is a patient-centred approached based on a behavioural change model that is delivered by a professional (131). The process often involves elements including patient-determined goals, self-discovery, and accountability (131). Another systematic review focused on the effect of health coaching on PA participation in those aged ≥60 years old and found overall a small but significant effect on PA levels in those receiving health coaching versus the control (SMD=0.27, 95%CI 0.18-0.37, p<0.001, I^2=61%) (132). In the sub-analysis a greater effect was found in those who received face-to- face intervention compared with those who had a telephone intervention only (132). The meta-regression results showed the health coaching was as effective in those with older adults with a

clinical condition as healthy older adults (132). Considering the burden of chronic conditions, this has strong implication for future research and policy makers.

Harvey and colleagues performed a small study investigating the effect of breaking a cycle of sedentary behaviour in frail older adults (133). A total of 35 participants was recruited from sheltered accommodations and 13 completed the study. It is not surprising the retention rate is low, and the most cited reason for drop out was medically or health related. Harvey and colleagues split the participants into two groups; one group mean age 83 years had the motivational sessions (at week 2, 6, 10) and an information pack for reference (133). The second group had the above and additional real time feedback with a device set with parameters that vibrated as a prompt and the mean age was 74 , therefore a much younger group in comparison with other group (133). Improved functional components were observed in both groups such as timed up and go being 4 seconds faster and sit to stand rises increasing by 2 more in 30 seconds (133).

1.4.4 Multicomponent interventions

Multicomponent interventions include a mix of structured, integrated, and behavioural elements described above. For instance, there are studies with a prescribed exercise component to be performed by participants at home then utilising remote monitoring only via telephone calls, and/or text messaging to provide support and motivation (134, 135). A systematic review performed by Geraedts and colleagues showed an overall benefit in remote monitoring compared with those without the monitoring, and equally effectiveness with those with direct supervision (135). In another systematic review focusing on remote monitoring, of the sixteen studies included, fourteen studies showed significant improvement in PA levels over the studies period and eight out of nine studies with follow up data showed maintenance of PA levels post removal of the stimulus (follow up period ranging from 1 to 18 months) (134). However, it seems the sustained effect may not be long lasting. Hobbs and colleagues found no such sustained effect at 24 months in their meta-analysis, which included 21 trials with the majority of interventions been multimodal and provided PA and lifestyle counselling (136). A sustained effect was noted at 12 months, SMD: 1.08, 95% CI: 0.16-1.99 (136). Reasonable adherence to intervention was reported by Van der Deijl and colleagues, the mean proportion of participants adhering to the intervention was 79.8% with the range between 50.3% and 100% (137); in this systematic review, sixteen studies that aimed to improve PA levels in community dwelling older adults were included. There was a wide range of the type of intervention noted in this systematic review including home based, group based, education, various physical activities (resistance, aerobics, walking and functional tasks) (137).

VIVIFRAIL is a multicomponent exercise programme that is part of the Strategy for the Promotion of Health and Quality of Life in the European Union. It consists of resistance training, gait re-training and balance training for persons aged >70 years (138). The main objective is to maintain the functionality of an older adult. This exercise programme has been trialled in a multi-centre randomized clinical trial, where they recruited 188 pre-frail/frail patients with mild cognitive impairment or dementia (aged >75years) from outpatient geriatrics clinics of three tertiary hospitals in Spain (139). Participants in the intervention group were given personalised sets of exercise programmes versus the control group that received usual care. The interventional group had significant increases in functional capacity ($p < 0.001$) and significant positive changes in cognitive function, muscle function, and depression score after 3 months ($P < 0.05$) compared to the control group. VIVIFRAIL is also being trialled in Brazil in a randomised clinical trial setting recruiting frail, pre-frail and robust older adults aged ≥60 years from geriatric clinics (140). The primary endpoint looked at the change in the inflammatory profile, and physical performance changes being the secondary outcome, but results are yet to be published. VIVIFRAIL was also trialled in a small group of Spanish nursing home residents, n=24, aged ≥75 years, as a response to the confinement that occurred due to the COVID-19 pandemic, and there were some positive findings (141).

1.4.5 Healthy Conversation Skills

This thesis reports a pilot study of a trial of Healthy Conversation Skills in older community dwelling adults to promote PA. Healthy Conversation Skills has been developed to empower the practitioner to use the form of open-ended questions or also known as “open-discovery” questions, which starts with “how” and “what” to explore an individual’s (e.g.: the participant or patient) various issues and concerns. Through the active conversation it will hopefully result in the generation of a solution by the individual to their own possible barriers and issues. Healthy Conversation Skills promotes the following five key competences:

1. identifying and creating opportunities to hold “healthy conversations”;
2. using open-ended (‘open discovery’) questions;
3. reflecting on practice;
4. listening more than talking;
5. supporting individually derived goal setting through SMARTER planning (Specific, Measurable, Action-oriented, Realistic, Timed, Evaluated, Reviewed).

Healthy Conversation Skills has been developed with the aim to be adopted by a wide variety of practitioners ranging from those working in the health care system (both hospital and community

setting) and as well as those working in fields in support of the health care system such as personal trainers working in leisure centres. There are several key features of this approach make it suitable for mainstream usage including the opportunistic nature of the approach and the practitioner is encouraged to listen more than talking to the individual. This approach acknowledges often in reality there will be time constraints on interactions between practitioners and their patients, therefore allowing the practitioners to “plant the seed” in an opportunistic manner and then to revisit the conversation at a later date.

To date Healthy Conversation Skills has largely been used in settings with younger adults and children. Healthy Conversation Skills has been implemented at Sure Start Children Centres with the aim to improve the confidence and competency of the frontline staff in delivering productive conversations with parents regarding healthy eating and PA, therefore supporting family with young children encouraging them to have healthy meal choices (142). After the training, it was noted the median confidence rating increased for conversations involving healthy diet and PA and as well as using open discovery questions (all $p<0.001$). The use of open discovery questions and confidence in conversation regarding healthy eating after training was significantly positively linked ($r=0.21$, $p=0.01$), and a non-significant positive trend was seen with conversation regarding PA ($r=0.15$, $p=0.06$).

The main perceived practical barrier reported to use of Healthy Conversation Skills in Sure Start Children Centres was lack of time, other influencing factors resulting in reduced used of the skill include parents not engaging with the staff and loss of confidence in using opening discovery questions (143). Key factors that facilitated the use of Healthy Conversation Skills included seeing the benefits of using the skills, finding opportunities, and having good relationships with parents. Staff have commented on the need to have had built a rapport with the parents first before feeling comfortable with using Healthy Conversation Skills, and the response from the parents appear to be a gauging barometer whether further Healthy Conversation skills will be likely to incorporated into the conversation. This seems to stem from the staff not wanting to alienate the parents and making them feel “judged”. However, when the staff received a positive response from the parents then there was a clear observation that further implementation of Healthy Conservation Skills was likely to occur.

The efficacy of Healthy Conversation Skills in improving the diets and PA levels of women attending Sure Start Children's Centres was formally assessed in an exploratory non-randomised controlled study (144). Although the intervention did not improve the women’s diet score or PA levels it did improve the women’s sense of control, RR: 0.35 (0.05 to 0.65), $p=0.02$ and general self-efficacy, RR: 0.26 (0.01 to 0.5), $p=0.04$.

Hollis and colleagues led a study investigating the impact of Healthy Conversation Skills on 77 health professionals working in New South Wales, Australia (145). Healthy Conversation Skills was well received with a significantly higher proportion using open discovery questions 96%, $p < 0.001$ post-training, and remained significantly higher than pre-training at follow-up, 87%, $p < 0.001$ compared with 25% at pre-training stage. Those working in clinical setting maintained higher confidence in supporting clients to make behaviour changes than those in non-clinical setting.

1.5 Research questions

The overarching topic area of this doctoral thesis is PA in the older adult population. I aim to study this in the following ways: (1) by assessing the relationship between past and current WBPA and bone, muscle, and body composition outcomes in the Hertfordshire Cohort (HCS) (2) by investigating the influencing factors that both facilitate and prevent PA in older adults and (3) to undertake further original research to explore the feasibility of a behavioural intervention, Healthy Conversation Skills, in older adults, to promote PA participation. This thesis hence adopts a mixed methodology approach incorporating qualitative and quantitative research. For the first two projects I utilise pre-existing data collected from the unique cohort of community dwelling older adults of the HCS. For the third project, I establish a new study with a nutritional postdoctoral fellow, Ilse Bloom, who will consider nutritional factors in this cohort. To the best of my knowledge Healthy Conversation Skills has not been trialled in an older population such as this group.

The questions I address are as follows:

1. What is the relationship between previous WBPA across the lifecourse and musculoskeletal health and body composition among participants from the Hertfordshire Cohort Study?
2. Does previous WBPA participation across the younger lifecourse track into older age?
3. What factors influence participation of PA in community dwelling older adults?
4. Can a participant-led behaviour change intervention in community-dwelling, older adults lead to changes in physical activity? Hertfordshire Cohort Study Nutrition and Physical Activity Study (NAPA) study

Chapter 2 **Methods**

2.1 The Hertfordshire Cohort Study - background

All three results chapters are sited within the HCS, either through analysis of existing data sets (quantitative); transcripts of previous focus groups (qualitative), or through a new intervention study that is a randomised controlled pilot study of Healthy Conversation Skills that measures the change in self-reported PA levels as its primary outcome at one year.

The HCS is a cohort of community dwelling older adults residing in Hertfordshire who have been extensively phenotyped with regards to their musculoskeletal health in later life and who have worked with the Medical Research Council Lifecourse Epidemiology Centre (MRC LEC) on many occasions.

The inception of the HCS came about as a result of studies in the 1980s led by David Barker that raised the possibility that environmental factors influencing development early in life may increase the risk of cardiovascular diseases in later life (146-148). The discovery of birth ledgers of those born in Hertfordshire from 1911 until 1948 presented an opportunity for the MRC LEC to establish a robust epidemiological study designed to investigate the relationship between early life determinants and diseases in later life. The birth ledgers were recorded by a team of midwives, nurses, and health visitors, who attended the women at childbirth and visited the children routinely throughout infant and childhood. The ledgers include information summarised in Figure 2.

Key data availability:
At birth • Name and address • Date of birth • Gestation • Sex • Weight
During infancy (1st year of life) • Method of feeding • Whether given a dummy • General comments on health
At first birthday • Weight • Whether weaned • Whether vaccinated (availability of disease-specific vaccines varied by birth year) • Number of teeth
From age 1–5 years • General comments on health

Figure 2 Midwives/Nurses/Health visitors ledgers (reproduced with permission (149))

The first wave of cohort studies recruited men and women born in Hertfordshire between 1920-1930 and remained living in there in the early 1990s. A number of studies were conducted investigating the relationship between early life development and the risk of developing cardio-metabolic disease, osteoporosis, and sarcopenia in later life.

A younger (second) cohort was recruited as the participants from the first wave became frail and unable to take part in further studies. The second cohort consists of 3000 men and women born between 1931-1939, and who remain living in Hertfordshire. This cohort became the long established “Hertfordshire Cohort Study”, whom have been studied for the past 20 years, and which forms the basis of this thesis.

Using the birth ledgers, 42974 births were recorded in Hertfordshire between 1931 and 1939 and with the aid of NHS Digital researchers at the MRC LEC traced 8650 men and women, who were still alive and living in Hertfordshire in 1998. Permission to contact the men and women was gained from their GPs and 3225 were recruited to participate in a home interview with a trained research nurse. 2997 (93%) subsequently attended a clinic for further physiological investigations. Much of this work was undertaken in phases by gender and geographical area.

Since the initial contact in 1998-2004, the HCS cohort members have been involved with numerous subsequent studies involving postal questionnaires, clinic visits, home visits, intervention studies, and focus groups, as summarised in Figure 3.

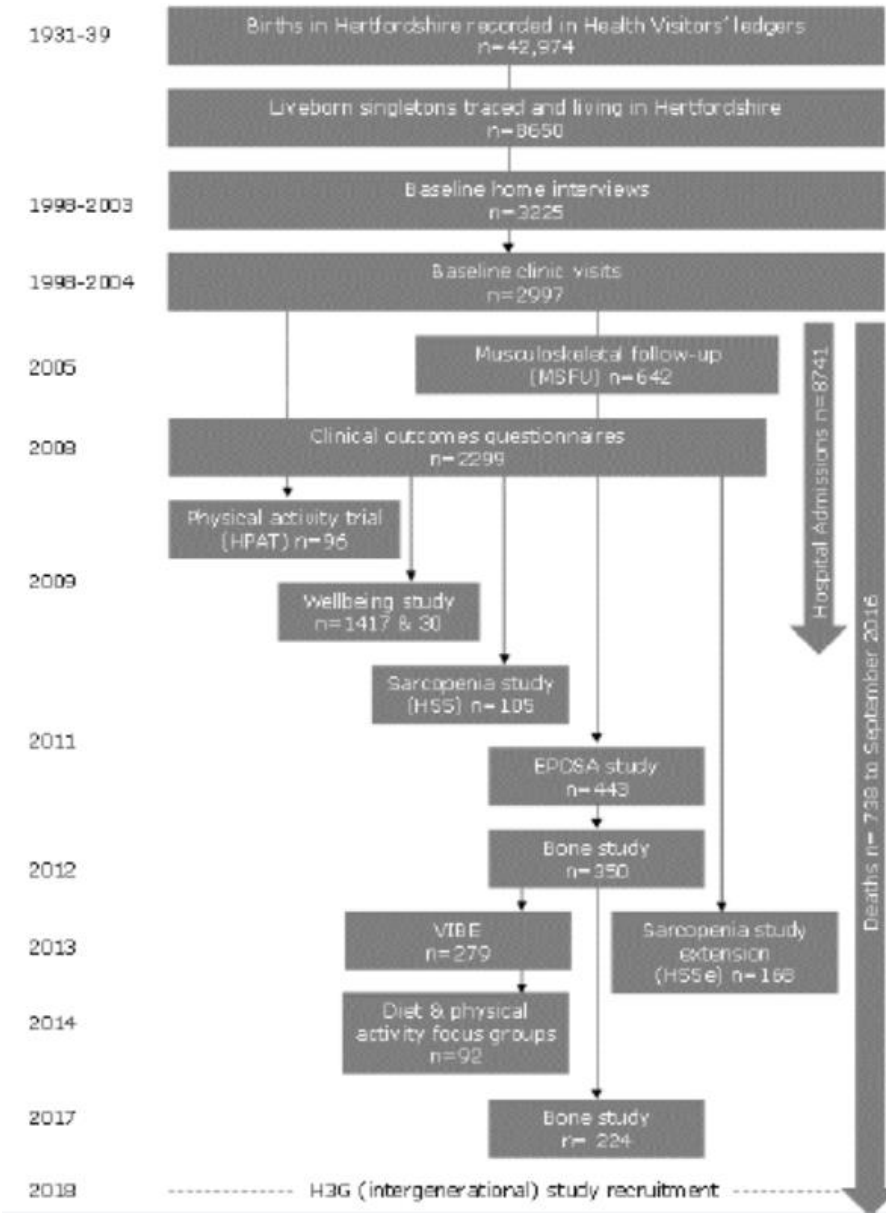


Figure 3 Summary of studies and participant recruitment from 1998-2018 (reproduced with permission (150))

2.2 Physical Activity Assessment

The HCS cohort of men and women have been shown to be representative of the general UK population including characteristics such as smoking status, weight, history of cardiovascular disease, stroke (149)

At baseline, 1998-2004, PA data were collected using the Dallosso physical activity questionnaire (149).

Accelerometery data were collected in 2013, Hertfordshire Cohort Study Vertical Impact on Bone in the Elderly (VIBE) study, as part of a larger collaboration with 3 other cohorts, MRC National

Survey of Health and Development (NSHD), Cohort for Skeletal Health in Bristol and Avon (COSHIBA), and the Master Athlete Cohort (MAC) (151).

2.3 Methods for "Relationship between previous weight bearing physical activity across the lifecourse and musculoskeletal health and body composition: using the Hertfordshire Cohort Study"- Chapter 4

Most of the data utilised in Chapter 5 are derived from the EPOSA (European Project on OSteoArthritis) Study conducted in 2011.

2.3.1 Questionnaire data

The EPOSA study was set to investigate the societal and personal burden and its determinants of osteoarthritis (OA) from an ageing European population(152). I will describe a summary of the study with details that are prudent to the data used in the analysis of Chapter 3.

EPOSA data collection started from November 2010 to March 2011. Participants were visited in their homes. In the UK, the HCS cohort of 258 participants were recruited, 128 men and 130 women for this phase of the study from the baseline cohort of 1677 men and 1540 women studied between 1998-2003. This cohort of men and women have been shown to be representative of the general UK population including characteristics such as smoking status, weight, history of cardiovascular disease, stroke (149). Trained study nurses visited participants at home and administered questionnaires including demographic factors, lifestyle, and current physical activities. The participants were asked about their smoking status, if smoked either previously or currently they were asked to quantify how much they smoked. Questions on alcohol consumption were also asked "Do you ever drink alcohol?". If the answer is yes then further detailed questions on the type and amount of alcohol consumed were asked, such as "How often do you currently drink shandy/low alcohol beer/lager/cider?", "How often do you currently drink spirits/liqueurs". Therefore, able to calculate units consumed per week. Dietary calcium intake was determined from the 24-item food frequency questionnaire that was administered as part of the questionnaire. Social class was coded from the 1990 OPCS Standard Occupational Classification (SOC90) unit group for occupation.

Duration of current PA in the past 14 days was reported using the validated LAPAQ. Frequency and duration of activities over the past 2 weeks were asked, this included walking outside, cycling, gardening, a maximum of two sports, and light/heavy household work. The frequency and

duration of each activities done will give a total time spend being active which is then divided by 14 to give an average PA time (mins/day).

Personal recall of previous participation of WBPA was collected in the VIBE study questionnaire in 2013. Detailed study methodology has been previously described (151). In brief the VIBE study was set up to characterise the type of high vertical impact that may occur in an older adult's day to day setting, and four older adult cohorts in the UK participated in the study: the MRC National Survey of Health and Development (NSHD), Hertfordshire Cohort Study (HCS), Cohort for Skeletal Health in Bristol and Avon (COSHIBA) and the Master Athlete Cohort (MAC). Questionnaire and accelerometery data were collected between 2013 and 2016. For the HCS cohort, only participants that were part of the UK arm of the EPOSA study were invited to this study.

Participants recalled the level of WBPA over four age groups: how often did you take part in sports and leisure time exercise involving weight bearing activity? (e.g., running, racquet sports, football, rugby, hockey, and dancing – not including walking, cycling, or swimming). The four age groups were split into: up to age 18 years, aged 18-29 years, ages 30-49 years and since age 50 years. Responses were categorised as none, once a month, once a week and more than once a week.

2.3.2 Body measurements

As part of the EPOSA study anthropometry measurements including height and weight were measured during the home visits, and Body Mass Index (BMI) was calculated. Height was measured to the nearest 0.001m using a wall mounted SECA stadiometer. Weight was measured to the nearest 0.1 kg using a calibrated SECA 770 digital floor scales. Body mass index (BMI) was calculated as weight in kilograms divided by height in squared meters.

A Jamar handheld dynamometer was used to measure the grip strength of each hand three times. The participant would sit in a chair and be encouraged to squeeze the dynamometer as long and as tightly as possible or until the needle stopped rising. The result was recorded to the nearest 1kg. Grip strength was measured alternately, beginning with the right hand and then the left. Low grip strength was defined as a maximum strength of <30kg for men and <20kg for women.

BMD measurements were taken at the Bone Study in 2012. The objectives of this study were to use pQCT and HR-pQCT scanning to characterise bone health and to explore the early life and environmental determinants of bone health in later life; and to investigate the relationship between muscle mass, strength and function and bone health.

BMD was measured on all participants using a Lunar Prodigy Advance DXA scanner (GE Medical Systems). The participants had their hips internally rotated and feet secured with straps. The scanning arm was then positioned so that an illuminated red cross is 10cm from the waist and about two thirds from the outer edge of hip. Once in the correct position, the region was scanned. This process was repeated with the contralateral side unless the participant had a hip replacement. Sites measured were femoral neck and total hip. Body composition (total lean mass (kg), and total fat mass (kg)) was also assessed by Lunar Prodigy Advance DXA scanner (GE Medical Systems).

Each phase of the HCS study relevant ethics approval and written informed consent was obtained from all participants.

2.4 Methods for "Factors influencing participation of physical activity in older adults: a qualitative study of Hertfordshire Cohort Study"- Chapter 5

In 2014 focus groups to explore experiences of diet and PA in older adults in the Hertfordshire Cohort Study took place. From this focus group study factors that may lead to changes in diet quality and PA levels in later life were investigated and the findings on diet quality have been published previously (153).

The focus group recruited participants from the long standing HCS. There were 443 HCS participants that completed a food-frequency questionnaire in 2011 in a phase of the HCS known as EPOSA. This allowed for comparison with previously collected data via an administered food frequency questionnaire during the baseline visits between 1998 and 2003. A prudent diet score was calculated for each participant based on their consumption of 24 indicator foods and this was used as an indicator of diet quality. A high prudent diet score indicated higher consumption of fruit, vegetables, wholegrain cereals and oily fish in their diets and changes in the diet scores over the 10-year period were then calculated. In men average diet quality remained stable over the 10-year period whereas an overall decline for the women: mean (SD) change in diet score per year 0.008 (0.099) and -0.025 (0.108) respectively. Of the 443 HCS participants with dietary data for the two timepoints, 408 participants were still alive and taking part in the study therefore were invited attend a focus group. The participants were divided into two groups- 'Diet-declined' and 'diet-stable' based on the prudent diet score changes over the 10-year period. In total 92 (23%) participants (43 women and 49 men; mean age=78 years) were successfully recruited into the study. Those did not take part in the study, 316 participants, were due to a variety of reasons including unavailability in the study time frame, non-response to invitation letter or unwillingness.

An invitation letter, participant information sheet and a reply slip were posted out to potential participants. If no response was received from a potential participant after 2 weeks, a reminder letter was sent out. Telephone calls were then made to willing participants to arrange a convenient time to attend a focus group. The focus groups took place in a community venue in Hertford, UK in 2014. The participants were reimbursed for travel costs incurred and refreshments were provided; no other incentive was offered to the participants for their involvement. The focus groups were facilitated by either I.B. or W.L., both with experiences in qualitative methods. Each focus group consisted of up to 10 men or women, with the eleventh focus group been a mixed gender group of 10 for practical reason.

The focus groups lasted between 75 to 99 minutes (mean of 90 minutes), and it followed a semi-structured discussion guide to facilitate the topic discussed. Semi-structured discussion keeps the focus the discussion but allows for freedom and flexibility for the participants to express their views (154). A copy of the semi-structured guide can be found in Appendix A: Hertfordshire Qualitative Study – Focus Group Discussion Guide. Topics discussed at the focus group include diet/food choices and PA. Discussions at the focus groups were audio-recorded and transcribed verbatim.

2.5 Methods for "Nutrition and Physical Activity Study (NAPA Study)"- Chapter 6

In this new phase of HCS, participants from the cohort were invited via postal invites. We aimed to recruit 206 older adults from a pool of 350 potential participants (see power calculation below). In total we recruited 178 participants at baseline. Please see Figure 10 for details.

The HCS cohort members are flagged on the National Health Service Central Register for ongoing notification of mortality. Therefore prior to sending the invitation pack to potential participants, an update of the latest notification of mortality was completed. Then an information leaflet and invitation letter were posted to participants. Those returning the reply sheet with their contact details in the pre-paid envelope were then contacted by phone to arrange a mutually convenient date and time for a researcher to pay a home visit. A detailed description of home visit will be covered in Home visits. Ethical amendment approval was obtained in September 2019 from HRA East of England - Cambridgeshire and Hertfordshire Research Ethics Committee, REC reference number 11/EE/0196 (Appendix C)

2.5.1 Sample size

Power calculations were performed prior to recruitment to the NAPA study.

The sample size required to detect a 20% difference in PA between the control and intervention group at 80% power was calculated, a one-sided test was used, therefore testing for a 20% increase in PA in the intervention group, a sample size of 103 participants in each group was estimated as required. A one-sided t-test was utilised as we only wanted to determine if there was a difference between groups in a specific direction i.e. that the intervention would result in positive change with regard to outcome measures.

2.5.2 Baseline data collection

Baseline data collection commenced in mid-November 2019 and finished by late March 2020. At baseline in total 167 of participants were visited at home out of 178 participants that had home visits scheduled. However due to the emerging COVID-19 pandemic, by March 2020, a decision was made to convert the remaining 11 home visits to scheduled telephone interviews. A random subsample of participants also wore an accelerometer at baseline, useable accelerometery data for 57 men and 40 women were collected.

2.5.2.1 Home visits

Participants were visited in their own home, except for those who completed questionnaires in March 2020. On arrival at the home visit written consent was obtained, which included consent for those having a 'healthy conversation' to be audio recorded at the home visit and subsequent telephone calls for quality control and research purposes if randomised to the intervention group.

2.5.2.1.1 Randomisation

Prior to the visit, participants were divided into 2 groups by random allocation; half were left with an information leaflet about PA and nutrition, and the other half had a healthy conversation with a researcher. The random allocation progress involved the participants been divided into two groups: women and men. Then the participant was allocated to JZ control or JZ intervention or IB control or IB intervention, in a rolling fashion by another member of the research team. JZ and IB being the two researchers conducting the home visits.

Then the following were administered:

1. a questionnaire that considered nutrition, PA, and environmental factors that may affect their nutrition (see Appendix D)

2. physical measurements including height, weight, gait speed, chair rises time and standing balance performance

3. grip strength measurement using a JAMAR dynamometer

4. Half of the participants received an approximately 15 -20 minutes conversation about healthy lifestyle using Healthy Conversation Skills. Prior to the recording of the healthy conversation, the researcher reminded the participant that audio recording would take place. Participants who do not wish to be audio recorded were still able to continue to participate in this study. 2 participants at different time points declined to have their conversations recorded.

At the end of the home visit, an accelerometer was left with some participants to record their levels of PA. The participants were selected randomly and based on the availability of the accelerometers, although a balance of accelerometers given to the control and intervention group was maintained throughout the process.

The participant was asked to wear the accelerometer – a GENEActiv monitor (ActivInsights Limited, Cambridge, UK) – on the dominant wrist, over a 7-day period. The participant was asked to then post the monitor back to MRC LEC using a pre-paid envelope. The whole home visit took approximately 1 hour and 30 minutes.

2.5.3 Type of data collected

2.5.3.1 Questionnaire

Participants were asked about their marital status, smoking status, alcohol intake, comorbidities, and medication use. Mental cognitive status of the participants at the time of completing the questionnaires was not formally assessed.

2.5.3.1.1 Nutrition and Diet

Nutritional risk was assessed using the 'Determine your Nutritional Health' (DETERMINE) checklist, developed by the US Nutrition Screening Initiative (155). Risk were also be assessed using the Patients Association nutrition checklist, which has been validated against the Malnutrition Universal Screening Tool (MUST) for identification of undernutrition risk (156). Diet was assessed using an administered 24-item food frequency questionnaire (FFQ). Based on a participant's reported frequency of consumption of these foods, a 'prudent' dietary pattern score was calculated which describes compliance with this pattern (157). Participants' prudent diet

scores were used as an indication of their diet quality. The Simplified Nutritional Appetite Questionnaire (SNAQ) was used to assess appetite.

2.5.3.1.2 Social and Psychological aspects

Self-efficacy was measured using the General Self-Efficacy 5-item scale, which was derived by factor analysis from the 9-item scale by Schwarzer. Food environments were also assessed. Participants were asked if they have any difficulties with cooking, shopping, or eating. They were also asked if they use any services to support them with these activities. Participants were asked the frequency of participation in a variety of activities and also questions regarding the size of their social networks, including the 6-item Lubben Social Network Scale, which has been validated to assess social networks and social support and to screen for social isolation in older people (158). Participants were asked about their history of falls and fractures and their self-perceived risk of fracture. EuroQoL EQ-5D was used to assess health-related quality of life including mobility, self-care, activities, pain, anxiety, and health. It is a standardised instrument developed by an inter-disciplinary five-country group and it is used worldwide (159). Participants were asked to self-report their activities of daily living using the Townsend Disability Scale, which has good reliability and validity (160).

2.5.3.1.3 Physical activity and function

Data on self-reported physical function were collected by administering the SF-36 physical functioning scale (SF-36 PF), which has been validated for use in older populations (161). PA data were collected using the Longitudinal Ageing Study Amsterdam physical activity questionnaire (LAPAQ). LAPAQ was developed in the Netherlands to assess levels of PA specifically in older adults; it has been validated with 7-day diary and pedometer and has good repeatability (112).

Height and weight were measured using the methods described in the section below. Grip strength was measured using a JAMAR dynamometer (see below for detail); this has been measured previously in this subgroup of the HCS participants. It is feasible, acceptable, and has good reliability, and low grip strength is consistently linked to poor outcomes such as falls and fractures (162). The Short Physical Performance Battery (SPPB) was used to assess three aspects of physical function: gait speed, ability to perform chair rises and balance testing. The SPPB is commonly used to assess physical function of older adults in clinical and research settings. It was developed by the National Institute on Aging for use in the Established Population for the Epidemiologic Studies of the Elderly (EPESE). It has good to excellent reliability and good reproducibility (162).

Fried Frailty score is calculated as such participants were considered frail if they had three out of the following five items: unintentional weight loss, self-reported exhaustion, weak grip strength, slow walking speed and low physical activity. Answering "Yes" to “In past 3-6 months, have you lost weight unintentionally” was considered to be unintentional weight loss; and answering, "A moderate amount of time" or "Most of the time" to ''everything is an effort'' or ''I could not get going'' was considered to be self-reported exhaustion. Cut-offs of <27kg (men) / <16kg (women) were used to define weak grip strength. Slow walking speed was defined as a gait speed of ≤ 0.8 m/s. Low PA was defined as the lowest gender-specific fifth of total activity time from LAPAQ.

SPPB is calculated by assigning points to the each of the measured sections: gait speed, repeated chair stand, and standing balance. The score ranges from 0-12, and a score between 3-9 indicates possible frailty (163).

2.5.3.2 Objectively measured outcomes

2.5.3.2.1 Height measurement

Height was measured with the participant standing using a pocket stadiometer. The measurer aimed to read the scale from as level a position as possible. If there was a lot of height disparity, the measurer would try to get level with the scale, by standing on chair/stool to measure a very tall person.

The baseplate was placed on the floor, selected as firm and level a surface as possible, and preferably near a perpendicular surface, such as a door architrave, which helped the eye to ensure that the tape was vertical.

The participant was asked to remove their shoes and stand on the baseplate with their back to the tape. They were told to stand as tall and straight as possible with feet together and arms held loosely at the side and shoulders relaxed (to avoid lordosis, slouching). They stood far enough forward on the baseplate such that the tape is not distorted when pulled to vertical (no part of body should touch the tape). The tape was checked that it was inserted correctly into the base plate.

The tape was then raised vertically and placed the head plate on the top of the participant's head, using the spirit level to check that the plate was horizontal. Height measurement was repeated 3 times (participant to move around in between). Read the height to the nearest 0.1 cm. If (severe) kyphosis is present, best possible reading is noted down alongside with a note of severity of kyphosis.

2.5.3.2.2 Weight measurement

The weighing scales was placed on a level hard surface and the scale was checked it started at zero when they were switched on. We weighed the participants without shoes and heavy items of clothing and heavy jewellery were removed if possible. Weight was measured once and recorded to the nearest 0.5kg.

2.5.3.2.3 Balance testing

Participants were asked to perform the “Semi-tandem stand” position first. In this position, the side of the heel of one foot touched the big toe of the other foot, with the participant deciding which foot to place forward.

The interviewer first demonstrated the task and then supported one arm while the participant positioned their feet. In all cases we made sure the participants stood near something solid to grab on to in case they started to lose their balance.

Participants were told that they may use their arms, bend their knees, or move their body to maintain their balance, but they should try not to move their feet. They were informed they should try to hold the position until the interviewer told them to stop.

The participants were asked if they were ready and when they were, support was release and timing began. Timing was stopped when the participant moved their feet or grasped the interviewer for support, or after 10 seconds has elapsed.

If unable to complete 10 seconds of “semi-tandem stand” position then they were evaluated in the “Side-by-side stand” position, feet together side by side.

If able to complete 10 seconds of the “semi-tandem stand” position then they were asked to attempt to complete 10 seconds of the “Tandem stand” position with the heel of one foot directly in front of and touching the toes of the other foot, with the participant deciding which foot to place forward.

2.5.3.2.4 Gait Speed Test

Gait speed was measured using 2.44 metres (8 feet).

An 8-foot (2.44 m) walking course was marked out, with no obstructions at either ends and around the walk course. Participants were instructed to “Walk to the other end of the course at your usual speed, just as if you were walking down the street to go to the store.”. The interviewers demonstrated the walk for the participant and told them to walk all the way past the

other end of the rope before they stopped. Participants were able to use assistive devices such as crutches or walking sticks if needed.

Participants were told to stand with both feet touching the starting line and were asked if they were ready and if yes, the participants were told to begin, and timing started. The interviewers walked behind and to the side of the participants and stopped timing when one of the participant's feet was completely across the end line. This test was repeated once.

2.5.3.2.5 Chair Stand Test

A straight-backed chair was placed next to a wall. The procedure was demonstrated and explained to the participants. The participants were asked to fold their arms across their chest and sit so that their feet were on the floor, then stood up from the chair once, kept arms folded across their chest. If participants could not rise without using arms, they were told to stand up using their arms for safety.

If successful, participants were asked to stand up and sit down five times as quickly as possible, without stopping in between, and kept their arms folded across their chest.

Time from the initial sitting position to the final standing position at the end of the fifth stand was noted down.

The following scenarios would warrant stopping of this test:

- Participant becomes tired or short of breath during repeated chair stands
- Participant uses his/her arms
- After 1 minute, if participant has not completed rises
- At the interviewer's discretion if concerned for participant's safety

If the participant stopped and appeared to be fatigued before completing the five stands, this was confirmed by asking "Can you continue?". If participant said "Yes," continue timing. If participant said "No," stop and reset the stopwatch.

2.5.3.2.6 JAMAR grip strength dynamometry

Participants were sat comfortably in a chair with arms and asked the participants to rest their forearms on the arms of the chair with the elbow at right angles and the wrist in a neutral position (just over the end of the chair). The same chair was used for all home visits.

The procedure was demonstrated and explained to the participants.

The dynamometer was placed in the right hand first; the hand was positioned so that the thumb was round one side of the handle, and the four fingers were around the other side. The instrument

The interviewer rested the base of the dynamometer on the palm of their hand while the participants held the dynamometer, supporting it lightly. The participants were encouraged to squeeze for as long and as tightly as possible or until the needle stopped rising. Once the needle stopped rising the participants were told to stop squeezing.

The grip strength was read in kg from the outside dial and the result recorded to the nearest 1kg. This was repeated in the left hand. Further two measurements for each hand were done, alternating sides – a total of three times on each side. The dominant hand was noted down for all.

2.5.3.2.7 Accelerometery

PA was also measured objectively using a validated method by collecting data with an accelerometer, GENEActiv worn on the dominant wrist for 7 days (164). The unit for measuring acceleration by the accelerometer is milli-g (mg).

The GENEActiv accelerometers were configured via GENEActiv PC software version 3.2. The accelerometers were all set at 100Hz frequency and 7 days of measurement period. Data extraction from the accelerometers were be done via the GENEActiv PC software and were saved as .Bin files with participant's ID, date of birth and left/right wrist detailed in the file name.

During the data collection phase, every 2-3 weeks, the statistician on the NAPA study team performed a random check on the quality of the accelerometer data collected at that point. Figure 5 shows the total number of useable accelerometery recordings collected at baseline.

Figure 4 A participant wearing an accelerometer

The GENEActiv accelerometers look like watches. The participants were given the choice of having the accelerometer being fitted by the visiting researcher or if they wished they could start wearing it later. All participants with the accelerometers were left with an instruction sheet detailing how to activate the accelerometer, reminding them to wear it at all times (as possible), and the accelerometer is shower/bath/swimming safe. If they required to take the accelerometer off for a prolonged period of time, the participants were asked to record this on a time diary sheet that was left with them.

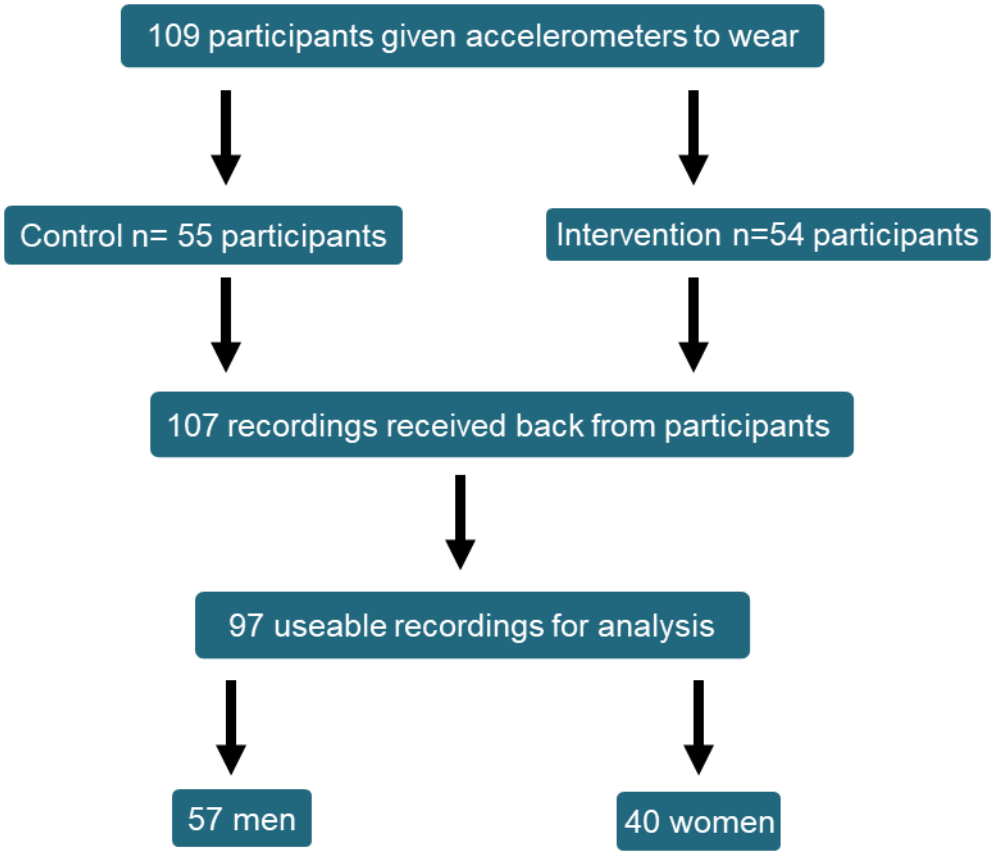


Figure 5 Consort flow chart for accelerometery data collected at baseline

2.5.3.3 Intervention

The two researchers conducted the home visits, both attended the Making Every Contact Count (MECC) course delivered by the Wessex team to received training in Healthy Conversation Skills. This consisted of a one-hour e-Learning module viewed prior to the two-half day face to face interactive training sessions. Within the sessions there were opportunities to role play the use of Healthy Conversation Skills and explore how SMARTER goal setting could be utilised in a real-life conversation. After each session, the researchers were asked to reflect on how they could practise Healthy Conversation Skills.

Within the healthy conversation group of participants, participants were asked if there were aspects of their lifestyle that they would like to modify. If a participant was unable to identify any changes they would like to make, then the researcher used information gleamed from the questionnaire to identify things to discuss around PA. The researcher then used their Healthy Conversation Skills training to support the participants to identify ways of navigating around the potential barriers, and to aid the participants to self-set goals.

As discussed previously, in brief, Healthy Conversation Skills consist of:

- Identifying/creating opportunities for having a healthy conversation
- Using open discovery questions, generally starting “how” and “what” that lead people to explore their own situation and discover their own solutions
- Spending more time listening than just giving information, to empower people to identify their own first steps to change
- Reflecting on practice to have more effective conversations
- Providing support for SMARTER goal setting (Specific, Measurable, Action-oriented, Realistic, Timed, Evaluated, Reviewed)
- Concluding the visit with a review of the current barriers, and offering encouragement to support possible solutions, including signposting to available local resources

Please see Appendix F for a guide on the style of the conversations that took place at the home visits. A modification to the approach taken with regards to SMARTER goal setting was made after the first few home visits. Instead of using the terms: “goal”, and “goal-setting” and try to establish each domain of the SMARTER goals for all participants; the researcher would use open discovery questions to gauge each participant’s interest, and whether they would be open to establish the specific domains of SMARTER goal setting. Those showed interest and engagement then as many of the domains were established as possible. Those did not show interest, attempts were made to establish any changes the participants may have wanted to make, however if engagement was not observed then the researcher would not purse this avenue any further but would attempt again at the next contact point. For the rationale for this modification, this is discussed in detail in Process Evaluation of the Intervention. Some of the participants were satisfied with his/her current state and overall well-being including level of PA and dietary intake, in this scenario the researcher supported the participant to maintain his/her current state of being.

2.5.3.3.1 Follow-up Telephone Calls

Participants who had a healthy conversation at the home visit received telephone calls at 1, 3, 6 and 9 months after the home visit. The aim of the follow-up calls was to ensure the participants were on track with the goals set at their home visit, and to facilitate goal adjustment if necessary. The length of the telephone calls was set at 15-20 minutes but in reality it varied from 12 minutes to 50 minutes with the majority being around 20 minutes. The purpose of these calls was to continue having healthy conversations to promote beneficial changes for the participants. Please see Appendix G for the style of the conversation that was carried out. For the interviewers, after a couple of initial home visits, it became evident this cohort of participants varied greatly from the younger cohorts that Healthy Conversation Skills have being previously trialled on, largely pregnant women. The use of terms “goal” or “goal setting” were not appropriate nor well received, therefore the researchers made the decision to not to reenforce the idea of goal setting, presented this as a gentle conversation about their daily lives and aspects of their lives that they may want to maintain or change with a focus on PA and diet.

Telephone calls were audio recorded for quality control and research purposes. Consent for this were obtained at the time of home visit. At the beginning of each call, the researcher reminded the participant that the conversation will be recorded and ensured they remained happy for the recording to occur. Some of the recordings were used for process evaluation of this pilot study.

2.5.4 One year follow-up visit

The one year follow up data were collected between November 2020- June 2021. Due to the ongoing COVID-19 pandemic restrictions the home visits were converted to postal questionnaires to allow for the study to continue. The participants received a telephone call from a member of the research team informing them of the change from a home visit to a postal questionnaire. Subsequently a questionnaire was posted out to the participant if they were happy to participate in the changed format. From the consort diagram, Figure 10, in total 11 participants dropped out between the baseline visits and at 1-year follow up, with a fairly equal split between the control group (n=5) and the intervention group (n=6). Therefore, from the 176 participants recruited at baseline we posted out 165 questionnaires at one year follow up. With the questionnaire being in the postal format, we do not have objective measurements from physical measurements in Section 7 of the questionnaire. Please see Appendix E for the 1-year follow up questionnaire.

Given the changes in data collection format, a further ethics amendment was sought in the summer of 2020 ahead of the data collection in November 2020. The questionnaire was re-formatted with one change- Section 8 was changed from “Environment Aspects” which focused

on food environment and access to supermarket, to “Home and Community Environment Instrument (HACE)” which focused on home/community mobility, community support and access to transportation.

Chapter 3 Relationship between previous weight bearing physical activity across the lifecourse and musculoskeletal health and body composition: using the Hertfordshire Cohort Study

3.1 Introduction

In this study we performed a life-course analysis of recalled PA and body composition outcomes using data from the HCS. Previous studies have taken a cross-sectional, rather than lifetime exposure approach (40, 42, 43). Studies involving children and adolescents have shown that regular participation in PA can have positive outcomes on bone structure in midlife (165, 166), while most research in older adults have shown those classified as active are more likely to experience a lower age related decline in BMD (43), retain better balance and remain independent (57). The few studies that have tracked PA from middle to later life have shown those participants who were active in their middle age were more likely to remain active in their older age (167); that higher participation in PA was linked to better BMD (168) and lower bone loss (169).

In this analysis we considered relationships between recalled PA from age 18 through to the eighth decade and BMD and body composition in adults from the HCS. We sought to consider (1) whether WBPA related to bone health measured by DXA in later life at a time when falls and fractures were becoming common (2) whether WBPA related to fat and lean mass (3) whether higher WBPA at a particular time point was of benefit (4) whether the same relationships were seen in men and women and finally (5) whether WBPA track throughout the lifecourse. Some of the results presented here have been published (170)

3.2 Methods

Detailed methodology for this results chapter has been described in 2.3. In brief 258 participants were recruited from the HCS, 128 men and 130 women for this phase of the study from the baseline cohort of 1677 men and 1540 women studied between 1998-2003. Trained study nurses visited participants at home and administered questionnaires including, demographics, lifestyle, and current PAs. Lifestyle factors included smoking status (current or historical), and alcohol consumption (units consumed per week) and dietary calcium intake which was determined using

a food-frequency questionnaire. Duration of current PA in the past 14 days was reported using LAPAQ. Participants recalled the level of WBPA over four age groups: up to ages 18 years, ages 18-29 years, ages 30-49 years and since ages 50 years.

Anthropometric measurements including height and weight were made, and BMI was calculated. Grip strength was measured using a Jamar handheld dynamometer

BMD was measured on all participants using a Lunar Prodigy Advance DXA scanner (GE Medical Systems). Sites measured were femoral neck and total hip. Body composition (total lean mass (kg), and total fat mass (kg)) was also assessed by Lunar Prodigy Advance DXA scanner (GE Medical Systems).

3.2.1 Statistical Analysis

Descriptive data on cohort characteristics were expressed using mean and standard deviations given their parametric distributions. Current PA time was expressed using median and interquartile ranges given its non-parametric nature. To explore the differences in PA frequencies in men and women, chi-squared tests were calculated. The BMD, total fat and lean mass variables were transformed using the Fisher-Yates rank-based inverse normal transformation to create z-scores, which allows uniformity to compare the individual variables and its relationship with past frequency of WBPA. Relationships between the frequency of past WBPA, the explanatory variable, and the following outcome variables were examined: i) BMD in later life, ii) lean mass and iii) fat mass using linear regression coefficients. The hypothesised outcomes were that a higher frequency of past WBPA would be associated with i) higher BMD in later life ii) higher lean mass and iii) lower fat mass. Analyses were conducted with and without adjusting for age, lean mass, social class, smoker status, alcohol consumption, PA, dietary calcium intake and number of comorbidities and, additionally, for years since menopause and HRT use in women. These confounders were selected due to a combination of data from existing literature and as well as theory driven. For instance, hormonal process and age are universally accepted to affect BMD and the habit of smoking (171) and heavy ingestion of alcohol can have a negative impact on BMD (172) whereas the relationship between socioeconomic status and BMD remains unclear (173-176). However, given the body of evidence available there is sufficient merit in including social status as a confounder in our analysis.

Kappa co-efficients were calculated to explore whether the levels of WBPA participation tracks throughout the age groups. The methodology proposed by Munoz and Bangdiwala was used for interpretation of the kappa co-efficient (177). This can be summarised as follows: Kappa co-

efficient :<0.00 indicates poor agreement, 0.00–0.20 fair agreement, 0.21–0.45 moderate agreement, 0.46–0.75 substantial agreement and 0.76–1.0 indicates near perfect agreement.

All above statistical analyses were performed using the Stata statistical software package, version 17 (Statacorp, Texas, USA); $p < 0.05$ was regarded as statistically significant.

3.3 Results

3.3.1 Baseline Characteristics

The baseline characteristics of participants are summarised in Table 3. The mean age of participants was 75.4 (SD 2.5) years for men and 75.7 (SD 2.6) years for women. Of the total 258 participants, 128 were men and 130 were women. The majority of the women had never smoked, 66.2%, whereas for men it was 33.8%. There was a significant percentage of men reported as ex-smokers, 56.3%, compared to 33.1% in women. In terms of co-morbidities, 19.5% men, and 28.5% women reported no co-morbidities; 39.1% men and 28.5% women reported 1 co-morbidity; 25.8% men and 23.1% women reported 2 co-morbidities, 8.6% men and 11.5% women reported 3 co-morbidities and lastly 7% men and 8.5% women reported ≥4 co-morbidities.

In comparison to the 2739 men and women that did not take part in this phase of the study, there were no differences in terms of birthweight, height, units of alcohol consumed per week and daily dietary calcium intake (mg). However, there were differences in some of the characteristics when compared to the remaining 2739 HCS participants. The 258 participants were slightly younger in age, mean (SD) age 66.3 (2.8), compared to 64.8 (2.7), p<0.001; more active, mean activity score (SD) of 59.6 (15.6) compared to 63.5 (14.3); had slightly heathier diets, mean prudent diet score (SD) of 0.01 (2.01) compared to 0.31 (2.11), p=0.025; and lower body weight (kg), median (IQR) of 74 (66-83) compared to 76.5 (67.5-85.8), p=0.004 of those that did not participate. It was noted the 258 participants had a higher percentage of those never smoked 54.7%, compared to 45.5% of the participants that did not take part, p=0.007, less co-morbidity overall as a group, and higher proportion of participants in the skilled/professional sector when compared to the remaining HCS cohort, as shown in Table 4.

Birth weight and weight at 1 year of age between the traced participants but who did not participate in the study and those recruited in the HCS have also been analysed previously and found to be similar (149). The mean (SD) birth weight and weight at 1 year were 3.5 kg (0.6) and 10.1 kg (1.1) in 992 men and 3.4 kg (0.5) and 9.6 kg (1.0) in 733 women for those traced but did not participate in the study. Those participated in the study had a mean (SD) birth weight and

weight at 1 year of 3.5 kg (0.6), 10.2 kg (1.1) in 768 men and 3.4 kg (0.5) and 9.7 kg (1.0) in 714 women.

	Men			Women			p-value
	Total N	**Mean**	**SD**	**Total N**	**Mean**	**SD**	
Age (years)	128	75.4	2.5	130	75.7	2.6	0.27
Height (cm)	128	172.5	6.7	129	159.6	5.9	**<0.01**
Weight (kg)	128	81.5	11.4	130	72.5	13.2	**<0.01**
BMI (kg/m^2)	128	27.4	3.6	129	28.4	4.9	0.06
Total lean mass (kg)	105	53.3	5.2	100	39.2	4.6	**<0.001**
Total fat mass (kg)	105	24.7	8.0	100	30.8	9.2	**<0.001**
	Total N	**Median**	**IQR**	**Total N**	**Median**	**IQR**	**p-value**
Daily dietary calcium intake (mg)	128	1237	(1005 – 1418)	130	1118	(941 – 1281)	0.01
Alcohol consumption (units per week)	128	7	(1.8 - 14.3)	130	0.8	(0.0 - 5.0)	<0.01
	Total N	**n**	**%**	**Total N**	**n**	**%**	**p-value**
Smoker status	128			130			
Never		49	38.3		86	66.2	
Ex / Current		79	61.7		44	33.9	**<0.01**
Social Class	122			130			
I-IIINM		56	45.9		68	52.3	
IIIM-V		66	54.1		62	47.7	0.31
Number of comorbidities	128			130			
0		25	19.5		37	28.5	0.268
1		50	39.1		37	28.5	
2		33	25.8		30	23.1	
3		11	8.6		15	11.5	
≥4		9	7.0		11	8.5	

Table 3 Baseline characteristics of current phase study participants

	Remainder of HCS			Current Phase Study			
	Total N	**N**	**%**	**Total N**	**N**	**%**	**p-value**
Smoker status	2737			258			**0.007**
Never		1244	45.5		141	54.7	
Ex		1137	41.5		96	37.2	
Current		356	13.0		21	8.1	
Social class	2696			252			**0.007**
I-IIINM		1089	40.4		124	49.2	
IIIM-V		1607	59.6		128	50.8	
No. comorbidities[1]	2593			247			**<0.001**
0		1207	46.5		146	59.1	
1		887	34.2		71	28.7	
2+		499	19.2		30	12.1	

Table 4 Comparison of summary characteristics between responders and non-responders.

3.3.2 Weight bearing physical activity

At the time of study, women were more physically active than men spending a median time of 206 minutes per day being physically active (IQR146-277), versus 194 minutes per day (IQR 110-298) for men. This trend is reversed when looking at the frequency of WBPA over the life course, shown in Table 5. Figure 6 shows men reported higher frequency of WBPA during their younger years with 53.4% of men reporting been active more than once a week in up to 18 years of age, compared with 30.3% in women (P=0.006). A similar trend was also seen in ages 18-29 years old with 41.6% of men reporting participating in WBPA more than once a week compared to 15.6% of women (P<0.001). For both men and women, the frequency of WBPA decreased as the age increased, in ages 30-49 years old 23.7% reported more than once a week in men and 12.5 % for women though this difference was non-significant (P=0.177). The rate decreases further in ages >50 years old, with 16.2% of men performing WBPA more than once a week, and only 8.5% of women (P=0.102).

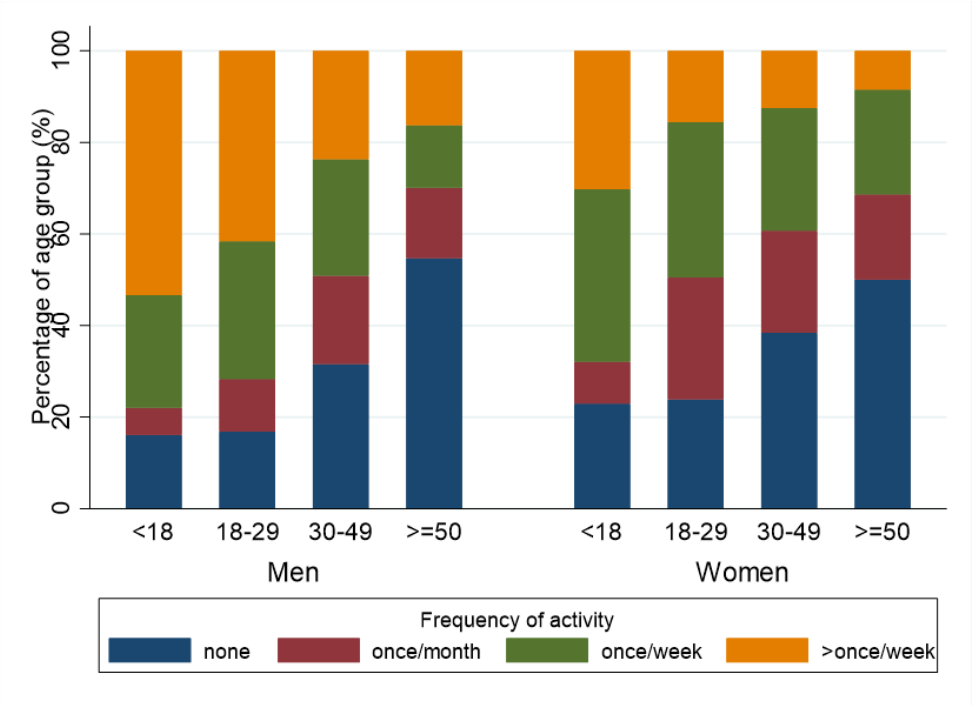


Figure 6 Proportion of physical activity participation by age group and gender.

Relationships between WBPA levels at different ages was explored using Kappa co-efficient and these decreased over time, as shown in Table 6.Whilst broadly similar, the tracking was generally stronger in women than men. We observed that participants who were active at 30-49 years were more likely to remain active in late adulthood with kappa in men 0.393 (95%CI: 0.295-0.442) and kappa in women 0.492 (95% CI: 0.400-0.555).

	Men			**Women**			
	Total, n	n	%	Total, n	n	%	p-value
Weight bearing activity up to age 18	118			109			**0.006**
none		19	16.1		25	22.9	
once a month		7	5.9		10	9.2	
once a week		29	24.6		41	37.6	
more than once a week		63	53.4		33	30.3	
Weight bearing activity aged 18-29	113			109			**<0.001**
none		19	16.8		26	23.9	
once a month		13	11.5		29	26.6	
once a week		34	30.1		37	33.9	
more than once a week		47	41.6		17	15.6	
Weight bearing activity aged 30-49	114			112			
None		36	31.6		43	38.4	0.177
once a month		22	19.3		25	22.3	
once a week		29	25.4		30	26.8	
more than once a week		27	23.7		14	12.5	
Weight bearing activity aged over 50	117			118			0.102
None		64	54.7		59	50.0	
once a month		18	15.4		22	18.6	
once a week		16	13.7		27	22.9	
more than once a week		19	16.2		10	8.5	

Table 5 Past frequency of weight bearing physical activity in the different age groups.

Men and women		Age (years)		
		18-29	30-49	≥50
Age (years)	<18	0.532 (0.504 - 0.563)	0.275 (0.266 - 0.337)	0.133 (0.091 - 0.174)
	18-29		0.424 (0.381 - 0.458)	0.199 (0.175 - 0.246)
	30-49			0.443 (0.376 - 0.507)

Table 6 Tracking relationship in WBPA participation as the cohort ages.

3.3.3 Grip strength

In both men and women, no relationships were apparent between past WBPA and grip strength in both adjusted and non-adjusted analysis. Adjustments included age, lean mass, social class, smoker status, alcohol consumption, PA, dietary calcium intake, number of comorbidities, and years since menopause and HRT use.

3.3.4 Body composition and weight bearing physical activity

I found no consistent graded relationships between total fat/lean mass and the frequency of WBPA in either gender at any age group. I did observe a weak relationship in men at ages >50years between total fat mass and exercising once a month (regression coefficient (β) 0.58 (95% confidence interval (CI) 0.02, 1.14), p=0.044) when adjusted for age, social class, smoker status, alcohol consumption, PA, dietary calcium intake and number of comorbidities and in women, at the ages 30-49 years, exercising once a month was also weakly associated with total lean mass both unadjusted and adjusted for the same confounders as men and as well as years since menopause and HRT use (β 0.56 95% CI: 0.00, 1.12), p=0.050; β 0.75 95% CI: 0.11, 1.39, p=0.023).

3.3.5 BMD and weight bearing physical activity

In contrast, more consistent graded relationships were observed when considering bone health as the outcome. There was a significant positive association, in women, between total hip BMD and WBPA (Figure 7) for those exercising more than once a week at ages 18-29 years (regression coefficient (β) 0.81 (95% confidence interval (CI) 0.15, 1.48), p=0.017) and 30-49 years (β 0.68 (95% CI: 0.02, 1.34), p=0.042) when adjusted for age, lean mass, social class, smoker status, alcohol consumption, PA, dietary calcium intake, number of comorbidities, and years since menopause and HRT use, compared to those reporting no WBPA. Similarly, there was also an association between femoral neck BMD and WBPA (Figure 8) at ages 18-29 years (β:0.74 95% CI: 0.08, 1.41, p=0.030) when adjusted for confounders. This relationship was not observed in men either before or after adjustment for confounders (Figure 7 and Figure 8).

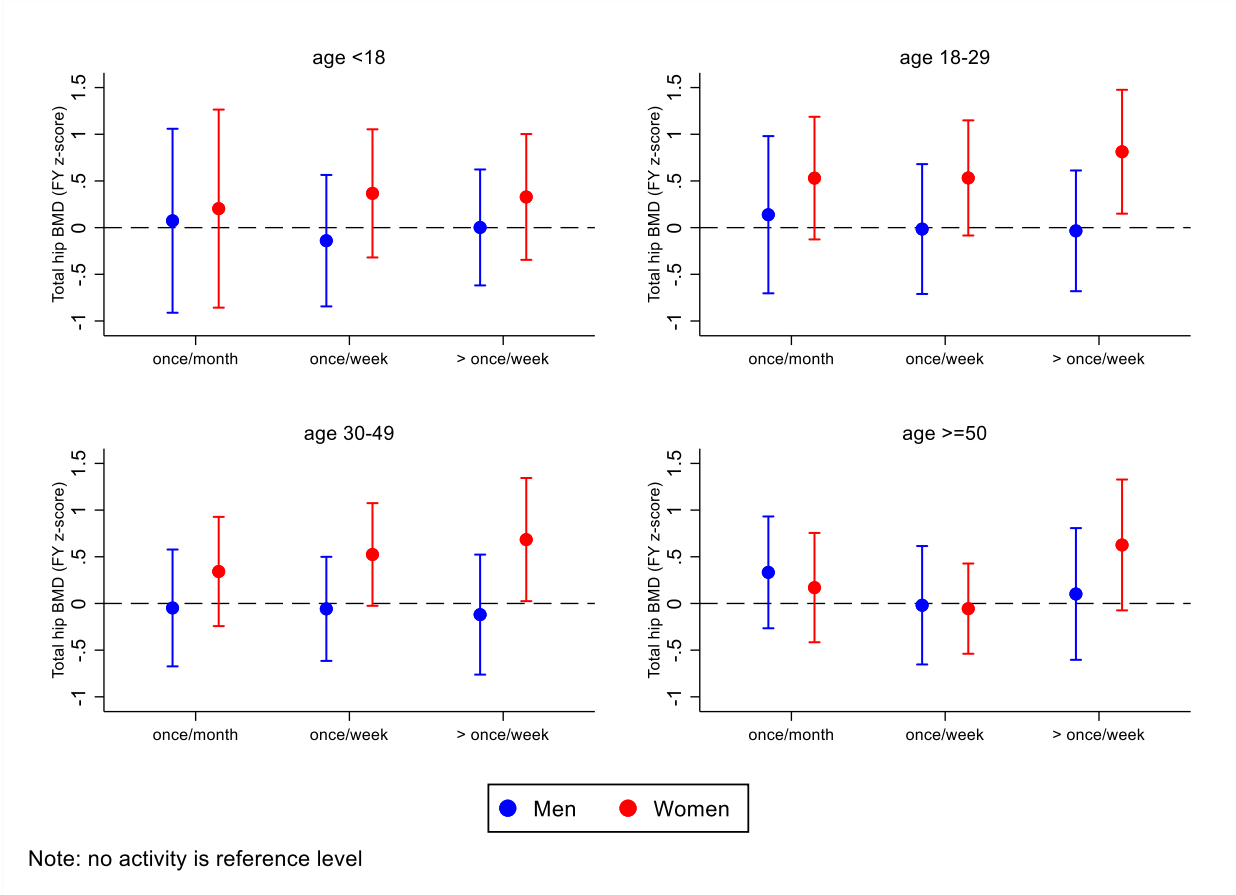


Figure 7 Regression coefficient and 95% CI for the association between past WBPA at different age groups and total hip BMD in men and women. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current PA, dietary calcium intake for all and for years since menopause and HRT use for women only.

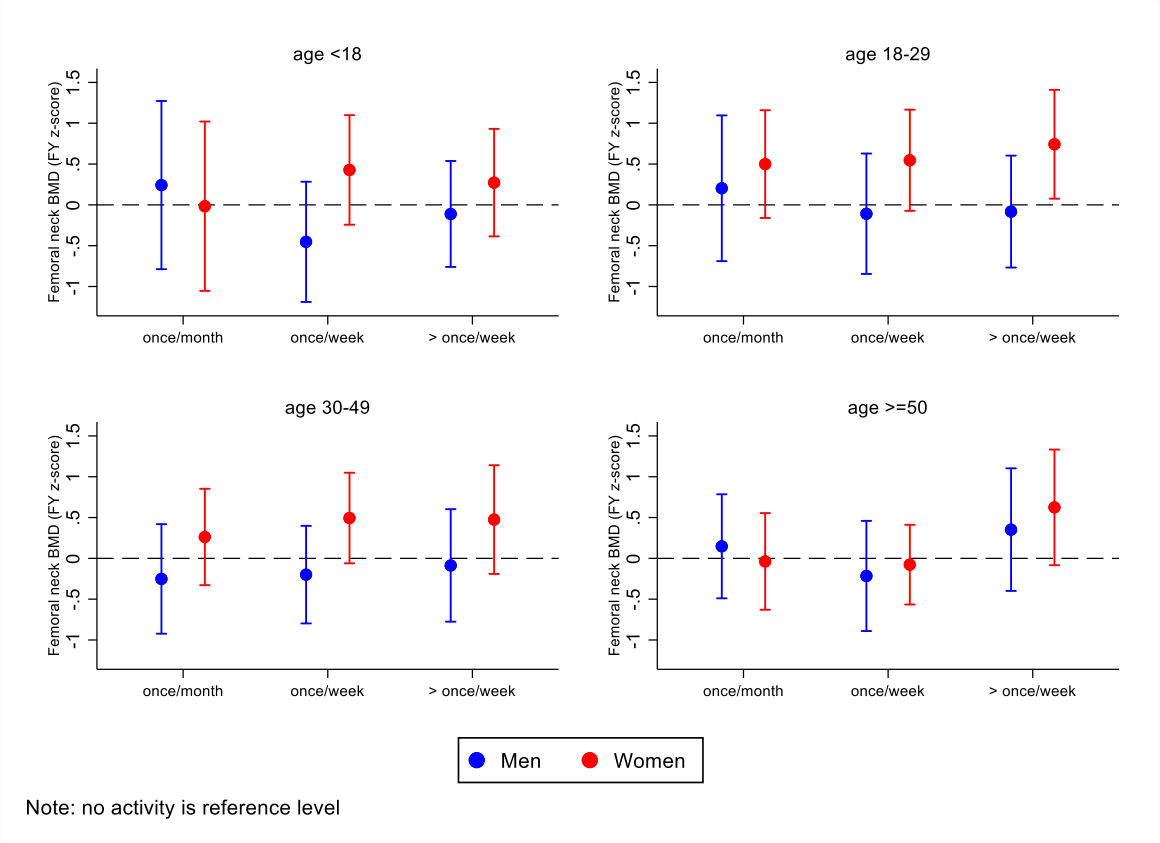


Figure 8 Regression coefficient and 95% CI for the association between past PA at different age groups and femoral neck BMD in men and women. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current PA, dietary calcium intake for all and for years since menopause and HRT use for women only.

3.4 Discussion

In this study we have examined the relationship between recalled WBPA over the lifecourse and musculoskeletal health in late adulthood. Men in our cohort group reported higher rates of participation in WBPA from 18 years to 29 years, compared to women. This could reflect the gender difference in WBPA participation during younger years. However, the overall frequency of WBPA decreased as age increased. This is likely to be caused by a multitude of contributory factors which will be explored in detail in the qualitative study, Chapter 4. Interestingly the median time of current PA in older age was slightly higher in women than men. The LAPAQ includes specific questions asking about the amount of time spent on both light and heavy household tasks, therefore this finding possibly reflects the fact that women in this cohort perhaps spend more time on household related tasks than men. However, in general men were more likely to be active in the past compared to women. Our study has demonstrated a positive relationship between higher frequency of past self-reported WBPA and BMD at total hip and femoral neck in women. This relationship was not seen in men. By contrast we found no

consistent relationships between WBPA and fat/ lean mass at any time point in either gender. The reasons for the observations regarding BMD and fat/lean mass will be discussed later in this section. In previous phases of HCS, PA has been well characterised in this cohort (178-180), and it was strongly linked to musculoskeletal health (181, 182). Those participants with low self-reported physical function have been shown to be more likely to have a higher number of risk factors for poor physical function and low level of PA (178).

Similar to the findings from the 1946 British Birth Cohort, in our current analyses, we note a strong positive relationship between past WBPA at ages 18-29 and ages 30-49 and total hip BMD at older adulthood in women, however in the 1946 British Birth Cohort the association was stronger in men than women (168). This may be due to methodological differences between the two studies in particular the type of PA data collected; in the 1946 British Birth Cohort researchers collected data on all LTPA whereas our study focused on WBPA only. Although our own sample size was modest compared to the 1946 British Birth Cohort, we were able to consider WBPA at earlier time points from <18 years compared with the 1946 British Birth Cohort which started at age 36. Similarly in the Tromsø Study, researchers also observed a positive linear trend in between areal BMD and LTPA levels in women and as well as men, after adjustments for baseline age, height, weight, and smoking status ($p<0.05$) (183). This relationship seen was consistent over various sites including total hip, femoral neck and trochanter area, and distal and ultra-distal area of forearm. This was a prospective, population-based study with 22 years of follow up that had data on LTPA on 1,766 women and 1,451 men aged 20–54 years at baseline and at various follow up points. In a subsample in this study, they also noted those sedentary at baseline and follow up had significantly lower areal BMD compared to those that at moderately active or active at both of these timepoints ($p \leq 0.01$). The Tromsø Study recently updated their findings and found LTPA was also linearly positively associated with hip areal BMD (184). In other work several authors have reported associations with WBPA and bone health in women which is consistent with our own findings (185, 186).

In our study, we see a gender difference in WBPA participation. We hypothesise women during the 1940s-1960s will have a different PA profile compared to men. Several studies of nationally-representative samples have shown men are more likely to participate in MVPA than women. However, women spend less time been sedentary than men in older adulthood (187-189), and we observed the median time spent been active was higher for women than men. This could be due to the proportion of PA attributed to household could have increased in comparison to the decreased proportion of vigorous PA that one may have participated in younger days. Then compounded by the traditional gender difference of women being more likely to be involved with household related tasks than men, therefore women may be perceived as being more active.

In this cohort we did not find any relationship between participation in WBPA and BMD in men, this could be due to a higher prevalence of men been physically active compared to their female counterparts therefore the apparent beneficial effect on BMD has been diluted. In contrast there were fewer active women in our cohort. Other studies have shown evidence of sexual dimorphism; in a Northern Finnish cohort, high level of past PA over life-course from 14 to 46 years of age was associated with larger vertebral cross-sectional area in women, whereas this association was not observed in men (186).

Over time attitudes towards PA have changed; a recent cross-sectional Australian wide telephone survey showed older adults, aged 65 years or older, were less likely to have the intention of increasing their PA compared to younger adults, aged less than 45 years old (73). This study also demonstrated older adults had different preferences in type of PA, preferring slower paced activities compared to younger adults. We see a reduction in the frequency of participation in WBPA as the HCS participants get older and this is in keeping with other longitudinal studies (168, 186).

The gender differences in PA participation can also be accounted for the different types of questions asked in different PA questionnaires. As highlighted in Table 2, there are a variety of PA questionnaires available, and not all of them are suitable for this study's cohort due to age limitations. Some of the questionnaires cover a large range of age such as the Global Physical Activity Questionnaire (GPAQ) which covers 18-75 years old (109), or the 7-Day Physical Activity Recall (7-Day PAR) covering 20-74 years old (110). There are questionnaires that particularly target the older adult population such as the Physical Activity Scale for the Elderly (PASE) (190) and the Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ) (112), both targeting ≥65 years old. In both LAPAQ and PASE they collect additional information on household related activities (light and heavy) which is very relevant to the older adult population. This extra information can elicit potential differences between older men and women. By contrast questionnaires covering larger age ranges such as GPAQ reflects their need to be appropriate for working adults as well as those who may have retired, therefore information collected focused on intensity of activity at 3 stages: work, recreational activities and travel to and from work. In the Tromsø Study they utilised their own questions asking the following 4 components (183):

1. "Reading, watching TV, or other sedentary activity.
2. Walking, cycling, or other forms of exercise at least 4 h a week.
3. Participation in recreational sports, heavy gardening etc. at least 4 h a week (including walking or cycling to place of work, Sunday walking, etc.).
4. Participation in hard training or sports competitions regularly several times a week."

The participants were asked these components over a period of 12 months and if the differences between the summer and winters months were very significant then an average was asked to be put down.

Another consideration is the differing effect exerted by different types of PA on BMD. PA applies mechanical force to bone enhancing bone formation and bone mass (35, 36). Models have shown loading force can induce new periosteal apposition, and prevent an increase of cortical porosity and endosteal resorption induced by disuse (191). Previous studies have investigated how different types of exercise can affect BMD. The types of PA are largely split into two categories, weight bearing and non-weight bearing and within these two categories they can be further sub-divided into static, low and high impact. Interventions devised in randomised controlled trials have been largely heterogeneous with regards to types of exercise (39, 40, 42, 43). Bolam et al demonstrated resistance training alone or combination with high impact loading activities have the potential to attenuate and or reverse decline of BMD in middle aged or older men (43). In one meta-analysis, it was calculated less than ten women would need to exercise to derive benefit in BMD at femoral neck and lumbar spine sites (40). In another meta-analysis of nineteen studies, it was found that participation in exercise of mixed loading impact is associated with significant increase in mean BMD values for lumber spine and femoral neck in older adults (42).

The lack of association between previous WBPA and fat/lean mass composition could be related to the particular type of PA that we assessed here. Activity that focuses on weight bearing might be expected to have little effect on fat/lean mass. In support of this explanation, previously published data from the HCS has showed that more active older adults (as measured by accelerometer therefore can more likely cardiovascular or metabolic driven activities) had lower fat mass and higher appendicular lean mass index (51). In other work, PA measured as excess metabolic equivalent (MET)-hours per week which can be estimated from activities such as walking, and moderate and vigorous PA have been inversely associated with percentage of body fat, and for those with the same BMI, the participants who were more active had a lower body fat percentage (47). Finally in another cross-sectional analysis of UK Biobank participants, researchers found greater PA as measured by accelerometers was associated with lower body fat percentage in both men and women (46). Thus I conclude that different types of PA in later life might have benefits on different aspects of health, and it is important to consider this when making recommendations regarding types of activity in older adults. Another consideration for the non-relationship seen here between fat/lean mass with frequency of past WBPA could be due to the size of the study population being not large enough to observe any potential relationship.

Effects of PA taken by the general population without an exercise intervention was observed using the 2007-2010 National Health and Nutrition Examination Survey; here aerobic PA was positively associated with BMD at the proximal femur for women, and lumbar spine and proximal femur for men (192). In particular, significantly higher BMD was observed at the femoral neck for women exceeding the 2008 Physical Activity Guidelines for Americans by 2-4 times per week, and in both lumbar spine and femoral neck sites for men exceeding 4 times or more per week. This is in support of my hypothesis that for men a higher threshold level of WBPA is required to detect a beneficial effect on BMD.

I also investigated if the presence of previous WBPA in earlier life would track over the lifecourse. In Table 6, it demonstrated that if a participant reported being active when aged 30-49 they were more likely to remain active when aged ≥50 (Kappa co-efficient 0.443) than compared to those that were active aged <18 (Kappa co-efficient 0.133). Table 6 demonstrated that if the habit of being active is maintained throughout the lifecourse then the higher the likelihood of remaining active in older age.

The British Regional Heart Study is an ongoing prospective cohort study involving 7735 men recruited from cities in the UK that were first examined in 1978–1980 aged 40–59 years old and then followed up at 12, 16 and 20 years. It showed moderate agreement in general PA participation in between the waves of the study (Kappa co-efficient: 0.23–0.26), with a stronger tracking for specifically sporting participation (Kappa co-efficient: 0.35–0.38) (167). The Women's Health Initiative Observational Study, USA, used data on recalled PA during various timepoints in childhood and current adult PA participation for 48,066 women (193). Those women with the highest level of PA during childhood had higher levels of PA compared to those did not (adjusted estimate (MET-hr/week) 2.22 (1.88-2.55) p-value<0.001), and those with the longitudinal pattern of being always active were 2.82 MET-hr/week more active than those always being inactive, p<0.001. Whilst it is difficult to directly compare our study with the two studies described here, there does appear to be a pattern of those that were active in the past being more likely to remain active later in life than compared with those who were inactive in the past.

There are strengths and limitations to our study. Our cohort is a group of community dwelling men and women that have been previously shown to be representative of the general UK population with regards to lifestyle characteristics such as BMI and smoking (149). Of the 258 participants, the main differences compared with the remaining HCS cohort that did not take part are that participants were slightly younger, more active, and had a slightly healthier diet. I acknowledge the limitation of using recall data i.e.: the use of self-reported WBPA earlier in life. However, it is unlikely differential recall bias will occur systematically in this study therefore this

should not affect the validity of the results. I also acknowledge that previous recall of WBPA does not include information such as intensity and duration and nor do we have data on manual labour of the participants, however social class (i.e.: manual vs non-manual) was included in the adjustments. In addition, current PA level was validated in a subset of our cohort (151) and the BMD data set did not include lumbar spine.

3.4.1 Conclusion

In conclusion, we have found a positive association between frequency of past WBPA and BMD at later life in women but not in men. This could be reflecting the gender difference with regards to the amount of WBPA needed for the BMD benefit to be observed later in life. This supports a public health message that encourages young women to participate in regular WBPA throughout the life-course.

Chapter 4 Factors influencing participation of physical activity in older adults: a qualitative study of Hertfordshire Cohort Study

4.1 Introduction

In the previous data chapter, I have investigated the benefits of participating in WBPA across the lifecourse. The data showed that fewer participants reported participating in WBPA in later life, although those who remained active in their thirties and forties were more likely to remain active in their older age. In this chapter I will explore the factors that influence PA participation in a group of community dwelling older adults. The results presented here have been published (194).

Both WHO and the UK Chief Medical Officers have separately published PA guidelines advocating a range of PA including muscle strengthening, improving balance and 150 minutes of moderate-intensity aerobic activity per week (24, 195). However a high proportion of adults remain inactive, with the latest global estimation of adults who are physically inactive being more than 1 in 4 (28% or 1.4 billion people), although there are regional variations (196).The level of physical inactiveness has been defined as adults not meeting the WHO recommendations regarding PA i.e. ≥ 150 min of moderate-intensity, or 75 min of vigorous-intensity PA per week, or any equivalent combination of the two. However, this figure increases in the subpopulation of older adults, and data from a cohort of 10 European countries showed the prevalence of physical inactivity (defined as engaged in vigorous PA ≤ once a week) in older adults aged 65-75 years old can vary from 55.4% to 83.3% in women and 46.6% to 73.7 in men (16).

Understanding older adults' perspectives on the drivers for participation in PA can aid us in supporting PA participation in later life. Previous reviews have highlighted several facilitators and barriers that can be largely categorised into the following groups: physical, social, environment and psychological factors (87, 197). Common enabling factors include both physical and mental health benefits deriving from been physically active, and encouragement from peers, family and support network are also paramount in continuing to be active (87, 197). Frequently cited barriers include physical limitations due to pain or existing medical conditions (198-200), and a lack of motivation (200-202). A number of psychological factors have been strongly linked to facilitating higher levels of PA in the older adult population: self-efficacy, positive thinking, and motivational internal thoughts (203-205). The Health and Retirement Study used questionnaire data from participants aged ≥65 years old (mean age = 76.32, SD = 7.74), and found that perceptions on

ageing perception, self-control, motivational force, perceived social relations, spiritual/religious engagement and perceived neighbourhood safety were associated with the participants' LTPA (203).

Many of the existing qualitative research on older adults' perception on PA involves structured PA programmes, such as resistance training, balance, and strength, and falls prevention programmes (87, 197). Less is known about older adults' perception regarding general PA which can incorporate a wide spectrum of activities such as household related activities, non-structured PAs including walking, and hobbies such as bowling. We had unique access to a group of community-dwelling older adults and the primary aim of this study was to explore influences on their participation in PA. The secondary aim was to gain insight into gender differences, if any, on factors affecting PA.

The use of focus groups is a commonly used method in collecting qualitative data, and this approach has the distinct advantage of capturing a wide range of information including aspects that may have not been anticipated by researchers. The topic of PA participation is broad therefore the use of focus groups can help to illuminate any unknown aspects on this topic. Traditionally the recruitment of participants for focus groups is usually through convenience or purposeful sampling, and sometimes through random sampling (206). Purposeful sampling selects participants for their particular characteristic trait/s that is/are vital to the research question for instance recruiting participants from the local osteoporosis support group to explore PA habits of those with osteoporosis, whereas convenience sampling could involve approaching any local support group or local organisational group for participants to explore the PA habit of those with osteoporosis. The use of a random sample is less common, for example approaching every 3rd person seen on the street. The approach used in this focus study is purposeful sampling with the aim to investigate the points of view of community dwelling older adults in general PA participation. The methodology of our focus group recruitment is detailed in the section below and 2.4.

4.2 Methods

Detailed description of the methodology for the Hertfordshire Cohort Study diet and physical activity focus groups can be found in 2.4. In brief 92 participants (43 women and 49 men, mean age=78 years) took part in the focus groups. They were split into groups based on their prudent diet change scores, "diet stable" and "diet decline". Each focus group consists of up to 10 men or women, with the eleventh focus group been a mixed gender group of 10 for practical reasons. During the focus group a semi-structured discussion guide, Appendix A, was utilised to facilitate

the topics (diet and PA) discussed. The sole focus of this chapter is the PA aspect of the discussions that took place in these focus groups. Discussions at the focus groups were audio-recorded and transcribed verbatim

4.2.1 Data analysis

Using the transcripts, a coding framework, Appendix B, was developed and refined to show the emerging themes and categories from the raw data, the transcripts. The process used was inductive coding where significant themes and categories emerged without the constraints of a pre-devised structure (207). All transcripts were double coded by 2 different researchers, J.Z. and I.B. Both researchers met on a regular basis to discuss the thematic analysis, and also had periodic meetings with W.L., a health psychology associate professor with abundant experience in qualitative data analysis, to ensure a third person is in agreement with the overall route taken by the main 2 researchers. If there are any discrepancies then a detailed discussion would take place firstly between J.Z. and I.B. to reach a resolution, and on some occasions further meetings with W.L. would take place to reach a suitable conclusion.

4.3 Results

4.3.1 Focus group characteristics

In total eleven focus groups (FG) took place with a total of 92 participants, baseline characteristics are displayed in Table 8 and Table 8. Forty-seven percent of participants were female, n=43, the median age was 74.7 years (IQR: 72.8 - 77.6) and all were white British. Comparing the baseline characteristics of the participants of the focus groups to the main body of the HCS which consist of 3217 participants there were no differences in activity score, maximum grip, height, weight, BMI, education, social class, smoker status and the number of co-morbidities. The focus group participants did have a healthier diet, mean (SD) diet score 0.51 (2.24) compared to -0.02 (2.01), p=0.014; were younger, median (IQR) age of 63.9 years (61.8-66.8) compared to 66.1 (63.9-68.2) years in the rest of the HCS, and lastly the focus group participants had a faster median (IQR) 6m timed up and go time of 9.1 (8.6-10.1) seconds compared to 10.5 (9.5-11.7) in the rest of the cohort, p<0.001.

	N	**Mean**	**SD**
Prudent diet score	91	0.45	1.59
Gait speed (m/s)	91	0.78	0.16
Maximum grip (kg)	91	30.1	10.1
Height (cm)	91	167.2	8.5
	N	**Median**	**IQR**
Age (years)	92	74.7	72.8 - 77.6
Weight (kg)	92	78.3	71.5 - 86.9
BMI (kg/m^2)	91	27.7	25.4 - 30.8
Alcohol consumption (units per week)	92	3.5	0.8 - 10.7
Activity time in last 2 weeks (min/day)	85	199	147 - 283
6m timed up and go (sec)	91	11.0	9.5 - 13.0
Chair rises time (sec)	85	15.6	14.0 - 17.4
Physical performance summary score	90	9.0	7.0 - 11.0

Table 7 Baseline characteristics of the focus groups- part 1.

	N	**N**	**%**
Sex	92		
Male		49	53.3
Female		43	46.7
Age left education	92		
<=14		14	15.2
>=15		78	84.8
Social class	89		
I-IIINM		43	48.3
IIIM-V		46	51.7
Smoker status	92		
Never		45	48.9
Ex		44	47.8
Current		3	3.3
Number of comorbidities	92		
0		18	19.6
1		37	40.2
2		25	27.2
3		7	7.6
4 or more		5	5.4
Tandem stand <10s	92	16	17.4
Low PP score (<=9)	90	47	52.2

Table 8 Baseline characteristics of the focus groups- part 2.

4.3.2 Thematic analysis

Thematic analysis of the data showed six themes as influences on PA as listed here:

1. Historical influences on PA
2. Retirement and bereavement
3. Age and medical related factors
4. PA environment
5. Social engagement
6. Psychological/personal factors

These themes are described in detail below, with quotes presented as illustrative examples. The primary aim of this study was to explore influences on PA among community-dwelling older people; the secondary aim was to explore differences between men (M) and women (W) and for this aim only data from the first ten FGs were used for analysis (i.e.: the single gendered groups), thus the mixed group is not included in the analysis looking for differences between men and women.

4.3.2.1 Historical influences on PA

Facilitators

Traits and habits created from earlier life stages such as previous work ethics/discipline were observed as many mentioned PA habits or routines from previous life stages, e.g., early life or working life continuing into older age.

> *'I suppose I would be lost without a healthy lifestyle. I've been used to all my life a fair amount of physical activity; an active life and I suppose it comes from a fairly hard-working life. Since I retired many years ago, I tried to expand that a little in my retirement' (FG11MW)*

> *'Well, I've got three dogs and I walk for an hour every day and I swim. I was a swimming teacher for 28 years, um so I am pretty active…' (FG4W)*

There were also expressions of fear of stopping and unable to restart or take up the activity again which was motivating them to continue with their PA levels, which strongly links to one of the other themes, psychological/personal factors. A few of the participants mentioned their exposure to sports or being active or the concept of playing outdoors during their early years which then subsequently formed their current habit.

"When you stop doing something then you never take it up again, so you go to keep doing what you've been doing all your life" (FG2M)

"Does this reflect our generation because I mean …from what we are when you think back when we were children??... What we used to do: we used to entertain ourselves, used to go outside and play. I was never in etcetera, so I was always active and always enjoyed it. I always enjoyed out with friends, etcetera all that type of thing. This (does) not reflect on now because these our children …now have the same experience??" (FG8M)

Barriers

Although some participants continued with previous routines or habits, others stopped due to a variety of reasons. There were discussions on busy lifestyle relating to work or raising a family, a new medical condition or event, or ageing (tiredness) that impeded with PA participation, leading them to stop and then not restart later on in life.

'Can't do so much now can you 'cos when I used to when I was younger, I obviously played football and swimming and that I used to do probably eighty lengths in an hour but now you know you you're slow, you think, oh you know you can't do the same you know' (FG5M)

'I don't do as much. I used to play badminton 3 times a week and table tennis as well as the swimming, so I don't do as much now … it's made me too tired yes. Haven't got the energy have we like we used to have.' (FG6W)

`I'm not given up for reason other really than age. I haven't got arthritis and I haven't got ageing knees or anything, but I just haven't got the energy to walk like I used to' (FG6W)

It was noted the reasons why the participants may have stopped or reduced their PA levels during their younger days differed between men and women. For men, some have stated that having to work and raise a family were the reasons why they reduced their PA participations during their younger years, whereas for women, they did not explicitly comment on this topic therefore it is difficult to clearly distinguish a true gender difference on this.

Within this theme the facilitators were strongly linked with psychological factors such as discipline, the idea of keeping going and fear of unable to restart an activity if they stopped. Enjoyment was also a strong facilitator for enabling PA participations maintenance within the theme of historical influences.

Interestingly within the context of prior historical influences to some participants the process of ageing can bring on physiological changes that were cited as a reason for them to reduce or stop PA participation; however, there were those who felt the need to continue regardless of their age or age-related changes. This contradictory sentiment was also highlighted in age and medical related factors, and psychological/personal factors themes.

4.3.2.2 Retirement and bereavement

Facilitators

Having more free time/freedom since retirement to participate in pursuits, finding and taking up new hobbies or belonging to new organisations/voluntary work was a key facilitator in this theme, and this was especially evident for men. Men spoke of the importance of keeping a routine after retirement. For instance, men discussed the need for part-time work after retirement and keeping going with either elements similar to their work or those wanting a complete change or break from their working life.

> *'I've been retired now 20 years um and when I finished work … I didn't go back I didn't get involved in anything work related. I didn't take on any spare time jobs or anything. The moment I retired I had a terrific change in life I suppose because my job was 24/7 7 days a week um and I left it all behind … I'm president of the sports club which runs three football teams, two cricket teams and I get involved in a lot of the village life um with but it's all committee church committees and so on' (FG10M)*

> *'Well I've done eight years over the top of sixty-five … I worked 'til I was seventy-three and got made redundant and that believe it or not (I) would still be working now if I hadn't been made redundant … I try (to) make myself get up by eight o'clock every morning, shower or wash (and) shave. I do like to have (a routine) first thing in the morning and then go on from there with the day…' (FG2M)*

> *'Once you've retired you gotta get out and do (what) you gotta do. You gotta keep going. I mean it's like getting up in the morning just because you're not working… Doesn't mean you can stay in bed 'til 9 o'clock. I get up at the same time as when I went to work. Yeah. Exactly the same' (FG10M)*

Whilst some men spoke of pacing themselves differently to when they were still working:

> *'You pace, you pace yourself differently when you're retired I think … 'cause you're not, you're not under pressure are you - you don't got to get up to go and work and so obviously your life changes a bit' (FG2M)*

The discussion around bereavement led to exploration of how this can lead to changes in PA, including taking up activities that they previously did not do. There were some noticeable gender differences in this regard.

Men spoke of the need to take up unfamiliar activities, e.g., housework, after losing their partner.

> *'Your life changes when your partner dies. Obviously, mine died just over three years ago so you have to change obviously because of what she used to do housework things like that … which I was I'm able to do as I'm fairly active which is a big factor' (FG2M)*

For women there was a heavier emphasis on having a supportive network such as a person going through similar loss or having a supportive family to help them navigate the challenging period and keep on participating in PA, and this strongly links with the social engagement theme.

> *'So that's quite social and communal as it were um I have a crazy neighbour … she's also in the same position. Her husband died a year before mine did and she has been such a long time in what I call getting back to more or less normal which has been quite hard work. I have felt that I needed to support her strongly even though I was in a similar position. So it's been difficult but she's back again now which is great…' (FG4W)*

Barriers

Although increased availability of time after retirement meant some could pursue their interests, some of the men also discussed having difficulty adapting to a lack of discipline or structure after retiring, therefore finding it more difficult to complete tasks:

> *'Yeah, I don't sit around. I like to work I just you know I worked all my life seven days a week most of it um and then to suddenly stop work and you find you've got a day you know. All the days are the same and you know you get very lazy actually because 'oh I won't do it this morning I'll do it this afternoon' whereas before…' (FG5M)*

One woman spoke of doing less walking due to loss of her husband, as they used to walk together. Women also spoke of the loss of husband, dog, friends or family members leading to a sense of isolation and loneliness; a few also mentioned a loss of confidence, or depression.

> *'Well I missed my dog so much when he was put down: it's really awful and so now I come into my house and I I feel like saying "Hello Louie". You know really really weird and sometimes I go and I don't speak to somebody ... unless I talk to myself I don't speak to*

anyone because all the houses nearly all the ladies are old ladies and everybody has died off…' (FG1W)

'I recently lost two friends, two brothers and a son-in-law I think that has caused the depression. I do my housework, I cook the dinners and um do what I can and we go out as much as we can and um belong to [Name] which is a church and uh keep fit and another club so um do what I can anyway' (FG7W)

Some women also spoke of reduced social interaction due to not being invited to couple related events and being in an unsupportive network or community.

'Facilitator And was there anyone else that said they were on their own? Now you are on your own, how did things change for you…

Participant Well it's an entirely different thing altogether, really is um I then joined uh a women's club things like that to get myself out in the first place and um then joined other clubs since and being in the company of other people that are in the same position that's right um yeah must give you a bit of confidence really

Participant You do find that whereas we were always well not always but quite a bit out and joining other couples you did find that you weren't invited so much (Noises of agreement)' (FG7W)

There are clear gender differences in this theme: men talk about affecting factors that are strongly related to psychological/personal factors such as the need to keep a routine, or lack of discipline, whereas women they appear to be heavily influenced by social surroundings such as having a support network or not been invited to couple orientated social activities.

4.3.2.3 Age and medical related factors

Facilitators

Many participants expressed the importance of maintaining PA despite age related changes such as stiffness and slowing down pace, and this attitude indirectly demonstrated the resilience of these participants. This was briefly highlighted in the historical influences on PA theme.

'Yes I think I still do the same things but a little slower' (FG11MW)

Discussion about the impact of sustaining a medical condition was talked at length, a proportion of the participants expressed having a medical condition has not stopped them from doing the PA that they want to do. Some expressed the need to readjust/adapt to the type of activity that can

be done after a medical event or been diagnosed with a medical condition (e.g. rehabilitation exercises or been more aware the need to be active and maintain healthy lifestyle).

> *'I mean I've got a heart pacemaker which you could say is a disadvantage but it's only for the arrhythmia of the heart … I've had a pacemaker for 12 years I've done 10 marathons with the pacemaker, so it doesn't affect you, you know quite fast marathons' (FG8M)*

> *'It's through back…back and knees um mostly back um but um you know I'm lucky I can still keep walking and I do I think you sort of you learn to live with pain I think when you're old (noises of agreement) … I think there are very few old people who don't have pain and I think it's the degree of it but you just have to ignore it a bit (FG9W)*

After a major medical event some participants seemed to accept their new baseline may be very different to before the event, however others seemed determined to work back to their original ability.

> *'I've had a hip replacement two and a half years ago and I did London 5 months after having the hip done' (FG10M)*

Interactions with medical professionals encouraged PA participation for some participants, including some wanting to prove medical professionals wrong.

> *'I had a bit of blood pressure, and I went to the doctor's, and they said keep up the bowling it's good exercise for you and all this sort of thing. So, I keep doing it' (FG3M)*

> *'The doctor said that I wouldn't be able to do any manual work afterwards. He said you'll have to pack up working, I said I can't … I run my own business … so he said won't be able to do manual work, you'll be doing office work … and I thought well I'm gonna prove you wrong … all the people it was had one done. I had to talk the surgeon into doing 2 of mine at the same time, never done it he said before … went back after six weeks I went in without crutches or walking sticks or anything and everybody was still on their crutches and they had one done. So he said how did you do that I said determination and um I said to the lady before she sent me out, she said right you do these exercises … I said how many do I do at a time so she well probably five six say don't make it too much. I said well can I not do more if it's not hurting me … I'm probably on the bed for two hours doing it' (FG10M)*

There was also widespread discussion regarding the belief of beneficial health effects of participating in PA.

'…We take health seriously. (I) used to walk about two hours a day and um you know take things quite seriously, but I think only because sometimes we feel lots of aches and pains, so we feel we've got to do it you know to get something out of life OK' (FG3M)

'Facilitator How much is keeping healthy and fit motivated by not having to end up in the doctor's surgery do you think? … that's ever in your mind sort of thinking if you keep healthy you don't have to be there?

Participant Every bit every bit' (FG2M)

'Participant I get back pain quite often and walking 'round … I continued walking and it disappeared

Participant If you didn't do any exercise it would seize up wouldn't it for good perhaps

Participant I think that's especially true as well with knees

Participant Oh yes' (FG9W)

However there were some discussions among men in one group about not thinking about health benefits when exercising or doing PA and engaging in PA more as a habit or routine instead.

'Facilitator Are there things you'd like … to do to be more healthy to do either exercise or changes in your diet or anything like that?

Participant Well I must admit I never think about being healthy … I suppose just something I've got or not got' (FG10M)

Barriers

The debilitating and limiting effects of health conditions on PA, and participants' ability to do certain activities were discussed at lengths.

'I only gave up work because of the knee otherwise I'd probably still be there now' (FG11MW)

'I would like to have travelled more I think um yeah once you've got back trouble you know you are restricted you really are' (FG1W)

Additionally, the subsequent changes to body condition and loss of ability (e.g., to drive or walk) after a major medical event, e.g., hip operation, chest operation were discussed.

> *'…They have to take me out now because I had a stroke, and I lost the sight … partial sight in me eyes…' (FG5M)*

> *'…I try to walk but I can't walk you know since I had the heart operation I can't walk as much as…' (FG6W)*

An important topic of discussion was the decline in capability or ability to do certain tasks or activities that they have been used to doing due to the natural ageing process, deconditioning of musculoskeletal health:

> *'… I mean as we're getting older most of us have either got a bad knee or a bad hip. In my case I used to do a lot more walking than I do now, but I just can't do it it's too painful…" (FG5M)*

Discussion of pain and discomfort as a barrier to doing PA was noted, however for others the pain and discomfort appear to be a challenge that through determination they 'walk through it'. In this theme it highlights how through psychological/personal factors such as determination, motivation, and self-efficacy different approaches have been adopted by these older adults at dealing with changes resulting from ageing and new medical conditions. This observation has been similarly noted earlier in the historical influences on PA section, where some of the older adults expressed the view of not wanting the ageing process to stop them from participating in activities.

4.3.2.4 Physical activity environment

Facilitators

Discussions on the availability of organisations, facilities, and community activities were widely discussed. On this topic, locality differences were noted, with some areas having more facilities and organisational set ups than other areas.

> *'A tremendous variety of activities and one of them is the walks we go on once a month but they have longer walks. They have eight mile walks, ten mile walks, fast walks, slow walks, they go to London and walk round in London. They have all sorts of activities' (FG7W)*

> *'The U3A has a very comprehensive um list of subjects…' (FG7W)*

'But I'm grateful for the U3A because there are so many different groups that you can do you know got cards and every sport, imaginable languages, we explore London concert groups, and you name it they do it…' (FG6W)

Availability of transport was widely spoken about and having access to a bus pass was discussed as it offered freedom and the ability to participate in pleasurable experiences. There were differences in the usage of bus passes, and while some appeared to be reliant on it, others appeared to rarely use it.

Having access to the right environment at home or near home was widely discussed as a motivator for PA, e.g., having access to a garden, big house, parks, and allotment.

'Participant: Just across the road from me is the [Name] park

Participant Yeah there's loads of walks about there

Participant I go 'round …

Participant There's no traffic down there' (FG5M)

'…I lead quite an active life. I um travel by train to London quite often. I garden, I do lots of work in my garden … I could do with a smaller garden at the moment but I have to keep it just so and I quite enjoy it. I find um you can just lose yourself in a garden' (FG7W)

Having a dog was spoken of as an important motivator to walk.

'…the dog insists on me taking it for a walk (noises of agreement). I'm not sure which one of us takes which but I (laughter) I had a, I had to have a new hip last 12 months ago and um neighbours sort of took him out whilst I wasn't able to, and they still do which means that 3 times a week I don't have to take it out (laughter). I think I have to when I get home, he'll probably be telling me it's time we went…' (FG11MW)

Good weather appeared to generally encourage the undertaking of PA.

Barriers

Cost and affordability of activities and transport was an issue for some people, and the lack of affordability could mean reduced participation in activities.

'Participant I mean the WEA that we, that my wife and I belong to I'm trying to think of the cost of the terms…

Participant Workers education association … and uh the trouble with it has become is, it is quite expensive because it doesn't have funding from any outside sources other than the fees they get from us users who all um our sort of age in general

Participant It's about 50 odd pounds per term

Participant Yes ours is a bit dearer about 60 something yes…

Participant But I mean that's a… that facility is there but I think it's also the cost for um perhaps us oldies if you like is… is the other thing that's now has to be considered' (FG11MW)

'Facilitator …How would it impact on your daily life do you think on the choices you're making to keep fit?

Participant Well you know you can do it

Facilitator But is there an impact of money? Do you weigh up the cost?

Participant I think if you… I think if you've not got the money to do things you tend to stay … some people I know anyway they tend to stay indoors which they lose that motivation to do things uh because they can't afford it and then it… it sort of they go down a slippery slope

Participant Yes down… down the spiral

Participant You know they it's a matter of sitting in the chair then. I know one or two people who actually you know they get up in the morning um and on goes the television and that's their day because they can't really afford to do anything else' (FG10M)

Some localities had greater availability of activities or facilities than others.

'Participant And Tai Chi but there's nothing around [place name]

Facilitator Oh so you haven't got many facilities

Participant No that's what I like I think that's good Tai Chi isn't it' (FG4W)

Some spoke about how the changing landscape has resulted in loss of green spaces or facilities.

'Well, that's getting less and less. Less open space than there was before, shrinking' (FG8M)

Availability of bus or transport appeared to vary, and some spoke about a lack of local transport, and not being able to drive could be a big restriction to some of the participants.

Moving to a new area was mentioned by a few people as a barrier to activity

> *'Well 5 years ago I moved from [place name] to [place name] so I'm not doing enough walking because it's I don't know I just don't feel I want to walk in those places where I don't know…' (FG6W)*

The discussions revealed varying knowledge with regards to availability of local facilities and activities e.g., some people had never heard of the U3A, University of the Third Age, and for others it was an important part of their lives. And this discussion in some of the groups led to some of the participants commenting on the need to 'got to look for it' and expressing the need to be motivated to seek out the available opportunities.

> *'I mean you know a lot an awful lot of people of our age group have never heard 'U3A what is that' you know and I would've thought they would've at least heard of it you know…' (FG9W)*

> *'Participant It's well supported you know I'm surprised that no one's heard of it, U3A*
>
> *Participant I never heard of it*
>
> *Participant Yeah all the activities you can think of you know and if you're up and coming you can, you could do it yourself' (FG10M)*

Some women spoke of a lack of advertisement or publicising of local availability of organisations and facilities. Women were more likely than men to speak of reduced opportunities suitable for older people.

4.3.2.5 Social Engagement

Facilitators

Participants spoke a great deal about their involvement in local/community groups or organisations (e.g. village committees, volunteering, U3A), and there was a distinction between the level of PA in the type of activity participated: some were more mentally stimulating than physically challenging. The social aspects of PA and lifestyle were highlighted as an important contributory factor.

> *'I think being able to get out and about is absolutely key isn't it (noises of agreement) if you're confined to your home for any reason, it's the beginning of the end' (FG9W)*

'Facilitator So the social side then is key, do you think for you remaining having a healthy lifestyle?

Participant Yes

Participant I think it makes you get out this is the thing' (FG1W)

There was quite a lot of discussion on comparison with peers with regards to their health status. This seemed to motivate healthier behaviour due to fear from examples of others and lots of expression of feeling fortunate or lucky compared to others as having comparatively good health.

'... So you see other people's lifestyles and you think to yourself "well they don't look quite as fit so I need to keep going"' (*FG3M)*

'I've got one or two friends with ... Alzheimer's disease and Parkinson's and it worries me ... that could be me one day ... and I think at some part of the back of your mind that uh you're trying to keep yourself in as good a shape as you can ...' (FG2M)

One man mentioned that hearing other men in the focus group's situations may prompt him to change his behaviour.

'I need to get me I need to get meself sorted out after listening (laughter) to these blokes here' (FG2M)

This illustrates the influence of social modelling, where the behaviours of the peers can affect one's behaviour.

The influence of family/peers/friends, including partner's health was an important topic of discussion.

'Well, you see even when the wife was ill she said 'still go out on that Wednesday' ...because she said you like doing it and that's it and I I've carried it on ever since' (FG2M)

'…My wife who died eighteen months ago, she had to walk because she had a problem with her leg circulation...so that encouraged me to walk as well. So, we did a lot of walking together' (FG5M)

'My husband comes with me as well, he's 90. He does exercise. He's better than me (laughs)' (FG7W)

There was discussion about the importance of having helpful or supportive neighbours or community, and also some discussions regarding disengaged or unsupportive neighbourhood/community. Women were more likely to mention these aspects than men.

> *'I've got two neighbours either side of me with young children both have had a baby and they're great (FG1W)*

For some women, friends are more important than family, as they did not want to be a burden to family. The role of family and friends appeared to be particularly important for those who had lost their partner/lived alone.

> *'I think the friends are very important...it's sometimes more important than family (noises of agreement) because you can't alter their lives. They've got their own lives to live' (FG7W)*

Barriers

Living alone can be a barrier to social interaction and PA. Some women felt the importance of activities that are single friendly, as some felt most activities available to them are couple orientated.

> *'…Within the area where you live if you knew there is another widow or a widower … then perhaps if you joined up together and went to meetings and things. I for instance have a friend who is fast approaching her 90th birthday and she's absolutely wonderful. She and I both lost our husbands in the same year and we were friends before then and now she will walk. She will do almost anything. She's beginning to get a little bit forgetful but um I don't think I would've done half the things that I did if she wasn't there for company (noises of agreement) and I think it is if you can get two or three people who are alone together to go along things rather than leaving them on their own' (FG7W)*

There was also substantial amount of discussion on the potential negative impact of a partner's health on activity e.g., due to time constraints and being in a carer role.

4.3.2.6 Psychological/personal factors

Facilitators

There was discussion across all groups that highlighted the importance of determination, discipline, positive thinking, motivation, independence, and self-efficacy. A notable strong desire not to be restricted, and to keep going was evident. Alongside the psychological aspect, this was strongly linked with an awareness of ageing, the fear of being unable to restart if they stopped

and the adaptation of pacing as an age-related modification to keep active as possible. Also, enjoyment of and being interested in PA were key facilitators in keeping active. The importance of being mentally stimulated and socially active were also recurring topics of discussion.

> *'When you stop doing something then you never take it up again, so you go to keep doing what you've been doing all your life' (FG8M)*
>
> *'I think our opportunities are quite good actually if you've got the motivation to go out and find them …' (FG1W)*
>
> *'Facilitator What actually motivates you to do exercise or to do any sort of physical activity? What is the motivation for you?*
>
> *Participant Well I took up bowls when I was 50. I still play a lot of bowls. I also am the grounds man for a bowls club where I'd work 3 days a week … I thoroughly enjoy it and it keeps me going' (FG11MW)*
>
> *'Facilitator So what motivates you to keep up that level of physical activity?*
>
> *Participant Partly because I enjoy and I got this belief that you know if I'm doing the marathons, I'll still be able to ride my motorbike, I'll still be able to fly my airplanes, I'll still be able to do all the things that I do. And if the minute I slow down and walk 'round Tescos with a trolley then I won't be able to do these things. That's why I keep doing it. I sort of have got the belief that if I did it today, I can do it tomorrow. So I try and do it every day' (FG8M)*
>
> *'Participant You've got to exercise and eat properly*
>
> *Participant It just depends whether you want to live (laughs)*
>
> *Participant Get out and about and talk to people*
>
> *Participant Yeah socialise*
>
> *Facilitator So the socialising bit is sort of integral to that kind of thinking about wellbeing and being healthy?*
>
> *Participant You've got to keep the brain fairly active' (FG4W)*

There was discussion about the importance of being able to take part in things therefore 'not feel old' and not wanting to be perceived as incapable purely due to their chronological age. This reflected the internal psychological driver of wanting to keep going, and determination of not

letting their chronological age of being a barrier. Alongside this feeling, some participants also commented on the importance of living near or interacting with people of all ages 'that keeps you young'.

> *Participant … For me a healthy lifestyle is being able to be alive to be able to go out and visit to take part in things still find able to enjoy new activities and items. Just generally not feel old actually (laughs) … people say oh you're doing very well for your age and I say well what am I supposed to be able to do at my age (laughs) oh you're doing very well and that annoys me…*
>
> *Participant I agree*
>
> *Participant Yeah*
>
> *Participant Yes*
>
> *Participant That annoys me you can't do that why can't I' (FG4W)*

There was widespread discussion regarding the belief of beneficial health effect in participating in PA which was often linked with the observed positive psychological mind sets.

Barriers

In terms of barriers in this theme, personal preferences could impede engagement with certain types of PA, for example dislike of group settings or organised activities. Although some also mentioned alternatives that they would prefer, and it could be important to take this into account in an intervention.

> *'…I'm not at all keen on this group thing I'd rather do things on my own with my wife and family…' (FG5M)*
>
> *'I go line dancing twice a week so that's my exercise I would never go to a gym (laughs) so I keep busy like that I belong to the U3A … I've got quite a wide circle of friends…' (FG9W)*

Amongst the men there was a discussion in one of the groups about level of education or feeling of inferiority that can also impact on choice of activities:

> *'No perhaps it's an educational thing really... you feel as if you're not sort of educated enough to join the group because some of the groups are quite you find lots of very professional ex-headmistresses and that you know what I mean I feel inferior' (FG3M)*

For some participants laziness was mentioned as a barrier to PA, and some acknowledged that they 'should' do more PA.

> *'… I still get on the bike and also the treadmill but not as long as I should do' (FG5M)*

As discussed previously for a lot of the participants the idea that age was irrelevant was important and the need to keep going to prevent future restrictions was important. However conversely for some there was the idea of ageing being the barrier to stop or restrict what they were able to do.

> *'…I enjoy doing not anything particularly strenuous or anything like that because I think as you get older you are restricted to a certain degree what you can do or achieve' (FG5M)*

There were some nuanced gender differences in this theme. For some women, not wanting to interfere with or be a burden on family was a motivator to keep fit, and depression was mentioned as an affecting factor to general life, and therefore resulting in lower rate of PA. Whereas these factors were not mentioned by the men in the focus groups.

Within this theme, there was a strong link with social engagement theme. For some participants their keen desire to continue to participate in activities was heavily influenced by the social elements of the PA or having a supportive network that encourage them to keep active.

Figure 9 is a pictorial representation of the results mentioned above. It shows psychological/personal factors, and social engagement are independent themes but can also mediate how a person respond or behave to an event or emotion therefore resulting in affecting the outcome of level of PA participated. The three themes in the light blue rectangular boxes are deemed as non-modifiable factors, and the three in the darker blue round edged rectangular boxes are classified as potentially modifiable factors.

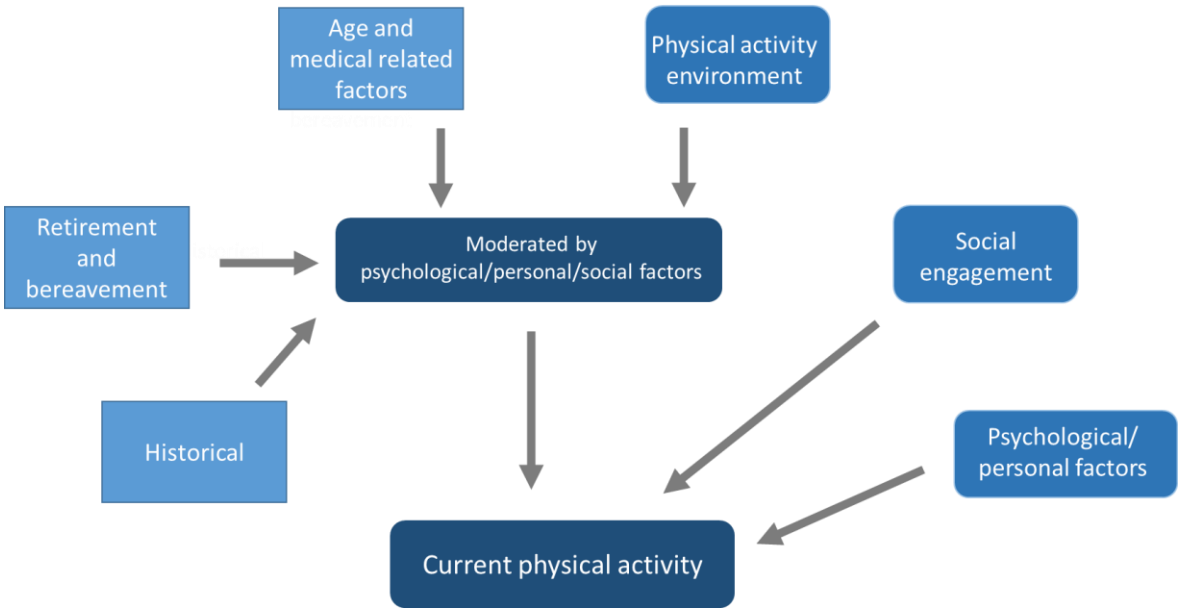


Figure 9 Inter-relationships between factors influencing PA in older adults

4.4 Discussion

We have shown six themes that may affect community dwelling older adults' participation in PA: historical influences; significant life events; getting older; PA environment; psychological/personal factors; and social engagement. There are strong psychological and social factors that influence older adults' level of PA in a community setting and some of the themes are strongly interlinked with each other. Psychological/personal factors and social engagement can also act as moderators in influencing the other four themes with regards to the outcome of PA participation level, as illustrated by Figure 9. Historical, retirement and bereavement, age and medical related factors are three themes that can be considered as non-modifiable. This is due to within these three categories the events have already happened or will occur (such as age-related decline), and therefore cannot be altered, or easily changed. The other three factors: PA environment, social engagement and psychological/personal factors can be seen as potentially modifiable. At a personal level, both social engagement and psychological/personal factors can be influenced and therefore changed. However, to change the PA environment at a personal level may not be possible due to cost implications to the individual; on a broader level, to improve the PA environment is likely to require input and investment from a range of stakeholders such as the local authority to facilitate meaningful changes.

The effect of how a participant psychologically approaches a significant change or event can strongly affect the outcome of PA participation, and this phenomenon has been observed in themes such as historical influences, retirement and bereavement and age and medical related

factors. In addition to the individual influences exerted by the independent six themes, it has also been noted enjoyment and social aspects of PA participation can be intrinsically linked with psychological factors such as determination and self-discipline. This is in line with previous studies that have shown LTPA to be significantly linked with self-efficacy (203), improved social, physical, emotional and cognitive function (208). Specifically, the role of positive thinking, and motivational internal thoughts have been extensively shown to be associated with older adults' LTPA (203-205). In a systematic review conducted by Notthoff and colleagues, they focused on 63 studies with older adults ≥60 years of age, and only included routine PA, and excluded studies involving intervention exercise programmes (205). They found motivation and self-efficacy were the two psychological characteristics that are consistently associated with higher level of PA (205). Similarly, previously published data from the same HCS focus group investigating the participants' perception on diet, where it was noted the role of psychological factors played an important part in food choices (153). This is suggestive of the fundamental nature of one's mind set, and the importance of one's mind set. Therefore, this can lead to a different outcome even in the same set of conditions.

PA is a broad term as discussed in Chapter 1 and the literature on older adults' perspective on PA have focussed on structured exercise programmes (209), interventions with a focus on falls prevention (210-212), other forms of PA (e.g.: LTPA, high impact PA) (75), and a combination of these sub-groups. Whilst there will be similarities drawn between the structured and non-structured PA and their influences, there will also be distinct differences. For instance, from a social and ecological perspective, relationships between positive influences of social environments and older adults' LTPA have been established in studies (88, 213). In our study, we found the accessibility and the availability of local environment such as organisations, hobbies, transport availability and parks were important influencers on whether an older adult is likely to participate in PA. Similarly, to our findings Franco and colleagues found in their systematic review environmental barriers were more important in the context of non-structured PA than structured exercise programme interventions (87). Older adults' leisure-time walking has been shown to be strongly influenced by walkability (which is composite index of residential density, street connectivity, and land-use mix), and aesthetically pleasing scenery (88). Also older adults are more likely to participate in LTPA if there are higher levels of perceived neighbourhood social cohesion (213), and this is strongly echoed in our focus groups. Participants in our focus groups have commented on the availability of walkable areas, green spaces, and noise from traffic as deciding factors on whether they are likely to go for walks. In a study carried out in Christchurch, New Zealand, those living in a more socioeconomic deprived neighbourhood felt their surrounding environment was "unattractive and not conducive to LTPA participation" in contrast

to those living in a higher socioeconomical neighbourhood who felt their area was “was well served with amenities for LTPA, attractive and walkable, and inhabited by socially responsible residents” (214). This clear comparison illustrates how impactful the surrounding environment can be on the likelihood of utilising local PA opportunities. Similarly, in a UK study that focussed on two areas of high deprivation in Glasgow showed run down areas, and a lack of local provision were not conducive to PA participation in this area (215).

However, for structured PA, influencing factors will differ from above and commonly cited factors affecting participation rate in our study included group size, cost of the activity, and social element to the activity. A systematic review by Franco and colleagues divided PA into structured exercise programmes and other types of PA which included LTPA, household activities, and other active activities. They showed factors involving “dependence on professional instructions, pain or discomfort, affordability and self-confidence” were more relevant to structured exercise programmes. For other forms of PA, factors such as environmental barriers and maintaining habits were more influential (87). In our study, similar findings were also observed on occasions when the participants expressed factors affecting their PA participation.

The presences of physical limitations or health related conditions have been noted to be intrinsically linked with older adults’ perception of being able to be physically active. Interestingly in our study we found polarising views on this matter. Some expressed not wanting to let health conditions be an impediment to their ability to participate in PA, therefore paying particular efforts in overcoming potential obstacles. On the other hand, some participants cited their health issues as being the barrier to keep themselves as active as previously. Halvarsson and colleagues interviewed older women (aged ≥65 years) after participating in a balance training programme (216). These women were diagnosed with osteoporosis and had either self-perceived fear of falling or experienced a fall within the past 12 months. The aim of the programme was to improve self-efficacy, balance and physical function (217). The participants found the programme improved their self-perceived empowerment and self-efficacy, increased confidence in their ability to approach ADLs, and employed risk reducing strategies to avoid falls. However, they found the underlying “internalised risk perception” related to their previous falls’ experience continued to influence their self-perceived high risk of falls despite the newly gained confidence and strategies in reducing falls (216). This will likely continue to impact on this group of women’s health outcome. Alongside our findings, this highlights the differences in psychological mind sets of the population, and on the topic of health issues: some will perceive it as a barrier to overcome, whereas in some population it becomes the barrier.

Gender differences have been observed in motivational factors in PA in older adults in previous literature and there are a few clear gender differences noted within our focus groups. The men in the groups would often talk about what they did after retirement, and it was clear retirement was a big milestone in a lot of the men's lives whereas the women in the groups did not mention retirement. This could reflect the traditional gender role profile of the older generation, where predominantly the man of the household would have gone out to work and the woman stayed at home. Along the same vein, some men have commented due to work or raising a young family they have had to previously stop or reduce their PA participation. Again, the women in the groups did not comment on this, therefore it is hard to draw a firm conclusion on whether having to work or raising a young family were influencing factors for the women as well.

We also noted a different reaction to bereavement between men and women; men have commented about the need to take on unfamiliar activities after the loss of their partners, for instance cooking and cleaning. However, the women felt the need for a strong support network was vital, otherwise they experienced isolation and depression more acutely after losing their partners. Women in the focus groups were more likely to mention the importance of supportive neighbours or community or friends than men in helping them to keep active.

In the literature, women of any age have been found to be more likely to be motivated by weight loss and improving appearance for PA participation (96, 98) and it has been noted men are more likely to participate in MVPA than women, but women were more likely to initiate indoor exercise than men (89). Both men and women have cited health benefits and wellbeing as key influencing factors for keeping active (78, 96). In a large Malaysian study of 1,360 Malaysian volunteers (703 males, 657 females), the researchers compared the motivations for PA participation for men and women and as well as different age groups using the 40-item Physical Activity and Leisure Motivation Scale (PALMS) which was designed to measure adult PA motivation (99). It was noted higher motivation for appearance and physical condition were reported by women more than men, whereas the main driver for men were being motivated by competition/ego and mastery. This study participants were split into two age groups: 20 to 40years (n = 763; M = 29.12; SD = 3.9) and those aged 41 to 64 years (n = 597; M = 54.21; SD = 4.32). There were notable differences in motivation between these two age groups, the younger group had a stronger affiliation with mastery and enjoyment as the motivator whereas for the older age group it was psychological condition and other's expectations as the motivators for PA participation. However, this study did not investigate if there were gender differences within each of the age groups, as there may be differences in what would motivate a man/woman in his/her thirties compared to a man/woman in his/her sixties. It is also important to highlight all the volunteers in this study participated in regular PA in the 6 months prior to the study, which was defined as at least 150 minutes of MVPA

per week. This type of sampling would self-select in those that were already motivated in PA participation therefore may not represent points of view of those who are less active. By contrast our focus groups had community-dwelling older adults that were selected because they lived in Hertfordshire rather than on their activity levels. Thus, they were more likely to have a wider range of PA levels within the participants which is likely to give us a wider representation of the facilitators and barriers to PA participation.

Finally Van Uffelen and colleagues looked into the motivators and preferences of PA participants in 1845 Australian older adults in their sixties (96). The participants were asked via questionnaires to rate their agreement/disagreement with seven motivating factors and 14 PA context preferences on a five-point Likert scale. Both men and women selected health issue prevention, feel good and weight loss as motivating factors. However, for women they were more likely to be motivated by appearance, meeting friends or weight loss to participate in PA than men. It was also noted women were less likely to participate in competitive or vigorous or outdoor PA than men.

4.4.1 Strengths and Limitations

The use of focus groups as the method for qualitative data collection has both positive and negative aspects (218). Given the general nature of the research question, the approach of using focus groups allows a broad range of perspectives and in-depth information to be collected from the participants. This method allows the participants to freely express their points of view in a group setting, and therefore avoid any potential loss of unknown data that may occur with traditional quantitative methods such as survey or questionnaires. The dynamic of focus groups allows for interactions between the participants that may organically result in findings that may not be apparent in other settings such as a one-on- one interview. Also by following a semi-structured discussion guide this would keep the topic of discussion on track.

On the converse side, in a group setting if the topic of discussion is of a sensitive nature, it may impede some participants on voicing their true points of view. In addition, it is reasonable to acknowledge that group dynamics, conformity and feeling of censorship may negatively impact on data collection in a focus group setting. Whilst the researchers who were present in the study's focus groups did not note down any obvious negative feelings or environment, it is not impossible to consider some of the participants may not have felt at ease to completely express their viewpoints.

In this study we recruited from an existing cohort study, HCS, who were recruited to another purpose (see section 2.1 for details). Therefore, it is possible that we have a good range of PA

participation levels, and a varied degree of health statuses within the participants thus, giving us a good range of points of views to be observed. One of the limitations of this study is the age range, IQR 72.8 - 77.6, which was pre-determined by the age range availability in the HCS. Thus it does not incorporate the full age range that is often included in the older adults' category (i.e.: ≥65 years). The focus group participants had healthier diets, were slightly younger and were marginally faster with the 6m timed up and go test compared to the rest of the HCS cohort. Another limitation is only white British older adults participated in the focus group, and there may be additional factors that would be unique to other ethnic groups that we will not have gleaned from this study. However, one of the strengths of this study is the inclusivity of a wide range of social-economical background of older adults within the cohort study.

The analysis of the data was done at the group level therefore some views maybe given weight to inaccurately. However, the analysis was done independently by two researchers through a rigorous process of double coding, thus reducing the probability of skewed views being presented. The majority of the focus groups were facilitated by 2 researchers however one group had one researcher present. Throughout the study process, a multidisciplinary team approach was utilised, therefore minimising the probability of misrepresentation although I do acknowledge this study only presents one view, and other interpretations are possible.

4.4.2 Conclusion

From our focus groups of community dwelling older adults, we conclude factors influencing PA can be wide ranging and contradictory at times, however there are common themes that have been noted. Consistently the presences of psychological/personal factors, and social engagement have been observed to be both independent influencing factors and moderators for other independent factors affecting PA levels. The influential reach of psychological mind set can be utilised to aid future interventions in keeping older adults active. By moving away from the traditional set up of using exercise programmes which can be rigid and may not trigger their interest nor enjoyment, clinicians might instead use encouragement and explore older adults' own interests and concerns to keep older adults as active as possible.

Chapter 5 Hertfordshire Cohort Study Nutrition and Physical Activity Study (NAPA Study)

5.1 Background

The importance of PA has been discussed in depth in Chapter 1. In this thesis I have already explored the benefits of participating in WBPA across the lifecourse, and the possible factors that may influence older adults' likelihood of remaining active. One of the strong themes noted from the focus group study was the impact of psychological mind set on various aspects of life such as the response to a significant life event. This leads to this chapter, which explores the utilisation of a participant led behavioural intervention in a group of community dwelling older adults with the aim of encouraging healthy lifestyle choices including keeping active and eating healthily.

As discussed previously, Healthy Conversation Skills was developed by a multidisciplinary team of psychologists and public health practitioners. In recent years it has been adopted by Health Education England (Wessex) as the mode of delivering on the "Making Every Contact Count" agenda established by the UK government. Healthy Conversation Skills is a patient-centred approach to empowering individuals to take their first steps to change (219). Through the use of open-ended questions known as open discovery questions, the facilitator can explore if the participant has particular areas they want to change. The driving force comes from the participant themself, and by using Healthy Conversation Skills, the participant is guided towards finding a solution for themself to the issue identified.

In this pilot study, Healthy Conversation Skills was trialled as an intervention to improve PA in older community dwelling adults, those aged 79 and over. This work is novel as it is the first trial of Healthy Conversation Skills in an older adult cohort and uses a telephone-based intervention.

5.2 Methods

Detailed description of the methodology can be found in 2.5. In brief, 178 participants from the HCS were recruited to the NAPA study. The participants were randomised into either control group (n=89) or the intervention group (n=87). The baseline data collection commenced in mid-November 2019 and finished by late March 2020, and the 1-year follow up occurred between November 2020- June 2021. Questionnaire data including lifestyle factors, medical history, diet, and PA were collected at both time points. At baseline the data were collected at home visits, therefore it also included objective measurements of height, weight, gait speed, chair rise tests,

and grip strength. A sub-group of the participants at baseline also wore an accelerometer, GeneActiv, for a 7-day period. Figure 10 shows the recruitment flow of the study as well as the number of participants that dropped out at different time points (including their reasons). The 1-year follow up procedure was changed due to the ongoing COVID-19 pandemic restrictions; therefore, questionnaires were posted out, and objective measurements such as height, weight, grip strength, gait speed, walking speed, chair rises and accelerometery could not be repeated. In total at the 1-year follow up n=155 questionnaires were received back.

5.2.1 Data Analysis

Descriptive statistics were used to quantify participant characteristics. To determine the distribution of each variable, the histogram command was used to view the shape of the distribution. Variables that were parametric in nature such as height, weight and BMI were expressed as mean (SD) and those that are non-parametric for instance age, alcohol consumption and SPPB score are expressed using median (IQR). Statistical significances were explored in some of the baseline characteristics. T-test and Man-Whitney U test were used for parametric and non-parametric variables. Where variables were reported as categories or percentages, Chi-square or Fisher tests were used instead.

5.2.1.1 Delta change analysis

For the 1-year change analysis, the duration from baseline to follow-up differed between participants and this ranged from 0.97 to 1.56 years. Therefore, annualisation of the changes between the baseline and follow up scores was performed to allow for comparison to be made between the participants. Annualisation of the changes was employed for the following trial outcomes: shortened LAPAQ, prudent diet, Townsend disability, SF-36 physical function, general self-efficacy, and LSNS-6. Distribution of these outcomes were determined through the visualisation of histograms, and normal distribution was observed for all outcomes.

Firstly, to analyse the differences between the control and intervention groups, a pooled sample of men and women within each of the group (i.e., control versus intervention) was examined using linear regression with adjustment for gender. Another analysis examining the differences between each gender within the two groups (i.e.: control men versus intervention men) using linear regression was also performed and examined using gender-specific t-tests. The analyses for the 1-year change were based on the sample of 155 participants who completed both the baseline and follow-up stages of the NAPA Study.

All above statistical analyses were performed using the Stata statistical software package, version 17 (Statacorp, Texas, USA); $p < 0.05$ was regarded as statistically significant.

5.2.1.2 Missing Data

For a number of the questionnaires returned, the LAPAQ section was not fully completed, hence the small n values noted in Table 14. One approach we considered was imputing missing entries for the entire domain with zeros however this made very little difference to the overall number of missing values. A review of the literature suggested there were a few different approaches taken by other study groups to address missing data in the context of using LAPAQ. One approach was only counting the number of activities/domains in which participants were active rather than the duration of the activity (220). This method would not be appropriate for the NAPA study as we were looking at changes between the amount of time being physically active at baseline and 1-year follow up. Another approach taken was the utilisation of a shorter version of LAPAQ where only 3 domains were included: walking, cycling and sporting. In this study the authors performed factor analysis which showed household activities did not correlated with other activities (analysis not shown in paper), furthermore the gardening section was also excluded as the correlation between self-reported PA and accelerometery data had improved without the inclusion of gardening (119). This method was tried with the NAPA study data, and it did improve the number of participants included in the analysis marginally. However, the correlation between this shortened LAPAQ and the full LAPAQ was approximately 0.5.

5.2.1.3 Processing of Accelerometery Data

Accelerometery data were processed in R (http://www.cran.r-project.org) using R-package GGIR, version 1.11-0. Previously validated algorithms by van Hees and colleagues were used to detect sleep (221), estimate and correct for calibration error (222); and impute any non-wear time with that participant's person specific average acceleration at similar times on other days of measurement.

Data from waking to waking and from midnight to midnight were extracted in bouts of at least one minute and estimated over 5-second aggregated time series (epochs) from the accelerometer, and data were stored using milligravity units (1 mg = 0.00981 m/s^2). As in a previous publication (223), PA was categorised accordingly: sedentary (<30 mg); light PA (≥30 mg and <100 mg); and MVPA (≥100 mg). Bouts were categorised as light PA or MVPA if the PA was within the specified ranges at least 80% of the time. PA data from participants with at least three days of valid data (daily wear time ≥2/3 of waking-to-waking and midnight-to-midnight defined

days) were retained for analysis. Daily time in each activity category was calculated as the mean of the measures over the number of days with valid data.

Pearson correlation between self-reported PA (from LAPAQ) and objective PA measure (from the accelerometers) was examined and calculations performed used the Stata statistical software package, version 17 (Statacorp, Texas, USA).

5.3 Results

Table 9, Table 10 and Table 11 show a summary of the baseline characteristics of all the participants (n=176) recruited at the baseline of the NAPA study. The median (IQR) ages for women in the control and intervention groups were 83.2 (81.9-85.4) and 84.2 (81.2-86.9) respectively, and for men were 83.6 (81.8-86.0) and 82.7 (81.3-84.8). The mean (SD) BMI for women in the control and intervention groups were 26.3 (4.5) and 27.3 (4.6) respectively, and for men were 27.9 (3.7) and 26.8 (3.0). Between the control and intervention groups of men the proportions of smokers (2.1% and 2.2% respectively), never smokers (52.1% and 56.5% respectively) and ex-smokers (45.8% and 41.3% respectively) were similar. By contrast for the women, the percentage of current smokers in the intervention women group was higher compared with the control group (4.9% versus 0%).

A higher percentage of men did not live alone compared with women in both intervention and control groups. Although the proportion of women in the control group living alone was higher than the intervention women group (51.2%, 39%), this was not statistically significant. The median score for SPPB test was lowest for intervention group women, 7.0 (6.0-9.0), compared to the other three groups, however, this difference was not statistically significant. The median scores for SF-36 Physical Functioning and Fried Frailty score were also lowest for the intervention group women compared to the other three groups; however, these differences did not reach significance.

Baseline characteristic	Mean (SD); median (lower quartile, upper quartile); or N(%)					
	Control			Intervention		
	All (n=89)	Men (n=48)	Women (n=41)	All (n=87)	Men (n=46)	Women (n=41)
Age (years)	83.4 (81.9-85.6)	83.6 (81.8-86.0)	83.2 (81.9-85.4)	83.1 (81.3-86.0)	82.7 (81.3-84.8)	84.2 (81.2-86.9)
Height (cm)	164.9 (9.1)	171.3 (5.6)	157.3 (6.0)	164.8 (9.5)	171.0 (6.7)	157.6 (6.7)
Weight (kg)	74.0 (14.4)	81.6 (10.7)	65.2 (13.1)	73.6 (12.4)	78.9 (10.7)	68.0 (11.7)
BMI (kg/m^2)	27.1 (4.1)	27.9 (3.7)	26.3 (4.5)	27.0 (3.8)	26.8 (3.0)	27.3 (4.6)
Smoking status						
Never	52 (59.1%)	25 (52.1%)	27 (67.5%)	56 (64.4%)	26 (56.5%)	30 (73.2%)
Ex	35 (39.8%)	22 (45.8%)	13 (32.5%)	28 (32.2%)	19 (41.3%)	9 (22.0%)
Current	1 (1.1%)	1 (2.1%)	0 (0.0%)	3 (3.4%)	1 (2.2%)	2 (4.9%)
Living Status						
Alone	32 (36.0%)	11 (22.9%)	21 (51.2%)	28 (32.2%)	12 (26.1%)	16 (39.0%)
Not alone	56 (62.9%)	37 (77.1%)	19 (46.3%)	57 (65.5%)	33 (71.7%)	24 (58.5%)
Others	1 (1.1%)	0 (0.0%)	1 (2.4%)	2 (2.3%)	1 (2.2%)	1 (2.4%)
Alcohol consumption (units per week)	1.5 (0.0-6.6)	1.6 (0.1-8.1)	0.8 (0.0-4.1)	2.6 (0.2-8.4)	4.4 (0.6-8.6)	1.1 (0.0-6.6)
LAPAQ physical activity (min/day) [a]	137.1 (70.0-180.0)	98.9 (60.0-150.0)	152.1 (116.1-220.5)	117.9 (77.1-171.8)	101.1 (65.7-142.9)	137.1 (84.3-180.0)
Prudent diet score	-0.1 (1.5)	-0.5 (1.3)	0.4 (1.7)	-0.0 (1.4)	-0.2 (1.4)	0.2 (1.3)
[a] LAPAQ: Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire						

Table 9 Baseline characteristics of all participants recruited at baseline of NAPA study- Part 1

Baseline characteristic	Mean (SD); median (lower quartile, upper quartile); or N(%)					
	Control			Intervention		
	All (n=89)	Men (n=48)	Women (n=41)	All (n=87)	Men (n=46)	Women (n=41)
SPPB score [a]	9.0 (6.0-10.0)	8.0 (7.0-11.0)	9.0 (6.0-10.0)	8.0 (6.0-10.0)	9.0 (6.0-11.0)	7.0 (6.0-9.0)
SF-36 Physical Function score[b]	80.0 (50.0-90.0)	75.0 (50.0-90.0)	80.0 (50.0-90.0)	75.0 (50.0-95.0)	85.0 (60.0-95.0)	60.0 (45.0-85.0)
Fried frailty Score	1.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	2.0 (1.0-2.0)
General self-efficacy	15.0 (14.0-15.5)	15.0 (14.0-16.0)	15.0 (14.0-15.0)	15.0 (14.0-15.0)	15.0 (14.0-15.0)	15.0 (14.0-15.0)
Townsend's disability score						
No disability	9 (10.2%)	6 (12.5%)	3 (7.5%)	13 (15.1%)	10 (22.2%)	3 (7.3%)
Mild disability	15 (17.0%)	6 (12.5%)	9 (22.5%)	17 (19.8%)	11 (24.4%)	6 (14.6%)
Some disability	43 (48.9%)	24 (50.0%)	19 (47.5%)	35 (40.7%)	18 (40.0%)	17 (41.5%)
Appreciable disability	15 (17.0%)	8 (16.7%)	7 (17.5%)	16 (18.6%)	3 (6.7%)	13 (31.7%)
Severe disability	6 (6.8%)	4 (8.3%)	2 (5.0%)	5 (5.8%)	3 (6.7%)	2 (4.9%)
LSNS-6 score [c]	17.2 (6.0)	17.0 (6.0)	17.5 (6.2)	17.3 (5.6)	17.7 (5.8)	17.0 (5.3)
[a] SPPB: Short Physical Performance Battery						
[b] SF-36 Physical Function score: Short Form 36 Health Survey Questionnaire						
[c] LSNS-6: Lubben Social Network Scale						

Table 10 Baseline characteristics of all participants recruited at baseline of NAPA study- Part 2

Baseline characteristic	**Mean (SD); median (lower quartile, upper quartile); or N(%)**					
	Control			**Intervention**		
	All (n=89)	**Men (n=48)**	**Women (n=41)**	**All (n=87)**	**Men (n=46)**	**Women (n=41)**
Number of comorbidities						
0	12 (13.5%)	6 (12.5%)	6 (14.6%)	5 (5.7%)	3 (6.5%)	2 (4.9%)
1	33 (37.1%)	17 (35.4%)	16 (39.0%)	18 (20.7%)	7 (15.2%)	11 (26.8%)
2	24 (27.0%)	16 (33.3%)	8 (19.5%)	38 (43.7%)	25 (54.3%)	13 (31.7%)
3 or more	20 (22.4%)	9 (18.8)	11 (26.8%)	26 (29.8)	11 (23.9%)	15 (36.6)
Number of medications taken						
0-4	46 (51.7%)	22 (45.8%)	24 (59%)	34 (38.9%)	19 (41.3%)	15 (36.6%)
5-10	38 (42.7%)	22 (45.8%)	16 (39%)	46 (52.8%)	21 (45.7%)	25 (61.0%)
11-15	5 (5.6%)	4 (8.3%)	1 (2%)	5 (5.7%)	4 (8.7%)	1 (2.4%)
16-20	0 (0%)	0 (0%)	0 (0%)	2 (2.2%)	2 (4.3%)	0 (0%)

Table 11 Baseline characteristics of all participants recruited at baseline of NAPA study- Part 3

The mean max grip strength (kg) for men was 33.2 (7.1), and for women it was 20.0 (5.7). The mean gait speed (m/s) for men was 0.6 (0.2), and 0.6 (0.2) for women. Table 12 shows the mean values for max grip strength and gait speed, and the percentage of those that are classified as low grip strength (<27kg men, <16kg women) or low gait speed (<=0.8 m/s) for the control and interventional groups, then also sub-divided into men and women within each of these groups. The mean and percentage values between the control and intervention groups in men and women were largely similar however for low grip strength and low gait speed there were some differences between the control and intervention women. Thus, a chi-square test was performed, but the observed differences did not reach statistical significance.

Baseline objectively measured characteristic	Mean (SD); median (lower quartile, upper quartile); or N(%)						P-value*
	Control			Intervention			
	All (n=89)	Men (n=48)	Women (41)	All (n=87)	Men (n=46)	Women (n=41)	
Maximum grip strength (kg)	27.2 (9.2)	33.4 (6.5)	20.1 (6.2)	26.7 (9.3)	33.0 (7.6)	19.9 (5.2)	
Gait speed (m/s)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)	0.6 (0.2)	0.7 (0.2)	0.6 (0.2)	
Low grip (<27kg men, <16kg women)	11 (13.4%)	3 (6.8%)	8 (21.1%)	15 (18.1%)	10 (23.3%)	5 (12.5%)	0.372
Low gait speed (<=0.8 m/s)	70 (84.3%)	36 (81.8%)	34 (87.2%)	71 (85.5%)	35 (81.4%)	36 (90.0%)	0.737
*P value compares statistical significance between the control and intervention women groups							

Table 12 Objectively measured physical outcomes at baseline NAPA study.

5.3.1 Accelerometery Data

At baseline we gave 109 participants an accelerometer to wear and received 107 recordings back. In total we had 97 useable recordings which consisted of 57 from men and 40 from women.

The median (lower quartile, upper quartile) self-reported PA levels (mins/day) were 98.6 (60.0, 139.3) for men, and 153.2 (124.2, 228.4) for women and the median for objectively measured PA was 25.5 (19.2, 28.4) mg for men and 27.1 (21.9, 32.2) mg for women (224). The Pearson correlations between these PA measures were 0.53 ($p<0.001$) among men and 0.46 ($p=0.003$) among women (224).

5.3.2 One Year Follow Up – study completion and participant characteristics

At one-year follow up in total 155 participants completed a follow up postal questionnaire. Figure 10 presents the timing and reasons for participant drop-out. In total there were 21 participants that dropped out. At baseline there were 87 participants in the intervention group, and in total 4 participants did not complete the intervention. Of these 2 dropped out of the study due to health issues, 1 moved out of the area, and 1 passed away. One of the criteria to be in this study is for the participant to remain living in Hertfordshire.

Table 13 shows a summary of the 155 participants that took part fully in the study. The characteristics of these 155 participants are similar to the baseline characteristics of the original 176 participants initially recruited. Further statistical tests were performed to assess whether any differences were statistically significant. There was a statistically significant difference in the

number of comorbidities in the control and intervention group (men and women combined). Both Townsend's disability score and SF-36 Physical Functioning were statistically significantly different ($p < 0.05$) between control and intervention groups among men.

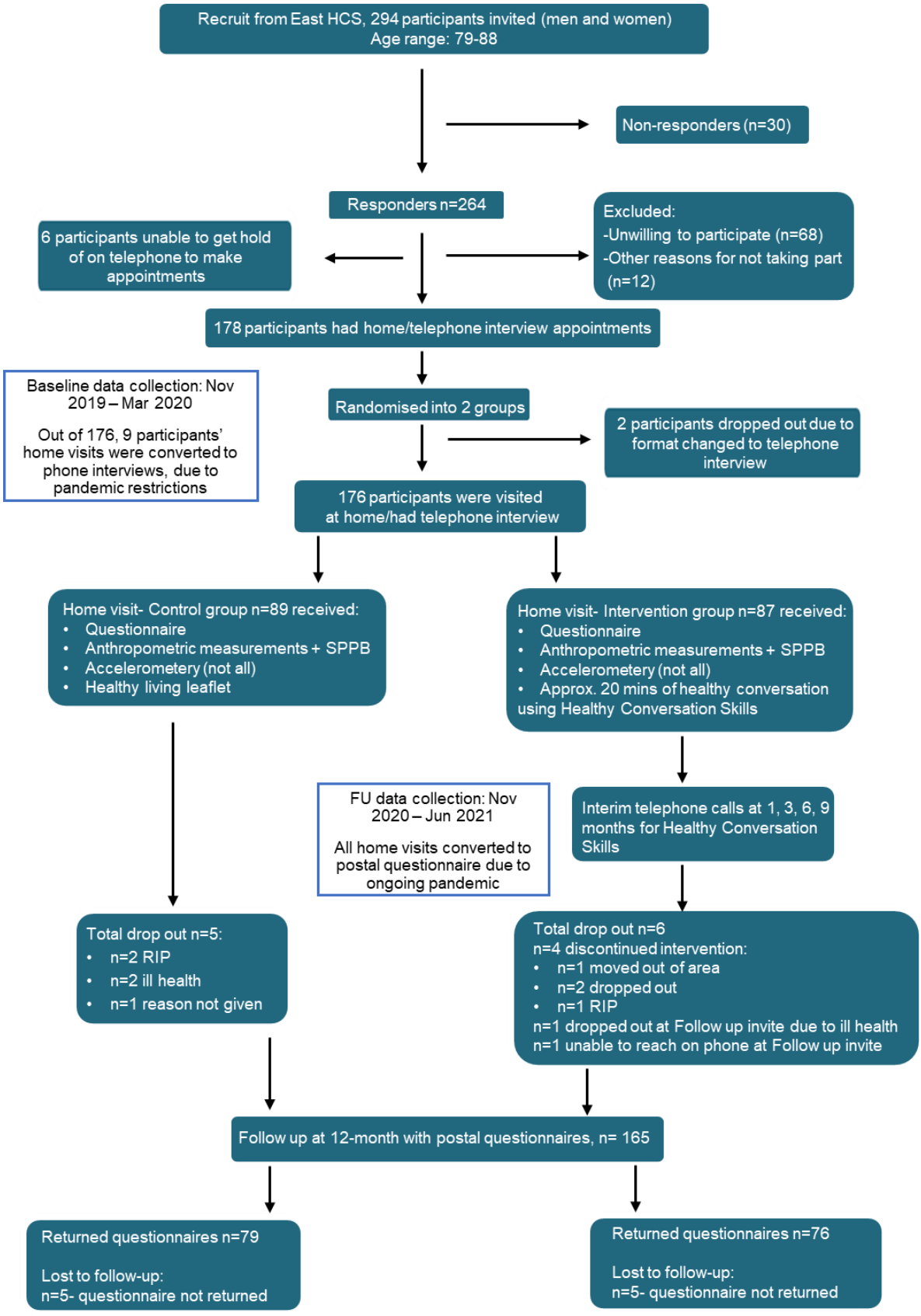


Figure 10 Nutrition and Physical Activity Study flow chart- baseline and follow up

Characteristic	Mean (SD); Median (lower quartile, upper quartile); N(%)					
	Control			Intervention		
	All (n= 79)	Men (n=43)	Women (n=36)	All (n=76)	Men (n=39)	Women (n=37
Age (years)	83.4 (81.7, 86.0)	83.6 (81.7, 86.3)	83.3 (81.7, 85.5)	82.8 (81.3, 85.0)	82.3 (81.3, 84.7)	84.2 (81.2, 86.
Height (cm)	164.8 (8.8)	171.0 (5.0)	157.3 (6.1)	164.7 (9.7)	171.6 (6.5)	157.2 (6.4)
Weight (kg)	74.3 (14.3)	81.8 (10.3)	65.4 (13.3)	73.8 (12.7)	80.0 (10.3)	67.6 (11.9)
BMI (kg/m^2)	27.3 (4.2)	28.0 (3.7)	26.3 (4.7)	27.1 (3.9)	26.9 (3.0)	27.2 (4.6)
Ever smoked	32 (41.0%)	21 (48.8%)	11 (31.4%)	25 (32.9%)	15 (38.5%)	10 (27.0%)
Alcohol (units per week)	1.6 (0.0, 6.6)	1.7 (0.1, 9.1)	0.8 (0.0, 5.5)	3.3 (0.2, 8.4)	4.5 (0.6, 8.6)	1.8 (0.0, 7.0)
Social class (manual)	45 (58.4%)	24 (58.5%)	21 (58.3%)	38 (52.8%)	20 (57.1%)	18 (48.6%)
Live alone	26 (32.9%)	8 (18.6%)	18 (50.0%)	25 (32.9%)	12 (30.8%)	13 (35.1%)
Grip strength (kg)	27.6 (8.7)	33.4 (6.6)	21.0 (5.4)	27.0 (9.7)	34.1 (7.5)	19.9 (5.4)
Gait speed (m/s)	0.61 (0.18)	0.62 (0.18)	0.61 (0.17)	0.65 (0.19)	0.70 (0.19)	0.60 (0.18)
EuroQoL anxiety/depression	18 (23.1%)	9 (21.4%)	9 (25.0%)	19 (25.0%)	8 (20.5%)	11 (29.7%)
Number of medications	4.0 (2.0, 7.0)	5.0 (2.0, 8.0)	4.0 (2.5, 6.0)	5.0 (3.0, 7.0)	5.0 (3.0, 7.0)	5.0 (4.0, 7.0)
Number of comorbidities[a]	2.0 (1.0, 2.0)	2.0 (1.0, 2.0)	1.5 (1.0, 3.0)	2.0 (1.5, 3.0)	2.0 (2.0, 3.0)	2.0 (1.0, 3.0)
LAPAQ score	133.6 (66.4, 188.6)	104.3 (60.0, 150.0)	152.1 (107.5, 228.4)	123.2 (79.6, 181.1)	111.4 (73.6, 171.8)	152.1 (96.8, 187.1)
Shortened LAPAQ score	30.0 (15.0, 60.0)	30.0 (10.0, 60.0)	32.1 (18.6, 70.0)	30.0 (14.6, 60.0)	30.0 (15.0, 60.0)	30.0 (14.3, 60.
Prudent diet score	0.0 (1.6)	-0.4 (1.3)	0.5 (1.7)	0.1 (1.3)	0.0 (1.3)	0.2 (1.3)
Townsend disability score[b]	4.0 (2.0, 6.0)	4.0 (3.0, 7.0)	4.0 (2.0, 6.0)	3.0 (1.0, 6.0)	2.0 (0.0, 4.0)	5.0 (3.0, 7.0)
SF-36 physical function score[b]	80.0 (50.0, 90.0)	70.0 (50.0, 90.0)	80.0 (50.0, 90.0)	75.0 (57.5, 95.0)	90.0 (70.0, 95.0)	65.0 (50.0, 85.
General self-efficacy score	15.0 (14.0, 16.0)	15.0 (14.0, 16.0)	15.0 (14.0, 16.0)	15.0 (14.0, 15.0)	15.0 (14.0, 15.0)	15.0 (14.0, 15.
LSNS-6 score	17.4 (5.9)	17.3 (6.1)	17.6 (5.7)	17.0 (5.4)	16.9 (5.4)	17.1 (5.5)
LAPAQ: Longitudinal Aging Study Amsterdam Physical Activity Questionnaire; shortened version only included walking cycling and sports domains						
EuroQoL anxiety/depression: moderate or extremely anxious/depressed; SF-36: Short Form 36 Health Survey Questionnaire: LSNS-6: Lubben Social Network Scale; SD: Standard deviation						
[a] Statistically significant difference ($p < 0.05$) between control and intervention groups among the combined sample o men and women						
[b] Statistically significant difference ($p < 0.05$) between control and intervention groups among men						
[c] Statistically significant difference ($p < 0.05$) between control and intervention groups among women						

Table 13 Characteristics of 155 participants that fully participated in the study.

5.3.2.1 Physical activity outcome

Measure	Men		Women		Gender-adjusted difference (95% CI) in annual change between control and intervention
	Control	Intervention	Control	Intervention	
Original LAPAQ	**(n=26)**	**(n=28)**	**(n=20)**	**(n=19)**	*-36.0 (-82.5,10.6), p=0.13*
Baseline	117.6 (87.4)	131.8 (90.0)	157.3 (84.3)	166.3 (85.4)	
Follow-up	143.4 (156.6)	147.1 (91.8)	211.9 (137.4)	150.0 (85.3)	
Annual change (+ve: improvement)	26.2 (112.8)	14.9 (115.5)	52.1 (123.6)	-18.0 (94.1)	
Imputed LAPAQ (all missing for an activity treated as no activity)	**(n=29)**	**(n=30)**	**(n=22)**	**(n=21)**	*-19.8 (-67.1,27.5), p=0.41*
Baseline	126.6 (104.4)	127.8 (88.8)	159.8 (80.7)	173.7 (88.4)	
Follow-up	136.9 (149.4)	143.9 (93.1)	205.7 (132.8)	166.7 (113.5)	
Annual change (+ve: improvement)	12.5 (123.1)	15.8 (112.5)	43.8 (120.9)	-7.7 (126.0)	
Shortened LAPAQ (walking, cycling, sports)	**(n=33)**	**(n=36)**	**(n=27)**	**(n=27)**	*3.4 (-15.4,22.1), p=0.72*
Baseline	41.3 (45.4)	50.0 (62.8)	40.9 (34.1)	32.4 (27.8)	
Follow-up	32.7 (49.2)	49.6 (54.1)	30.0 (42.1)	21.2 (24.8)	
Annual change (+ve: improvement)	-6.6 (46.5)	0.1 (71.9)	-9.8 (47.1)	-10.8 (28.5)	
Imputed shortened LAPAQ (walking, cycling, sports)(all missings for an activity treated as no activity)	**(n=35)**	**(n=36)**	**(n=30)**	**(n=30)**	*3.7 (-14.2,21.6), p=0.68*
Baseline	41.0 (44.6)	50.0 (62.8)	44.3 (34.3)	34.0 (27.5)	
Follow-up	30.9 (48.4)	49.6 (54.1)	30.6 (43.2)	19.6 (24.1)	
Annual change (+ve: improvement)	-8.2 (46.1)	0.1 (71.9)	-11.9 (46.9)	-13.7 (29.5)	

Table 14 Annual changes for self -reported PA outcome and regressions for differences between control and intervention groups (combined) adjusted for gender differences.

Measure	Men		Women		Gender-adjusted difference (95% CI) in annual change between control and intervention
	Control	Intervention	Control	Intervention	
Prudent diet score	**(n=19)**	**(n=16)**	**(n=13)**	**(n=15)**	*0.4 (-0.1,1.0), p=0.13*
Baseline	-0.49 (1.46)	-0.05 (1.33)	1.23 (1.72)	-0.05 (1.20)	
Follow-up	-0.21 (1.22)	0.58 (1.62)	0.82 (1.42)	0.10 (1.03)	
Annual change (+ve: improvement)	0.27 (1.24)	0.62 (1.46)	-0.37 (0.87)	0.15 (0.62)	
Townsend disability	**(n=32)**	**(n=30)**	**(n=25)**	**(n=30)**	*-0.5 (-1.1,0.2), p=0.20*
Baseline	3.6 (2.6)	2.8 (3.2)	4.1 (2.6)	4.5 (2.9)	
Follow-up	4.5 (3.3)	2.7 (2.8)	4.8 (3.3)	5.2 (3.7)	
Annual change (+ve: worsening)	0.8 (1.7)	-0.1 (1.9)	0.6 (1.8)	0.6 (2.2)	
SF-36 physical function	**(n=41)**	**(n=37)**	**(n=34)**	**(n=35)**	*4.5 (-0.4,9.4), p=0.07*
Baseline	67.7 (24.1)	78.6 (25.9)	70.6 (26.0)	67.7 (21.1)	
Follow-up	54.1 (27.4)	73.1 (23.6)	61.7 (25.4)	60.7 (25.0)	
Annual change (+ve: improvement)	-12.4 (18.0)	-5.5 (16.4)	-8.3 (11.8)	-6.6 (12.0)	
General self-efficacy score	**(n=37)**	**(n=34)**	**(n=30)**	**(n=30)**	*0.5 (-0.2,1.2), p=0.18*
Baseline	15.1 (2.0)	14.6 (1.7)	15.1 (2.2)	14.9 (2.0)	
Follow-up	14.8 (2.2)	14.8 (2.2)	14.1 (2.6)	14.3 (2.2)	
Annual change (+ve: improvement)	-0.3 (2.4)	0.2 (1.4)	-1.0 (2.2)	-0.6 (2.3)	
Lubben Social Network score	**(n=34)**	**(n=31)**	**(n=28)**	**(n=30)**	*-0.1 (-1.8,1.6), p=0.93*
Baseline	17.5 (6.1)	17.6 (5.0)	17.9 (5.3)	17.5 (5.3)	
Follow-up	17.3 (6.1)	17.1 (6.0)	17.6 (5.0)	17.4 (5.6)	
Annual change (+ve: improvement)	-0.1 (5.6)	-0.5 (5.0)	-0.3 (4.2)	0.0 (3.8)	

Table 15 Annual changes for self -reported outcomes and regressions for differences between control and intervention groups (combined) adjusted for gender differences

Table 14 and Table 15 show the annual change of self-reported outcomes as collected from the questionnaires. In the last column of the table, it shows regression coefficients comparing the control group to intervention group with adjustments for gender differences. Positive estimates of regression coefficients reflect either greater longitudinal increases or reduced declines for the outcome in the intervention group compared to the control group; negative estimates reflect reduced increases or greater declines for the outcome in the intervention group. The regression coefficients for each of the variables did not reach statistical significance. However, for SF36-

Physical Function, the intervention group had a slower decline compared with the control group that was close to reaching statistical significance, 4.5 (-0.4,9.4), p=0.07. The annual changes for original LAPAQ score and the shortened LAPAQ score differed. Using the original LAPAQ score, there was a decrease for intervention women, whereas for control women and all men the annual changes were positive. This pattern was also seen in imputed (to navigate the missing data) original LAPAQ score.

Outcomes	Men		Women		Obs [d]
	Estimate (95% CI)	P-value	Estimate (95% CI)	P-value	
LAPAQ [a]	-11.2 (-73.7, 51.2)	0.719	-70.2 (-141.7, 1.4)	0.054	93
LAPAQ (missing imputed)	3.2 (-58.2, 64.7)	0.917	-51.5 (-127.5, 24.6)	0.179	102
Shortened LAPAQ	6.7 (-22.7, 36.1)	0.649	-1.0 (-22.2, 20.3)	0.928	123
Shortened LAPAQ (missing imputed)	8.3 (-20.4, 37.0)	0.566	-1.7 (-22.0, 18.5)	0.865	131
Prudent diet score	0.4 (-0.6, 1.3)	0.445	0.5 (-0.1, 1.1)	0.075	63
Townsend disability score	-0.9 (-1.8, 0.0)	**0.048**	0.1 (-1.0, 1.2)	0.893	117
SF-36 physical function score [b]	6.9 (-0.9, 14.7)	0.081	1.7 (-4.0, 7.4)	0.549	147
General self-efficacy score	0.5 (-0.4, 1.5)	0.27	0.5 (-0.7, 1.6)	0.418	131
LSNS-6 score [c]	-0.4 (-3.0, 2.3)	0.774	0.3 (-1.8, 2.4)	0.797	123
LAPAQ [a]: Longitudinal Aging Study Amsterdam Physical Activity Questionnaire; shortened version only included walking, cycling and sports domains					
SF-36 [b]: Short Form 36 Health Survey Questionnaire					
LSNS-6 [c]: Lubben Social Network Scale					
Obs [d]: Number of non-missing values					

Table 16 Differences in annual changes in outcomes in men and women from baseline to follow-up between trial arms

In Table 16, the analysis comprises a comparison between control and intervention arms in men and then in women using gender-specific t-tests. For both men and women using the original LAPAQ score, and the shortened LAPAQ scores there was no significant finding. Townsend disability score showed a decrease in the intervention men group compared to the control group (p=0.048), a decrease in Townsend disability score indicates improvement in their self-assessment of physical function.

5.4 Process Evaluation of the Intervention

The process evaluation of intervention took place in November 2021-Feburary 2022 and was carried out by two MRC LEC research nurses JH and KM. This ensured neutral objective assessment of the intervention that took place. Process evaluation is a well-established practice that is used to assess various aspects of an intervention that traditional outcome measures such as efficacy will not be able to assess. The Medical Research Council has published guidelines to help with standardising how process evaluation can be carried out (225). Process evaluation focuses on the following key elements:

1. Context- consideration of the setting or environment that can affect the intervention implementation or mechanism or the study population. Also, it considers the effect that the surrounding could exert on the causal mechanism which then affect the outcome.

2. Implementation: how was the intervention delivered? How was the training of the intervention delivered? Measurement of what was delivered including fidelity, dose, any adaptations, and what was the reach of the intervention?

3. Mechanisms of impact: considers participants' responses to the intervention, any factors that mediate or impeded on the impact of the intervention, and any unexpected pathways?

And lastly is the outcome section, which all three above mentioned points would feed into.

Below describes the pragmatic guidelines and directions that were formulated to aid the research nurses through this process. The aims of process evaluation were to use a selected sample of participants from the NAPA study to assess:

- the implementation of the intervention: exploring how was the intervention delivered, how was the training delivered and what was delivered such as fidelity, dose, and adaptations.

- the mechanisms of impact of the intervention: this considers participants' responses and interactions with the interventions, barriers and mediators to the intervention, and any unexpected pathways.
- context that may be relevant to the implementation and mechanism of impact on the intervention.

It was agreed within the NAPA research team that ten participants from the intervention group were to be selected for process evaluation using the following criteria:

1. Must have completed the full intervention, i.e., have both case reports and recordings for the 5 time points (baseline home visit, 1, 3, 6, and 9-month follow-up telephone calls).

2. Selection process will be randomised (with the help of a statistician), but all participants must have had their 3-month follow-up call after the announcement of first lockdown (23rd March 2020). The rationale was that the home visits spanned from Nov 2019-March 2020, therefore there is a spread of when the 3-month follow-up would have taken place (some would have had it pre-lockdown and others would have had it post-lockdown). This criterion ensures consistency and removes one possible confounding factor.

3. Aim for equal number of men and women, and reasonable spread between JZ and IB's interviews (a small % of JZ's participants had their 1-month and 3-month follow-up

telephone calls done by IB during April-May, as JZ was recalled to clinical practice due to COVID-19).

Whilst listening to the recording of each interaction the research nurse had 3 coding documents to fill out:

1. Follow up Phone call- Competency Coding Tool, Appendix H coded to 2 out of the 4 competencies, which were “asked open discovery questions” and “more time spent listening than giving information”. The research team decided not to code to “reflected on own practice” and “supported SMARTER goal setting” because the nature of the baseline conversations and telephone calls did not lend themselves for the researcher to perform any reflective practice. The use of the SMARTER goal setting was modified for this cohort, which will be discussed in detail in the Implementation section.

2. Process Evaluation of Healthy Conversation Skills Intervention in NAPA study checklist, Appendix I, contains tick boxes for activities and topics including:

- PA: gardening, walking, household chores, leisure activities, classes, other
- Diet
- Mental health: mood, depression, anxiety

Also, participants were assessed to see if there were signs of resistance to the intervention and statements of resistance could include: “don’t talk to me about…”, “don’t remind me…”, “I think I am fine…”, “My daughter is looking out for me on that….so I’m okay”. Focus on any changes made by the participant because of the intervention was also noted. Indicator words or phrases of change could include: “change(d)”, “more”, “less”, “improved”, “better”, “now”, “before” and the research nurses were encouraged to look at case report to compare levels of PA at the different time points. Lastly special attention was paid to the context of the whole intervention, and in particular the impact of COVID-19 on the participant’s ability to socialise, access to services or shops or to perform PA. Indicator words or phrases could include the of inability to attend usual social activities, do their own shopping, or venture out, e.g., into town centre or go for walks

3. SPRING Case Report coding frame v1.3 – adapted for NAPA, Appendix J, specifically assesses how well was the participant being supported in terms of using the SMARTER goal setting approach. In the NAPA study, the SMARTER goal aspect of Healthy Conversation Skills was modified during the early phase of the baseline NAPA data collection. This was due to after the use of the terms “goal” and “goal setting” were not

well received by some of the earlier participants, and both visiting researchers felt these terms were not appropriate for this age group, and can cause unnecessary negative reaction from the participants. Therefore, these terms were not used but the ethos of the SMARTER goals were utilised to the best of the researchers' abilities.

5.4.1 Baseline quantitative characteristics of the participants

The ten randomly selected participants for process evaluation were equally distributed between the two researchers, i.e.: five from JZ's group and five from IB's group. Table 17 shows the baseline characteristics of these participants. Statistical significance testing was not conducted as the sample number is small, n=10. Therefore, any similarity or differences noted is more of guidance and may be helpful in the context of Process Evaluation to explain why some participants may have behaved or responded in a certain way.

There was an equal split between men and women and reasonably similar median ages between the two genders, 82.3 years (IQR: 81.3, 82.3) for men and 83.1 years (81.9, 84.4) for women. The differences between height, weight and BMI were to be expected as the participants were grouped by their gender and these characteristics are known to have gender differences. There were similar proportion of smokers versus non-smokers and those living alone and not alone in both men and women. The median alcohol consumed (units per week) for men is 8.4 (4.2, 14.5), and 7.0 (0, 9) for women. Men were more active than women with a mean activity time of 183.6 (82.1) mins/ day whereas women in this group had a mean of 159.9 (15.9) mins/day based on the LAPAQ questionnaire. Interestingly there was a difference for the Lubben social network scale (LSNS-6) score, with the men scoring higher on an average of 20.4 (3.2) compared with a lower mean for the women 12.8 (6.5).

Baseline characteristic	Mean (SD); median (lower quartile, upper quartile); or N(%)	
	Male (n=5)	Female (n=5)
Sex (female)	5 (50%)	5 (50%)
Age (years)	82.3 (81.3, 82.3)	83.1 (81.9, 84.4)
Height (cm)	171.2 (4.8)	159.4 (8.7)
Weight (kg)	80.5 (7.3)	63.9 (16.4)
BMI (kg/m^2)	27.5 (3.1)	24.9 (4.6)
Smoking status		
Never	3 (60%)	4 (80%)
Ex	2 (40%)	1 (20%)
Current	0 (0%)	0 (0%)
Living status		
Not living alone	4 (80%)	3 (60%)
Living alone	1 (20%)	2 (40%)
Alcohol consumption (units per week)	8.4 (4.2, 14.5)	7.0 (0, 9)
LAPAQ physical activity (min/day)	183.6 (82.1)	159.9 (15.9)
Prudent diet score	0.7 (1.3)	1.1 (1.1)
Lubben social network scale (LSNS-6)	20.4 (3.2)	12.8 (6.5)
Number of comorbidities		
0	0 (0%)	0 (0%)
1	0 (0%)	1 (20%)
2	5 (100%)	3 (60%)
3 or more	0 (0%)	1 (20%)
Number of medications taken		
0-2	0 (0%)	1 (20%)
3-5	5 (100%)	2 (40%)
6-8	0 (0%)	2 (40%)

Table 17 Baseline characteristic of the 10 participants for Process Evaluation

5.4.2 Findings

From the works undertaken by the research nurses the results from process evaluation will be discussed under the following three headings as per the MRC guidelines (225): 1) Implementation, 2) Context, 3) Mechanisms of impact

5.4.2.1 Implementation

In the study, the intervention was carried out by two researchers who had received Healthy Conversation Skills training from a Making Every Contact Count (MECC) course delivered by the Wessex team. This consisted of a one-hour e-Learning module viewed prior to the two-half day face to face interactive training sessions. Within the sessions there were opportunities to role play

the use of Healthy Conversation Skills and explore how SMARTER goal setting could be utilised in a real-life conversation. After each session, the researchers were asked to reflect on how they could practise Healthy Conversation Skills.

At the start of the study, the two researchers discussed at length how Healthy Conversation Skills can be applied to the older adults in the HCS. These older adults are in their seventies and eighties, and therefore older compared to previous cohorts that Healthy Conversation Skills has been trialled on. Thus, there were likely to be characteristics that were unique to this age group that may result in modification of implementation of Healthy Conversation Skills. One modification made early on was the avoidance of using the terms “goal” and “goal setting”. These terms were not well received in the first few home visits, and both researchers felt the negative responses from the participants independently. Hence a decision was made early on to avoid the use of these terms, and a more relaxed and flexible approach was adopted, as described in Intervention.

The use of open discovery questions and active listening were helpful attributes from Healthy Conversation Skills to gauge the receptiveness of the participant to a conversation about making healthier lifestyle choices. This can often lead to encouraging conversations about what and how they can improve certain aspects of their lifestyle. The flexible approach to the use of SMARTER goal setting adopted after first few home visits meant not all seven domains would be necessarily addressed in each of the conversations, and which domains were addressed was situation dependent. The researcher would base on the flow of the conversation and the responses from the participant to gauge how many domains of the SMARTER goal setting could be clearly established. Regular interim meetings between the two field researchers took place throughout the time period that home visits took place to ensure the delivery of Healthy Conversation Skills remained consistent. We discussed issues that may have occurred during recent home visits, and whether further adaptations were needed. The flexible adaptation of SMARTER goal setting was appropriate and user friendly to this group of older adults, as it allowed the participants to be as involved with the goal setting aspect as much as they wanted. However, using this approach, there is the possibility not all participants were made to feel that they were being driven to make healthier lifestyle changes or that they were part of an intervention, therefore may not have applied themselves. However, there were participants that were aware some form of intervention was occurring during these conversations, one participant said “Am I being a disappointment to you” in one of the telephone follow up calls.

There were signs of resistance from the participants, and this may have affected the efficacy of the Healthy Conversation Skills. Common comments from this group to show signs of resistance

with regards to the concept of PA or diet or the idea of making changes included: “Don’t talk to me about…” “…I’m fine” “….I’m okay”. On listening to the recordings of the conversations it was felt there were times when the researchers were perhaps too gentle and did not want to ‘rock the boat’. This was not unique to this cohort, as the staff from the Sure Start Children Centre also expressed similar notions with regards what were the barriers to using Healthy Conversation Skills (143).

The researchers were assessed for their competency on the use of open discovery questions, active listening (i.e.: listening more than giving advice or information), Appendix H, and the use of SMARTER goal setting against a standard competency framework, Appendix J, based on the audio recordings from all five timepoints, for all ten participants. For one participant there was no recording at 9 months as permission was not given, and another participant’s 1 month recording, the assessors were unable to hear the participant clearly, therefore the section on use of SMARTER goal setting was not assessed.

Timepoint/ Researcher	No. of calls made	Asking Open Discovery Questions[a]	Active Listening[a]	Supporting SMARTER goal setting[b]	Mean HCS score[c]
Baseline					
1	5	4	3.8	1.6	9.4
2	5	3	3.8	1.3	8.1
1-month FU					
1	5	3.6	4	1.4	9
2	5	3.6	3.8	1.4	8.8
3-month FU					
1	5	3.6	3.8	1.5	8.9
2	5	2.8	3.6	1.3	7.7
6-month FU					
1	5	3.2	3.8	1.4	8.4
2	5	2.8	3	1.4	7.2
9-month FU					
1	5	3.2	3.6	1.4	8.2
2	5	2	2.5	1.2	5.7
Total					
1	25	3.5	3.8	1.4	8.7
2	25	2.9	3.4	1.3	7.6

[a] Scale 0 – 4: 0 = no competency; 4 = high competency.

[b] This was assessed using an adapted coding rubric: scale 0 – 2, where 0 = no competency; 2 = high competency.

[c]Mean HCS score out of 10

Table 18 Mean competency scores for three Healthy Conversation Skills for each researcher at each timepoint. (researcher 1: IB; researcher 2: JZ)

The scores in Table 18 show that overall Healthy Conversation Skills was delivered at a reasonably high standard with mean scores of 8.7 and 7.6 out of 10. This overall score is a composite of the mean scores for three sections: asking open discovery questions (max score is 4), active listening (max score is 4), and supporting SMARTER goals (max score is 2).

Healthy Conversation Skills was delivered at five timepoints throughout the 1-year interval, and this was decided after consultations with the health psychologist who developed the training. The frequency of the contact points was a delicate balance between the likelihood of achieving efficacy, participant burden and replicability of the intervention in real life practice. Having 5 contact points throughout the 1-year interval would not be too burdensome and could be

replicated by medical professionals because if an older adult individual has chronic health conditions, they are likely to consult with their General Practitioner regularly throughout a year. Therefore, for this cohort of older adult, many of them will be used to having interactions with medical professionals regularly and may not view these interactions as burdensome.

5.4.2.2 Context

The intervention in the NAPA study is a participant- led behavioural intervention, therefore context is an important aspect to examine and discuss as humans are heavily influenced by their environment and surroundings. First to be discussed is the advent of COVID-19 and its subsequent effect. The news of a new virus reached mainstream media in January 2020. This initially did not affect the study as at that point the virus was contained within the Asia continent, therefore the home visits continued unaffected. However, as the situation evolved quickly, by February 2020, the virus has reached the UK, and at the home visits it became a talking point. In line with the government guidelines, the participants in the study all fell in the vulnerable category given their age and the high chance of having chronic health conditions. Soon it became evident the home visits had to be halted, and an alternative solution had to be sought. Therefore, the final eleven participants' home visits were changed to telephone interviews, in which two participants dropped out at this stage. This did not affect the ten randomly selected NAPA participants for process evaluation, as they all received home visits. However, it is worth mentioning here as this meant a small number of participants had their initial healthy conversations via the telephone instead of a face-to-face delivery. Whilst this fortunately only affected a small proportion of the participants, the loss of ability to read these participants' facial expressions, postures and auras may have likely impacted on how the conversations were delivered.

The restriction issued by the government due to this new virus was unprecedented. On 23rd March 2020, the Prime Minister announced the first national lockdown, and for people to stay at home unless for specific reasons as listed below:

1) "shopping for basic necessities, as infrequently as possible
2) one form of exercise a day - for example a run, walk, or cycle - alone or with members of your household
3) any medical need, to provide care or to help a vulnerable person; and
4) travelling to and from work, but only where this is absolutely necessary and cannot be done from home."(226)

The aim of the NAPA intervention was to encourage the participants to be as active as they wished to be. However, the mandated restrictions would have clearly impacted on the lifestyle of

the participants such as not being able to partake in their usual PA, and to be limited to one form of PA per day. Also, the message given out to the general public at the time was those in the vulnerable group should be shielding, which meant they were advised not to venture out of their house unless it was absolutely necessary such as seeking medical help. From the conversations with the participants in the intervention group, many stopped doing their usual food shop, and during the height of the lockdown stopped going outside of their houses and restricted themselves to their homes and gardens only. This will likely impact negatively on the amount of PA performed per day and may have accelerated age-related musculoskeletal decline due to reduced use. During the summer months, when the nation was not in complete lockdown, and PA was encouraged for all to partake in by the government, there were unintended negative impacts on some of these older adults. One participant was wary of going out for walks as the paths around her home felt "too narrow" therefore she did not feel she could safely socially distance from others. Another participant found the footpaths outside of her home being more popular than usual (perhaps due to many were working from home) which acted as a deterrent for her to go out for her usual walks.

Likely there will be long lasting impact on some of these older adults' daily behaviours beyond the time of the lockdowns. For instance, from the intervention telephone calls, some participants were keen to be allowed to do their usual routine and resume their usual social interactions and found the subsequent lockdowns to be restrictive and frustrating. However, there were participants that remained reluctant to resume their previous routines and have found new adaptations and expressed they were likely to continue to do so for the foreseeable future. One participant openly said, "I'm getting old and lazy now- especially with this blinking virus about…".

The inability for some of the social clubs or organisations to be restarted after the lockdown could also be a stumbling block. Some of these clubs or organisations were run by older adults and have a small number of members, therefore there is the possibility with the forced hiatus there may not be the drive or people to restart the clubs or organisations. This will likely affect the quality of life of these older adults, as often these clubs and organisations are the main source of social interactions outside of their usual family and close friends' support network. In some of the participants' cases this is the only source of regular social interactions for them, as their family live far away, and most of their friends have passed away.

5.4.2.3 Mechanisms of Impact

Healthy Conversation Skills is a flexible approach that requires both engagement from the participants and the ability of the practitioner to deliver the conversation in an effective manner. The use of open discover question approach was well tolerated by the participants. How they

respond to these questions would have been affected by the participants' readiness to change, which was assessed by observing if there were signs of resistance as described in Implementation and Appendix I. Once a participant is at the stage of wanting to make changes, from listening to the conversations, it seems there is supportive evidence that having the healthy conversation had helped some to be more proactive with regards to their PA levels. These participants were more likely to make plans or express what they were currently doing in follow up phone calls compared with the baseline conversations:

> *Participant "There's always something to do out there…(about her garden)…I do go out as much as I can."*
>
> *Participant "… I still go for a walk every day…"*
>
> *Participant "I've tried to organise another walk for later this month (a member of local walking group)…a lot of people are still very reticent to go out…I'm quite amazed that a lot of people are still isolating themselves."*

At the beginning of the NAPA study, the researchers made a modification with regards to the language used on the matter of SMARTER goals and goal setting. The term `goal' was actively not used during these healthy conversations. Instead, questions such as "how do you feel about your activities or lifestyle?" were used, and this could be followed up with "Any changes you would want to make?" or "Anything that you are concerned about?"- often these questions can elicit some of the participant's concerns, which represented the goal as described by SMARTER. The use of following questions: "how do you think you may address…(the concern)" or "how would you go about sorting …(the concern)" would then start the process of establishing a plan to achieve their concern. This would represent the SMARTER goal setting which included specific, measurable, achievable, realistic, timed, evaluate, and review. In those participants that were not as responsive to Healthy Conversation Skills, not all aspects of the SMARTER goal domains were established. Therefore, this modification may have altered the underlying mechanism of Healthy Conversation Skills, by diluting the essences of Healthy Conversation Skills with the more flexible approach. However, the contextual influence is very important, and here with the older adult population a tailored approach was appropriate. The high percentage of engagement rate, 95%, suggested a tailored approach was reasonable and acceptable to these older adults.

The intervention was primarily delivered via telephone, with the first contact being a home visit (for majority of the NAPA participants). The high engagement rate in the intervention group is indicative of acceptability of the intervention to this group of older adults. From the recordings it seems the subsequent four telephone follow up calls were well received regardless how receptive

the participant was to the actual intervention. With the unpredicted event of the pandemic, remote access has proven to be a useful and acceptable route in this group of older adults to deal with unexpected changes.

One of the overall findings felt by the research nurses after listened to the audio recordings was there were occasions when the researchers could have been more assertive with their conversations therefore may have impacted on the efficacy of the intervention. The assessors have speculated that the researchers may `not have wanted to rock the boat' hence the `softer' approach. On this matter, face to face conversations may resolve or at least reduce the likelihood of this from happening, as there will be additional feedback from the participant that a telephone call could not provide such as facial expression, and body language. This extra information may have helped the researcher to assess how receptive the participant was to the healthy conversation.

5.4.3 Additional findings from listening to audio tapes

There were important findings noted after listening to the audio recordings of the healthy conversations. Similar to the themes described in Chapter 4, the following themes were found to be influential on the impact of the intervention: psychological, social aspect, PA environment, medical or physical health changes, and bereavement or ill health of partner. These factors will be discussed in the section below.

5.5 Discussion

In this pilot study, we have demonstrated it is feasible to deliver a telephone-based intervention in community dwelling older adults aged 79-89 years. The study was not powered to show efficacy in improvement in PA, but importantly it demonstrated the feasibility of having healthy conversations with those in their eighties and nineties. In our study we did find that the use of Healthy Conversation Skills decreased Townsend disability score in men. The lower the Townsend disability score the lower the degree of disability.

To the best of the author's knowledge the use of Healthy Conversation Skills in older adults has not been previously published, and this is particularly novel as the cohort are in the late end of the age spectrum of older adults. A high percentage, 95%, of the intervention group fully completed the intervention (all the scheduled phone calls). It is encouraging to observe a low drop-out rate, as often in PA intervention studies involving older adults, the drop-out rate can be high especially if many participants in the cohort are frail (133, 137). Here with the high retention rate throughout each stage of the study it shows the possibility of the intervention being

acceptable to this group of older adults. The frequency and length of follow up calls have been set as such because of its potential utility in a clinical setting. The higher frequency of the follow up calls would likely increase the probability of the behavioural changes however in a clinical setting such as community service or secondary care e.g.: frailty service, a higher frequency would render it too labour intensive therefore less likely to be adapted.

Healthy Conversation Skills have been trialled in younger population cohorts including children (227), pregnant women (228, 229), and parents of children (144). In a cohort of seventy pregnant women, in Canada, half were randomised into the intervention that received Healthy Conversation Skills and the remainder in the active control group, this study also recruited a further n=55 women to be in their passive control group (228). They found the diet score between baseline and follow up visit improved for those in the intervention group compared with control group, and at 34 weeks of gestation those in the control group self-reported being less active than those in the intervention group. The efficacy in the use of Healthy Conversation Skills in improving diet and PA were trialled on parents (women only) of children attended Sure Start Children's Centres in the South of England (144). Whilst this study did not show an increase in PA levels or diet improvement, however the women in this study found they felt more empowered in making healthier food choices. Lastly, Healthy Conversation Skills is also currently being investigated in Southampton Pregnancy Intervention for the Next Generation (SPRING) trial (ISRCTN07227232) (229).

Direct comparison between these three studies and the NAPA study would not be appropriate as they vary vastly. The lifecourse stage for the Canadian study and SPRING both involved pregnant women and the Sure Start Children's Centres study involved parents of the children, whereas NAPA involved older adults in their eighties. The drivers for these cohorts to choose healthy lifestyle choices will likely to be very different. For the mothers of the children the ability to choose healthy lifestyle choice resolve around the lack of control they felt about making these choices, and self-regulatory approaches including goal setting were an effective and welcomed way of maintaining and supporting behavioural changes (144). By contrast in older adults the driving force and impeding factors can be largely grouped into psychological, social aspect, PA environment, medical or physical health changes, and bereavement or ill health of partner.

It was noted those with positive mind sets had more active baseline routines compared to those less positively minded. This is in line with current literature on factors influencing older adults' PA levels (203, 205). However, it can be argued that it would be easier for a person to return to a familiar routine rather than making changes. From listening to the audio recordings of the ten NAPA participants, those with more active routines at baseline were more likely to keep active

compared to those who did not. This leads to the thought that perhaps in this age group, the ability to maintain the current level of PA should be seen as equal to an increase in PA level in a younger cohort with a similar intervention. With ageing, there is the physiological natural ageing of the bodily systems, and musculoskeletal system being one of them. Therefore, given this backdrop, the ability to maintain and slow down the decline of musculoskeletal system should be seen positively.

The benefits of WBPA and exercise affecting balance and strength are still relatively new concepts compared with other well-known public health messaging such as smoking causes cancer or having five portions of fruit and vegetables per day. WBPA was added in the 2019 update of the UK PA guidelines (24), and therefore this knowledge is unlikely to have filtered to the general population. From the recordings it was evident there was the need to educate some of the older adults about the benefits of continuing these exercises or their usual PA to prevent them from further falls or slow down the rate of decline of their musculoskeletal system. However, another barrier related to this, is the fear of falling whilst doing general PA or exercises when they have had a recent fall (216). Hence there is the need for falls prevention education for the general older adult population ideally prior to falling.

There are established falls prevention programmes for older adults that have experienced a fall (217, 230), however these interventions may be too late, as the seed of fear has already been stowed with the initial fall. A prevention programme or talks to community dwelling older adults that have not had the initial fall may be a better time to target to educate on the benefits of ongoing WBPA and balance and strength exercises as ways of preventing falls. This approach echoes the ethos of Healthy Ageing (13).

The NAPA study was carried out in the community with a baseline home visit and subsequent follow up calls, unlike previous studies involving Healthy Conversation Skills, which have been primarily in clinical settings or a children's centre (144, 228, 229). The process of going to a place e.g., hospital, children centre, for a face-to-face meeting may trigger a more cemented thought process with regards to the content discussed at these healthy conversations, especially if the setting is medical. By contrast the NAPA study took place in the comforts of the participants' homes and was then followed by subsequent telephone calls. Therefore, the NAPA setting, being one's home, was more casual and familiar to the participants. This may have resulted in the participants not taking the content of the conversations as seriously compared to it being delivered in a more formal setting.

Past behavioural approaches in promoting PA in older adults have been heterogenous however most would involve participant-centred approaches using an established behavioural change

model (131). The use of social cognitive theory and particularly utilising self-efficacy element has been a popular approach (231). Previous pure behavioural interventions can often involve elements including patient-determined goals, self-discovery and accountability (131). The NAPA study utilised a behavioural approach that focused on the empowerment of self-efficacy, and self-directed goal setting. Both goal setting and increasing self-efficacy have been found previously to increase PA behaviours (231). A distinct advantage of Healthy Conversation Skills compared with previous behavioural approaches is its ability being versatile. It is easily accessible and can be taught to a wide range of professionals (145, 232). In our study both researchers were newly introduced to and trained to use Healthy Conversation Skills and found the learning process approachable and felt confident in delivering healthy conversations after the training sessions.

The impact of COVID-19 on the intervention has been to a certain extent discussed in the Context section of process evaluation. This will be further addressed in Chapter 6.

5.5.1 Discussion on additional findings from process evaluation

From process evaluation, there were additional observations noted after listening to the recordings of the ten participants. Firstly, the wide range of psychological mind sets was evident. Those of positive mind set seem to focus on keeping going and findings ways of how to overcome the barriers they face. Others seem to settle on the fact that they are ageing therefore it is inevitable to find things difficult and slowing down is an acceptable ageing phenomenon. The use of Healthy Conversation Skills on those with ageing on their mind set was feasible as the use of open discovery questions was a gentle way of probing the idea of increasing their ability to do things. However, the success of this was dependent on how receptive the participant was to this idea at the time. There were cases where the participants appeared resistant to the idea initially however at later contact points seemed to be more open to the idea of being more active. There were also participants that have switched from being receptive to being less so, cited ageing, tiredness, and pain as common reasons. Then there were those who remained either resistant or not receptive throughout the entire intervention. Of course, there were participants that were receptive at all 5 time points. Another example of how different psychological mind sets can affect behavioural outcomes was the event of an acute change such as illness of partner, bereavement, or a change in health in the participant. After an appropriate period had elapsed after the event, it was observed those with positive mind set were more likely to refocus back on keeping themselves active as possible or getting back to their usual active routine.

The timepoints for the change in attitude varied for different participants and there were too many confounding factors for the research team to clearly depict the precise reason or reasons

for the change. However, there were several clear contributary factors with regards to the change in attitude. Firstly, the weather, this is a known factor that can affect how much PA older adults may perform, in particularly on those activities that are outside (199). Thus, it was feasible that when the telephone conversation coincided with good weather, the participant may have felt positive and be receptive to the idea being physically active, whereas if the weather was cold and wet then the opposite effect may occur. One notable point on levels of resistance, was that the participants were more receptive to continue or increase engaging in activities they already performed or enjoyed, rather than the addition of a new activity for the benefit of their health. This finding is in line with previous literature (233). Another reason could be the external influences around the participant such as family, friends or neighbours that may have insidiously affected the participant's way of thinking thus resulting in being receptive to the intervention but not necessarily voicing the root of their motive. The effect of role modelling was likely to contribute for some participants, as observed previously in the qualitative study, Chapter 4. The state of the participant's own health is likely be part of the reason for some participants to change their attitude. Some participants reported that because of their health they were not keen or unable to increase or maintain their PA. Other participants would indirectly blame their health as the reason for slowing down or doing less than before, by mentioning ageing and feeling tired as the reason. In these situations, it could be a combination of the physiological effect of ageing exerted on the individual and as well as the societal idea of being older meant one should/could slow down therefore resulted in a reduction in PA.

As mentioned above, the external influences of family, friends, neighbours, and the community can affect how participants responded to the intervention. For some participants their family members helped them to remain active or reminded them to continue to perform newly adopted exercises, as some struggled to remember to incorporate new exercises into their daily routines. Those with a more active daily routine at baseline often found it easier to continue as it had already been embedded alongside their usual routines. Often these activities tended to have social aspects to them such as golfing, playing bowls or walking with a neighbour or in a group thus highlighting the potential motivating effect of social interactions in the continual participation of PA.

Physical health factors or medical conditions have been observed as a barrier from the recordings. It was noted throughout the 9 months follow up, there were timepoints where participants may have had to reduce their PA levels due to a new medical condition or an acute medical event. For some, this reduction was transient, and at the next follow up call the individual was back or close to their prior PA level. But there were those throughout the different timepoints, the researchers observed a gradual decline after the initial health event. There was also another group of

participants, over the 9-months period who declined gradually without an obvious trigger being mentioned. Often in these cases the participants mentioned getting tired more easily, not as energetic as previously, and they sounded weary at times when expressing these comments. Therefore, in these situations, the researcher assessed whether it was reasonable to probe about their PA levels and any subsequent conversations about keeping active.

On a similar note, the health of the participant's partner or recent loss of the partner was also noted as a barrier to PA participation. The event of a participant's partner being unwell or resulting in hospitalisation was observed to impact on participants' daily routines. It was evident during these periods, the sole focus for the participant was to look after the unwell partner. Therefore, the topic of PA participation or keeping active was deemed to be unimportant to them at that point in time. However, for those with partners with chronic medical conditions, there was a different attitude noted. Here, the participants were more likely to want to make plans to keep themselves active and occupied outside of their role as carers. However, being a carer, was also a barrier, as some expressed the difficulty of finding the time to keep themselves active.

PA environment was another influencing factor on whether the participant was likely to keep active or increase their PA levels thus can affect the outcome of the intervention. Whilst all the participants were all living in the county of Hertfordshire, there were substantial differences in terms of the type of neighbourhoods the participants lived in. Some participants lived in remote villages surrounded by fields while others lived in built-up town communities. Some participants had gardens of varying sizes whilst others did not. These differences can affect the accessibility and ability of the participants to participate in certain forms of PA, and this effect became more evident with the lockdowns. Those with gardens were more likely to mention they were working in their gardens therefore a form of PA, and those who were keen gardeners may mention they have increased spending time in their garden due to the lockdowns. However, this was weather dependent, as the first lockdown fell in March, and comments about the wet weather stopping them from working in their gardens were common. As the months turned warmer these participants started to mention that they were spending a lot of time in their gardens. For those without a garden, the amount of PA performed outside of their homes reflected the surrounding environment. One participant mentioned she would only go for a walk if she had a neighbour with her, and only at specific times and specific route to avoid the youths in her local area. Another participant mentioned how he enjoyed the daily walk around his local area, as it was a way of keeping social interactions with his neighbours safely.

5.5.2 Strengths and Limitations

One of the key strengths is the inclusion of older adults aged 79 and above, older than is usually studied. Many other older adults' studies have younger cohorts compared to the HCS, as the definition of older adults starts from either ≥60 or 65 years old (87, 231, 234). All the participants in the HCS lived in the community therefore provided us with insights with regards to optimal approach in improving their lifestyle choices before the transition to require additional care support at home or supported accommodation or care homes. Another strength was the use of a randomised control trial design, including the random allocation of participants to trial arms. The HCS is a well characterised cohort of study population, and participants have been shown previously to be representative of the general UK population with regards to lifestyle characteristics such as BMI and smoking (149). We have also captured a unique insight of a group of older adults and their response to the COVID-19 pandemic.

One of the limitations is that our cohort is made up of only Caucasian men and women in the UK, therefore the findings do not represent other ethnicities. The recruited 176 participants compared to the initial baseline recruitment of participants in 1999-2002, will likely show a healthy bias, similar to what was observed in Chapter 3. In an intervention utilising behavioural component (empowering self-efficacy), a healthy bias may affect the uptake of the intervention thus the outcome. It can be speculated if the cohort is in poorer health, then the uptake of healthy conversations may be affected as these participants might be pre-occupied with their health care issues therefore not able to focus on PA. The research team is mindful that the cohort is part of an established research study, it is possible that they may be more receptive to this intervention than a group of community dwelling older adults who have not previously been involved with research studies. Lastly, the pilot study was not powered to show efficacy of Healthy Conversation Skills in improving PA levels in older adults. This was due to a combination of insufficient number of participants recruited and the proportion of incomplete postal questionnaire at 1-year follow up. Therefore, findings from this study from the analysis undertaken will need to be replicated with a larger study cohort. However, the data collected and analysis undertaken provide valuable pilot data that can be used to inform power calculations for future larger studies.

5.5.3 Conclusion

We have conducted a pilot study on the use of Healthy Conversation Skills on community-living older adults. We found it was feasible to deliver this intervention via telephone, and the utilisation of Healthy Conversation Skills was feasible in older adults.

Focus groups with the NAPA participants would be helpful before a large-scaled study takes place to investigate the efficacy of Healthy Conversation Skills on maintaining or improving PA levels in older adults.

Chapter 6 **Discussion**

6.1 Main Findings

In this thesis I have considered PA in community dwelling older adults. Firstly, the musculoskeletal benefit of performing WBPA across the lifecourse was explored in HCS, a cohort of community dwelling older adults. Women who reported regular WBPA in their 20s-40s were found to have higher total hip BMD compared those who did not. In this HCS cohort, men were more likely to report participation in WBPA during their younger years, ages up to 18 and 18-29 years, than women. The overall trend showed a decrease in WBPA participation as the cohort aged. Those remaining physically active in their 30s-40s were more likely to remain active in older age.

This was followed by an exploration of the factors that affected PA participations in this group of older adults. Six key themes were highlighted as influential factors including psychological, and social engagement, which can also act as moderators with regards to how a person may react to non-modifiable factors.

This led to a pilot study to trial the novel use of Healthy Conversation Skills, which focused on self-efficacy and supported participant-led changes, in older adults. For the first time, I demonstrated that this approach was feasible and acceptable in this age group. Of note, this work was conducted during the COVID-19 pandemic, when restrictions were in place that limited the choices, participants might make regarding modification of PA. In this chapter I will discuss the overall conclusion of this thesis whilst addressing key findings from my research questions.

6.2 Synthesis of main findings: contribution to our understanding of the relationship between physical activity participation and older adults

The musculoskeletal benefits from participating in WBPA has been demonstrated in recent years, leading to its inclusion in the latest edition of the UK PA guidelines (24). WBPA can include a wide range of activities such as dancing, racquet sports and running, but the key component is that the activity works against gravity. WBPA can contribute to the improvement in physical function (235), balance (236), and bone health (168, 170).

This is particularly relevant for an older adult cohort, as the maintenance of physical function is vital in preserving independence and quality of life. However, natural age-related decline in the musculoskeletal system is a well know phenomenon. Additionally, in an older adult population, the presence of a comorbidity or multi-comorbidities is common, and this can independently

contribute towards musculoskeletal decline. In this thesis, the presence of tracking was noted i.e., those participants who reported regular WBPA in their 40s were most likely to remain active in their old age. Also, those who reported WBPA from up to 18 years to 49 years, were more likely to remain active when they reached older adult age. It would be helpful to explore the drivers and barriers that influenced this group of older adults to remain active throughout the lifecourse. This may yield potential modifiable factors that can be targeted in future interventions. It was also demonstrated regular WBPA for women in the age groups, 18-29 years, and 30-49 years, was associated with higher total hip BMD than those performed no WBPA. The above message of regular WBPA across the lifecourse associated with better bone health in older age, might be used in the education of the public to promote PA across the lifecourse.

Factors driving PA participation in older adults were investigated using some of the participants from the same study group, HCS, in a focus group setting. Rich qualitative data were yielded from this phase of study and six themes were identified as key influencing factors that can affect the outcome of current level of PA participation. The HCS consisted of white British population only. The key six themes identified in the focus group study all had enabling and disabling aspects that contributed towards the end outcome of PA participation. The participation of PA in this focus group included a broad spectrum of activities ranging from household related activities to LTPA which encapsulated exercises and hobbies. Given this wide range of activities, nuanced differences in affecting factors were noted. For instance, walking related activities were commonly affected by surrounding environment and weather, whereas activities involving classes, or an organised event were more likely to be affected by the cost of the attendance, availability, and accessibility of class or event. The significance of role modelling was also noted in the focus groups, and this was a powerful way of motivating the participants to avoid being inactive if they wish to avoid the consequences they observed from their peers. Here the participants were relating themselves to their social peers and using the negative consequence witnessed as a motivation to keep active. Whilst role modelling is a well know phenomenon however this has not been well explored in the context PA promoting in older adults (237).

However, there is a unifying theme that seem to modulate the likelihood of PA participation which is the psychological or social aspect of a participant. This seems to act as a filter and consequently polarising views were noted in the focus group, for instance in response to a common event such as retirement, some participants were adamant they did not wish to slow down when they retired, and were afraid once they have slowed down, they may find it difficult to restart again. However, others felt that once retired, they would like to take a relaxed approach, and some mentioned there is no longer the need for the pace of life they led whilst working. This oscillating finding can be utilised in future research in promoting PA in older adults.

For example, those participants in the relaxed camp may benefit from education on the concept of Healthy Ageing and the benefits of keeping active, which then may lay the foundation for them to consider remaining active or restart their activities. Following on from the educational sessions, further inputs such as educating the older adults on available activity facilities local to them could aid in promoting PA. However, for those already remaining active, these educational sessions alone may suffice. As this serves the purpose of validating the older adults' own belief or action and give them the encouragement and confidence to continue with their chosen route.

The average mean age of the participants in this focus group study was 78 years old. This is of importance as the age definition for older adults can vary from 55 years to 65 years old in a research setting, and much of the work published in this area relate to this younger age range. There will be physiological and psychological differences between participants in their late fifties to those in their late seventies. Spiteri and colleagues reported that participants aged 50-64 years (middle-aged) were motivated by goal setting, the belief that an activity will be beneficial, and social influences, while for those aged 65-70 years (older- aged) important influences were social influences, reinforcement, and assistance in managing change in their systematic review (238). Additionally, societal pressure and stereotypes of what constituent `ageing', or `being older' will likely impact on the outcome of PA levels, and past research have shown negative stereotypes such as being lonely or unwell have been linked with old age by both young people and older adults themselves (239). The negative influence can impact on older adult's functions such as memory recall (240), and those with low self-perception of ageing have been associated with increased all-cause mortality (241), and poor functional health (242).

Much previous research on factors affecting PA levels in older adults was PA specific or recruited specific group of older adults in the context of informing an intervention to improve PA (87, 199, 205), therefore their findings were geared to specific areas. Our focus group study provided us a unique insight to a group of community dwelling older adults that were largely independent. Thus, gave us insight as to what drive a group of community dwelling older adults to partake in general PA. This has high utilisation value, as the general population of older adults will be community dwelling and will likely participate in many of the activities mentioned in this study. The combination of the principles of Healthy Ageing (13), our findings from the qualitative study, and the natural progression of musculoskeletal ageing, a change in the focus when promoting PA in older adult is warranted. The focus should be on maintaining current levels of PA, rather than trying to establish new habits. Similarly, the ability to maintain current levels of PA despite ageing should be viewed the same way as an increase in PA in younger adults, when assessing efficacy of PA interventions. This approach may not be appropriate for those with very low baseline PA level,

where the focus could be focussed on increasing PA which may need new habits to be established.

Interventions in prompting PA in older adults are plentiful, and as discussed in Types of intervention there is a myriad of different approaches that have been adopted in the past, and to varying degrees of success. For a successful health behaviour change this will require two key elements: the motivation for change and specific skill set to facilitate the change. For older adults, the drivers for their motivations and their stressors will differ to the other stages in the lifecourse, as discussed earlier in this section. Key motivators for older adults include reinforcement, and assistance in managing change; therefore, sessions with practitioners or researchers to provide encouragement, education and support may give a better result (243).

In the final part of this thesis, I considered whether PA might be modified through Healthy Conversation Skills. Interestingly barrier identification and problem solving were found to be negatively associated with PA changes in a systematic/meta-analysis review that investigated the type of intervention techniques that are effective in changing PA (244). However, consideration of the approaches taken by the studies mentioned in the review in identifying barriers or solving problems are relevant. This is because identifying barriers and issues to solve is a sensitive process as the researcher is highlighting negative traits or elements about the participant, and for some participants this process this may not be as welcomed as for others, hence the negative association. This leads to the consideration of a participant's readiness to change. This was theorised by researchers Prochaska and DiClemente in the late 1970s in attempts to understand why some smokers were able to quit on their own, while others may need further management. The Transtheoretical Model (also called the Stages of Change Model) was developed.

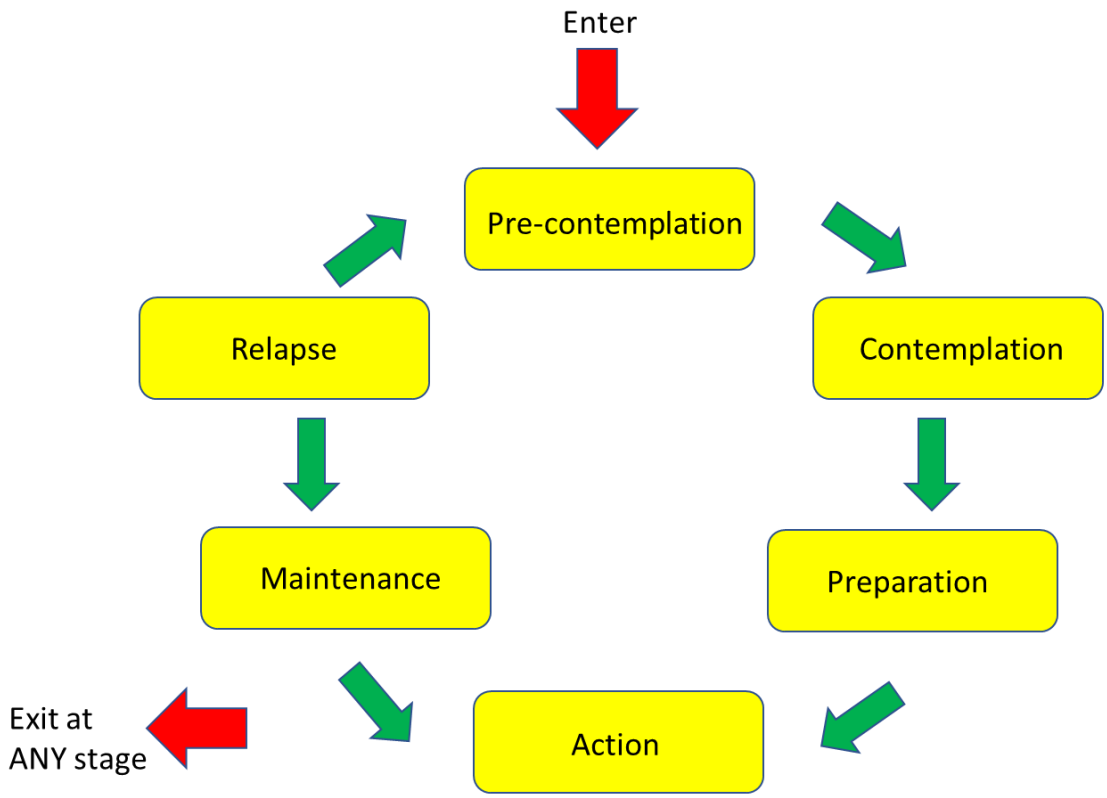


Figure 11 Diagram depicting the 6 stages of changes as described by the Transtheoretical Model.

At each of the six stages in the Transtheoretical Model (245), the readiness of a person to make changes will vary drastically, therefore will require different types of intervention to achieve a change. Those in the pre-contemplation stage may not be aware of the problem existing nor the pros and cons of making a health behaviour change. However, as an individual enters the contemplation phase, they will start to recognise their behaviour may be problematic and start to appreciate the pros and cons of making a behavioural change. At this stage there may be the intention to make a health behaviour change in the foreseeable future however some may remain ambivalent to make actual changes. In the preparation stage, there will be small steps made towards making behavioural changes, and a change is likely to take place soon. This is followed by the action phase, where there has been a recent change (usually within 6 months). In the maintenance phase, effort and work are required to maintain the new health behaviour and usually the change is maintained for longer than 6 months. At this stage some of the effort will be inputted to prevent relapse into earlier stages of the cycle. There is a further stage in the Transtheoretical Model that is not demonstrated in Figure 11, the termination stage, where the individual has no desire to relapse into their previous behaviour and are sure that their changed behaviour will not relapse. In reality, this stage is rarely reached, therefore in the context of healthy behaviour interventions this stage is omitted.

Some previous research have considered this aspect of readiness in their study protocols. In a Taiwanese study, older adults assessed to be in either the contemplation or preparation stage were recruited to a 6-months study. The intervention group performed elastic band exercises for 40 minutes, three times per week for 6 months, plus additional strategies to aid health behaviour changes and the control group performed their usual daily activities (246). The exercise programme helped the participants to maintain functional fitness, which improved significantly in 6 months. Whilst we did not explicitly measure the readiness of our participants to making changes in the NAPA study, signs of resistances were noted during process evaluation, and this could be used as a surrogate marker. It is likely those who were open to the healthy conversations and made active effort to make changes or maintained their PA level were in the contemplation or preparation stages. It can also be argued that for those participants who were already highly active, they might already be in the action or maintenance stage, depending on how long they have sustained their high levels of PA for. The dynamic cycle of Transtheoretical Model was observed during process evaluation, as signs of resistances changed at different timepoints in some of the individual. Therefore, the readiness of the NAPA participants will have affected the efficacy of the intervention, and the outcome will likely improve if the intervention was applied to only those who are in the contemplation stage or beyond.

One of the limitations using the Transtheoretical model is that the context in which the intervention is being applied is not considered. Therefore, within the NAPA study the reasons for these older adults behaving differently between the follow up calls would have not been incorporated using this model. Process evaluation demonstrated the importance of context in terms of fully understanding how the intervention can be utilised most effectively. For instance, there were those who temporarily had to change their lifestyle drastically due to the hospitalisation of their partner. Through the lens of the Transtheoretical Model, the behaviour of these participants may have appeared to place them in the relapse stage. In reality these acute events are common occurrences in this age group of older adults and should not be considered as relapses as these are exceptional circumstances and it is reasonable for the participants to alter their daily routine (therefore their daily PA levels) in response. Another limitation of the model is that the model considers that all will have made coherent and thought-out plans for transitioning between the stages, where for some this would be done without conscious planning whilst for others this planning process would have likely to occur. For instance, in NAPA, there were engaged participants that made detailed plans of activities they would like to achieve in the coming months, thus displayed coherent and throughout plans. In contrast many participants did not make clear plans in the prior contact points and at the next call revealed they started a new activity or increased their activities due to a range of reasons such as good weather and social

elements. However, I do accept some of these participants may have had a private thought-out process that occurred between the follow up calls.

There are no other studies to directly compare with the NAPA study. Healthy Conversation Skills have been used as interventions in younger cohorts: pregnant women (228, 229) and parents of children (144), however it would be difficult to compare these studies are they are very different. To summarise, the key differences include firstly the lifecourse stages are different, and secondly the setting in which the studies were set out varied greatly, hence would make fair comparison between the studies very difficult. One unique consideration for the older adult cohort is the use of wording "goal setting" or "goal/s" and as previously mentioned in 2.5.3.3.1, after the initial few home visits it became evident these two terms were not appropriate for this age group. There were negative responses, both verbally and non-verbally, and were noted by both researchers independently. Thus, it was discussed at an early stage of the baseline home visits, the word involving "goal" was to be avoided to reduced resistance to the intervention uptake. Due to this key change in the way Healthy Conversation Skills was delivered, this may have altered the dynamic of the intervention, and therefore may affect the efficacy of Healthy Conversation Skills on PA levels in comparison to the use of it in a younger adult cohort. However, whilst for some of the participants they may have not gathered the drive of the intervention was to maintain or increase their PA levels and felt the interim telephone calls were more like a "well-being" call, it was evident from the language used by other participants; they were aware an intervention was being delivered. Further qualitative research into refining the type of wording that can be used in older adults to convey the message of goal setting would be beneficial in improving its efficacy.

Amongst the various studies that have previously utilised Healthy Conversation Skills, there are shared commonalities. The use of Healthy Conversation Skills has been found to be a feasible and acceptable method of intervention in the different cohorts. It helped the participants to feel empowered to make changes in their lifestyle and feedback from the clinical practitioners in the SPRING study showed its useability in a real life clinical setting (247). However, there are some drawbacks with this approach, there were reports of participants felt being judged and under pressure (247), and this is likely to partially due to how well versed the practitioner is in using Healthy Conversation Skills. The confidence in using Healthy Conversation Skills seems to be related to the frequency of its usage, and if not used frequently this then can become a barrier to the practitioner (143, 145). The ability to use Healthy Conversation Skills in such varied cohorts demonstrates the versatility of the method.

The COVID-19 pandemic will have had an impact on the NAPA study. One positive finding from this unexpected turn of event is the study demonstrated it is possible to engage older adults by

telephone during a global pandemic when a proportion of the population were shielding. The scope of NAPA was to encourage these older adults to eat healthily and remain physically active. However, the restrictions placed by the government would have impeded on these two matters with PA being most adversely affected. This is likely due to most of the NAPA participants would have been classified as "vulnerable". The vulnerable group were advised to shield therefore to stay indoors as much as possible. The consequent reduction in PA levels may have aided a quicker musculoskeletal decline through the lack of use compared with the usual age-related decline that would have naturally occurred in this age group. Direct impact of COVID-19 on this group of older adults were assessed, via a sub-study to NAPA. The COVID-19 extension study took place between August 2020-October 2020 to investigate the effects of the lockdown on PA, diet, mental wellbeing, and social isolation (248). This work was led by a postdoctoral research assistant (GB) and a third-year medical student. Results showed 47% respondents reported being less physically active than pre-pandemic, with only 5% reported being more physically active than before the pandemic. Unfortunately, the decrease in daily PA due to the restrictions from the pandemic was not unique to our cohort of older adults, this was observed across the world in older adults (249-252). Diet quality remained largely unchanged in HCS, and 27% reported reduction of alcohol consumed compared to before the pandemic. The results of the COVID-19 extension study support my earlier hypothesis of PA being more adversely affected than diet because of the COVID-19 restrictions. This could be the restrictions had a direct impact on PA as the public were encouraged to stay at home as much as possible, whereas food shopping could be circumvented with the availability of online home deliveries, and in some cases family and neighbours stepped up to help with food shopping therefore reducing potential negative impact on the older adult's diet. Interestingly and by contrast the long-established cohort study, Longitudinal Aging Study Amsterdam, found their participants (n= 1119, aged 62-98 y, 52.8% female) reported a negative impact on nutrition due to COVID-19 pandemic as they felt they snacked more frequently or would skip meals (249).

6.3 Strengths and weaknesses of thesis

Specific strengths and weaknesses of each sub-study have been previously addressed in each of the individual chapters. In this section I will summarise overarching strengths and weaknesses of my thesis.

This thesis uses a well -studied cohort of community dwelling older adults residing in the county of Hertfordshire. There are strengths and limitations with the sole use of this cohort for the entire thesis. A strength is that this is a well-studied group, therefore for the qualitative study, this may mean the participants are comfortable with being involved with research and the research team.

Therefore, they may be more likely to be open with their thoughts and views allowing a unique insight to this group of older adults. For the NAPA study, this was first time Healthy Conversation Skills being utilised in the older adult age group, therefore having a cohort of participants that are familiar with research can be helpful in testing a novel approach, as they could be open to try new strategies. The main limitation with the sole use of one cohort is representativeness of the findings in my thesis. With a well-studied cohort, the presence of health selection bias is likely to be present. At baseline HCS has been shown to be representative of the general UK population of this age with regards to lifestyle characteristics such as BMI and smoking (149).Therefore the findings from this thesis might be applicable to geographical areas with high proportions of Caucasians. However, given all participants in the HCS are Caucasians therefore the findings cannot be generalised to include those of ethnic minority origins, and thus cannot be considered representative of the general UK population.

Questionnaire data have been used extensively in this thesis, thus self-reported measures relating to health, PA and lifestyle were used for Chapters 3 and 5. Measurement error is commonly associated with such measures. In Chapters 3 and 5, validated methods of FFQ and LAPAQ were used to collect data on diet quality and PA level in older adults. LAPAQ has been validated against 7 day diary and pedometers (112) and has been shown to have reasonable reproducibility (111), and repeatability (112). However, it seemed to underestimate the amount of PA when compared with accelerometery data (111, 253). However, given the analyses throughout the thesis consistently used data derived from LAPAQ at different timepoints, the validity of our analyses remains as often we were looking at delta changes rather than absolute values. Recall of previous WBPA data was used in Chapter 3, and this would be prone to recall bias, however this is a systematic bias therefore should not affect the outcome of the analysis. Due to the age group of the cohort being on the older end of the age spectrum, another pertinent issue to consider is the cognitive status of participants at the time of completing the questionnaires. This was not formally assessed, and applied capacity was utilised as all participants were consented for participation in the study. At the stage of the participant completing the consent form, the researcher had to assess whether the participant had capacity. It is important to state cognitive function and capacity are not the same thing, and a person can start to have cognitive impairment and still retain capacity. Therefore, I do acknowledge not formally assessing the cognitive function of the participants could have impacted my study. The possibility of cognitive function impacting recall was explored in one study that reported self-reported PA measured via questionnaires versus PA measured by accelerometers (119). The authors found the mean differences between self-reported and accelerometer-assessed PA were associated with cognitive function in men but not in women in a cohort of 1172 community-dwelling older adults (aged 65-90 years). Robust

objective measurements were used for Chapters 3 and 5 and similar protocols were followed for the obtainment of grip strength, height, and weight at both timepoints. Each measurement was repeated 3 times, for grip strength this applied to both sides, but weight was measured once. Grip strength measurement is feasible, acceptable and has good reliability. Low grip strength has been consistently linked to poor outcomes including falls and fractures (162). For Chapter 3, BMD measurements were taken, and this followed a standard protocol for obtainment of BMD via DXA scanner. For Chapter 5, gait speed, balance test and chair raises were measured as part of SPPB, which was developed by the National Institute of Ageing. The standard protocol for the measurements were followed and SPPB has been shown to have good to excellent reliability and good reproducibility (162).

With the ongoing COVID-19 pandemic at the start of the 1-year follow up data collection in November 2020, it was evident there were logistic obstacles that required consideration. Firstly, due to the restrictions of the pandemic, a repeat home visit at 1-year follow up was not possible, therefore the loss of objectively measured outcomes. Secondly, we were unable to co-ordinate the delivery and return of the accelerometers via the postal/delivery system. From our previous experience at baseline where the accelerometers were predominantly fitted by the visiting researcher at the home visit, we had incurred cases where the accelerometer was lost in the post on return. Therefore, to rely on the postal/delivery system to get the accelerometer to the participant and then back to us was likely to result in the loss of the accelerometer. Therefore, in conclusion it was deemed not possible to orchestrate the collection of accelerometery data at the 1-year follow up. We were therefore reliant on self-reported outcome measures at 1-year.

The final key strength of this thesis is the combination of quantitative and qualitative data analyses with an intervention trialled in a pilot study. The integration of the two different types of data analyses have allowed a more insightful glimpse into the relationship between older adults and PA, especially understanding the determinants in affecting the amount of PA performed. This, then cumulated in the novel trial of a pilot study using a behavioural method in promoting PA in older adults.

6.4 Implication for further research and future practice

Process evaluation has yielded enlightening information on the delivery of Healthy Conversation Skills in a cohort of older adults. Prior to repeating the NAPA study using a larger cohort, it might be informative if the participants of the NAPA study were invited to give their thoughts on the study. A select sample of those in both control and intervention groups should be interviewed. There is merit in having the thoughts of the both groups as the control group can give a fresh

opinion on how they would have liked a participant-led behaviour intervention to be carried out. Those in the intervention group can feed back on what aspects of the current intervention worked for them and what aspects should be changed.

A suggested modification to the criteria for recruitment of participants, is to recruit older adults that are in the contemplation or preparation stage of the transtheoretical model only. By applying Healthy Conversation Skills to those in states that are receptive to change, this may improve the efficacy of Healthy Conversation Skills in promoting PA in older adults. This is likely to be a common barrier met by those involved in behavioural change interventions, and the lack of perceived "efficacy" of the behavioural intervention can contribute negatively to further funding of research in this area. Another question to consider is whether the measurements of outcome commonly used are most sensitive in picking up the changes induced by a behavioural intervention? Behavioural intervention is complex as it can be affected by a wide range of factors as demonstrated by process evaluation. Therefore, the traditional objective measures such as fitness measurements, BMD, and time spent being active, can reflect one aspect of the success of the behavioural intervention. However, they tend not to consider contextual factors and psychological aspects.

To achieve a behavioural change at a population level, several crucial elements are required: the readiness of the population, the appropriate behavioural intervention or modifier to facilitate the likelihood of a successful modification, and the right environment to propel such a change. Psychology's influence on policy making has been crucial on past health related policies including tobacco regulations, and childhood obesity (254). The concept of "Healthy Ageing" is still in its infancy and this will require years of further research, and exposure to the mass public for it to become as familiar as the movement in stop smoking. Combining the expertise of health psychologists and data from studies such as the NAPA study may make it possible to generate and refine a set of policies and guidelines to shape a successful campaign on Healthy Ageing,

Small incremental steps in generating awareness of Healthy Ageing have been observed over the last 8 years from different health bodies in the UK. NHS England in partnership with Age UK, Public Health England, and the Chief Fire Officer's Association and older people published a practical guideline on how to achieve healthy ageing (255), and a separate guide for careers of older adults (256). Ongoing research has resulted in a shift of the messaging in the 2019 edition of UK Chief Medical Officers' Physical Activity Guidelines which stressed any increase in levels of PA can lead to better health outcomes (24). A well-thought-out public campaign using this new message can be instrumental in promoting a more active general population. In a joint statement made by Public Health England and Centre for Ageing Better in 2019, collaborative efforts will be

made to lead on the endeavours set out by WHO/UN in the Decade of Healthy Ageing 2020-2030 to promote Healthy Ageing (257). Some of the key principles in this statement focus on “removing barriers and creating more opportunities for older adults to contribute to society” and “challenging ageist and negative language, culture and practices”. Both are pertinent points and were observed in the qualitative study, Chapter 4. Learning from our focus groups study, a drive to encourage employment of older adults in organisations and workplaces can be a good start to integrate older adults with younger adults and help them to feel valued. To achieve this successfully, it will be complex, and no single solution will solve all. However, having this framework in place is a starting point for changes to evolve over the years, and for us as a population to adapt to a healthier approach to life, and thus ageing.

6.5 Conclusion

In my thesis I have explored the benefits, motivators, barriers, and a trial of a possible method to modify PA in older adults. The positive benefits of WBPA on BMD in women was demonstrated, and tracking showed those remained active in their middle age were more likely to remain active in later life. Qualitative data illustrated the power of psychological and social elements in determining PA later in the lifecourse. Utilising findings from this study, the novel use of Healthy Conversation Skills in an older adult cohort was developed and reported in the NAPA study. This pilot study proved it was feasible to deliver a telephone-based intervention using Healthy Conversation Skills to older adults, and following the high engagement rate, probable acceptability can be inferred.

The future of intervention in promoting PA in older adults involves the use of behaviour approach such as Healthy Conversation Skills, as this can build the concept of Healthy Ageing within our society. In addition, future policies and guidelines should focus on the principles of Healthy Ageing to help the public to make transition to a healthier lifestyle across the lifecourse.

Appendix A Hertfordshire Qualitative Study – Focus Group Discussion Guide

Main research aim: To gain a better understanding of the factors that influence food choice, diet quality and physical activity in older adults.

Welcome, thank you and housekeeping:

(tape-recording, fire exits/alarms, toilets, mobile phones, timings for the day)

Introduction: 'This study is interested in the lifestyle choices of older adults, in order to consider how they might be supported to maintain or improve their overall health. The purpose of the discussion today is to learn more about your food choices and physical activity.'

Introduction & opening question:

'Can you tell us who you are and say what a healthy lifestyle means to you?'

Questions (diet):

- What foods do you enjoy, eat often, rarely, or never?
- What do you think influences your food choices? *(Refer to prompt list if necessary)*
- What prevents you from choosing other (healthier?) foods? *(Refer to prompt list if necessary)*
- How do you think your diet has changed over the last 10-15 years?
- What caused those changes to happen?

Questions (physical activity):

- What sort of physical activity do you do (in leisure time, structured or not, frequency…)?
- What motivates you to exercise? *(Refer to prompt list if necessary)*

- What do you think prevents you from doing more (any) physical activity? *(Refer to prompt list if necessary)*
- How do you think your exercise habits have changed over the last 10-15 years?
- What caused those changes to happen?

Questions (general):

- What do you think could help people maintain a healthy lifestyle as they get older?
- In order to help people achieve this, what services/initiatives do you think should be added/improved in the community?
- How would you feel about taking part in a lifestyle-focused intervention study?

Ending questions: We are almost finished with our discussion:

- What, if anything, have we not covered?
- What, if anything, would you like to add?

Prompts – Possible influences on <u>food choice/diet quality</u> in older people:

Dietary knowledge	Past experiences	Habit	Cooking skills
Social setting	Social support	Eating alone	Loss of a partner / loneliness
Physical and mental health / wellbeing	Weight concerns	Appetite	Taste
Priority of food	Transport	Access	Money
Self-efficacy			

Prompts – Possible influences on <u>physical activity</u> in older people:

Knowledge	Disease Management	Advice from healthcare professional	Physical and mental health / wellbeing
Fear and Negative Experiences	Social Isolation	Social Activity	Environment

Time	Money	Lack of Interest	Self-Efficacy

Appendix B Coding Framework for Hertfordshire Cohort Study: Focus Group Study

Focus group analysis coding framework – Hertfordshire Qualitative Study
Research question: What influences physical activity in community-dwelling older adults?

Theme	Sub-theme	Descriptor	Example Quotes
1. **Past life experiences**	*None*	Memories of childhood experiences of PA, e.g. school days. Past PA behaviour and habit formation, e.g. related to working life, raising family. Past life experiences as barriers to PA	'Well I was just thinking from our school days and what was available to us then I mean sport played a very big part in education those days it's got less and less currently so therefore I learnt to love sport 'cos I actually played it at school and I've always played a form of sport I've even played netball so um' FG08 'I used to teach Keep Fit for 50 years and when I retired I now still attend it a Keep Fit class' FG11
2. **Significant life events**	2.1 Retirement	Change of pace due to retirement, work involvement or changes in activities post-retirement	'Yeah I don't sit around I like to work I just you know I worked all my life seven days a week most of it um and then to suddenly stop work and you find you've got a day you know all the days are the same and you know you get very lazy actually because 'oh I won't do it this morning I'll do it this afternoon'' FG05
	2.2. Bereavement	Impact on PA due to loss of partner or family member or peers (including illness prior to loss)	'Mine is one because my husband died so we used to go out together I haven't got him and the second reason I don't walk is because I've moved' FG06
3. **Getting older**	*None*	Changes related to ageing process e.g. energy levels, gradual/inevitable decline. Medical conditions and events: medical impediments to PA; encouragement from &/or interactions with medical personnel	'As you get a bit older I think you are a bit more limited with the things you can do so it is a gradual change' FG05 'Each year I think you notice ooh I could've done more last year than I can do now mm definitely I find' FG07 'I mean as we're getting older most of us have either got a bad knee or a bad hip in my case I used to do a lot more walking than I do now but I just can't do it it's too painful' FG05 'I did go to a Tai Chi class and did used to go swimming but I'm currently attending a cardiologist at [hospital name] and I'm waiting the outcome of that before I ask those questions about whether I can or not' FG04
4. **Physical activity environment**	4.1 Availability of local services and facilities	Provision of services/activities e.g. from council; familiarity of surroundings, rural v urban, garden	'Well 5 years ago I moved from [place name] to [place name] so I'm not doing enough walking because it's I don't know I just don't feel I want to walk in those places where I don't know' FG06 'There's a difference between living in a rural place and an urban place' FG04 'Our council does less and when I retired … they ran fun for 50s and that's where I was introduced to walking and I belong to a walking club now because of that, but they don't do that any longer' FG09
	4.2 Accessibility	Access to activities/classes/ medical care, including cost and transport options	'… I know one or two people who actually, you know they get up in the morning and on goes the television and that's their day, because they can't really afford to do anything else' (FG10M)
5. **Psychological/ personal factors**	5.1 Mental state	Mental well-being, self-esteem, enjoyment of PA, low mood/depression	'Unfortunately my husband suffers from dementia which means our life has changed rapidly in the last 12 months 18 months or so we used to spend a lot of time going abroad on holidays and things like that um now I find um I do get depressed because of this and um so we belong to Age UK and those sort of things we got to their exercise classes and things and um it's difficult really to say but I feel I feel relatively fit I mean um I'm quite stiff when I get up in the morning and often suffer with a backache but um apart from that we're both physically okay but it is as I say I do get very very depressed' (FG7W) 'I do a lot of mental work like magazines and things like that I like to keep me brain going' FG09
	5.2 Motivation and maintaining independence	Determination to maintain independence, keep mentally active & keep going, self-efficacy	'When you stop doing something then you never take it up again so you go to keep doing what you've been doing all your life' FG08 'I do gardening I'll do anything driving I do antique fairs as long as I'm busy it gives you if you've got when you say when you wake up in the morning as long as you've got something to do it's something to do you know it's something to look forward to you think oh tomorrow I've got to do this do that that keeps you going it's no good sitting around doing nothing vegetating is it' FG08
	5.3 Beliefs and self-awareness	Beliefs about current level of PA & intentions, preferences; idea of being 'older', taking naps	'I try not to go to sleep after lunch it's only too easy to do it but I don't want to get in the habit of it…' FG09
6. **Social capital**	*None*	Influence of partner/family/friends/ peers/community on own or others' PA activity levels, choices or attitudes;	'Well I'm lucky I come from a village and they are very very friendly' FG01

Coding Frame PA 23rd July 2021

Focus group analysis coding framework – Hertfordshire Qualitative Study

Research question: What influences **physical activity** in community-dwelling older adults?

Theme	Sub-theme	Descriptor	Example Quotes
		social aspects of going out/taking part in activities, eg exercise classes, U3A; belonging to societies/groups/ volunteering. Social isolation. Having a dog as a motivator.	'Well the grandchildren I've got five grandchildren and three great-grandchildren they really keep you active we see a lot of them and that is a lot of ... but they do keep you active' FG03 'We walk once a month with the U3A' FG03 'So really what you want is someone who's more or less your age who will stroll along and' FG06 'Well you meet local groups of people you have a chat you do your exercise and you may go off afterwards go and have a cup of coffee so' FG07 'I have a dog I walk the dog twice a day my hips do play up like today but I still go for a walk um I'm a masochist as well I think (laughs) FG04

Current types of PA undertaken (providing context to these people's lives in relation to PA): Any forms of activity e.g. sports, gardening, housework, hobbies, dog walks, alone or with others/groups

Appendix C Ethical Approval Documents for the NAPA study

NHS
Health Research Authority

East of England - Cambridgeshire and Hertfordshire Research Ethics Committee

The Old Chapel
Royal Standard Place
Nottingham
NG1 6FS

27 September 2019

Dear Dr Nichols Fuggle,

Study title:	**Understanding the early life and environmental determinants of bone strength and structure using participants from the Hertfordshire Cohort Study.**
REC reference:	**11/EE/0196**
Protocol number:	**8012**
EudraCT number:	**N/A**
Amendment number:	**Substantial Amendment 04**
Amendment date:	**09 August 2019**
IRAS project ID:	**80524**

The above amendment was reviewed on 06 September 2019 by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Covering letter on headed paper [Response to Committee Queries - REC Committee Cover Letter]		24 September 2019
Letters of invitation to participant [HCS Nutrition and PA Study Invitation Letter]	V1.0	19 June 2019
Non-validated questionnaire [HCS Nutrition and PA Study Questionnaire]	V1.0	19 June 2019
Notice of Substantial Amendment (non-CTIMP)	Substantial Amendment 04	09 August 2019
Other [HCS Nutrition and PA Study Telephone Guide]	V1.0	19 June 2019
Other [HCS Nutrition and PA Study Contact Sheet]	V1.0	19 June 2019
Other [Original REC form signed by new CI]		30 August 2019

Other [HCS Nutrition and PA Study Conduct Information, Tracked]	V1.1, Tracked	24 September 2019
Participant consent form [HCS Nutrition and PA Study Consent Form]	V1.0	03 July 2019
Participant information sheet (PIS) [GENEActiv Physical Activity Monitor: Participant Information]	V1.0	19 June 2019
Participant information sheet (PIS) [HCS Nutrition and PA Study Participant Information Leaflet, Tracked]	V1.1, Tracked	24 September 2019
Research protocol or project proposal [Protocol HCS Nutrition and PA Study, Tracked]	V1.9, Tracked	24 September 2019
Sample diary card/patient card [HCS Nutrition and PA Study GENEActiv participant diary]	V1.0	19 June 2019
Summary CV for Chief Investigator (CI) [CV Jean Zhang]		

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

Working with NHS Care Organisations

Sponsors should ensure that they notify the R&D office for the relevant NHS care organisation of this amendment in line with the terms detailed in the categorisation email issued by the lead nation for the study.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

HRA Learning

We are pleased to welcome researchers and research staff to our HRA Learning Events and online learning opportunities– see details at: https://www.hra.nhs.uk/planning-and-improving-research/learning/

11/EE/0196: Please quote this number on all correspondence

Yours sincerely,

P.P
Mr David Grayson
Chair

E-mail: nrescommittee.eastofengland-cambsandherts@nhs.net

Enclosures: *List of names and professions of members who took part in the review*

Copy to: *Diana Galpin*

East of England - Cambridgeshire and Hertfordshire Research Ethics Committee

Attendance at Sub-Committee of the REC meeting on 06 September 2019

Committee Members:

Name	*Profession*	*Present*
Dr Mauro Buraglio	Independent Consultant in Clinical Pharmacology and Clinical Development	Yes
Mr David Grayson (Chair)	Retired Local Government Administrator	Yes

Also in attendance:

Name	*Position (or reason for attending)*
Miss Katie Arnold	Approvals Administrator

University of
Southampton

Dr N R Fuggle
University of Southampton
Human Development and Health Sciences

Date: 16th July 2019

Dear Dr Fuggle,

Professional Indemnity and Clinical Trials Insurance

Project Title: Understanding the early life and environmental determinants of bone microarchitecture using participants from the Hertfordshire Cohort Study **(amendment 4)**

ERGO Ref: 12827
Participant Numbers: increased by 200

Thank you for submitting the documents notifying the substantive amendment on this project.

Having taken note of the information provided, I can confirm that this project will continue to be covered under the terms and conditions of the above policy.

If there are any changes to the above details, please advise us as failure to do so may invalidate the insurance.

Mrs Jenny King
Senior Insurance Services Assistant

Tel: 023 8059 2417
email: jsk1n08@soton.ac.uk
Finance Department, University of Southampton, Highfield Campus, Southampton SO17 1BJ U.K.
Tel: +44(0)23 8059 5000 Fax: +44(0)23 8059 2195 www.southampton.ac.uk

Appendix C

Document for the ethics amendment for changes made for 1-year follow up and the COVID-19 Extension Study.

NHS
Health Research Authority

East of England - Cambridgeshire and Hertfordshire Research Ethics Committee

The Old Chapel
Royal Standard Place
Nottingham
NG1 6FS

Please note: This is the favourable opinion of the REC only and does not allow the amendment to be implemented at NHS sites in England until the outcome of the HRA assessment has been confirmed.

24 June 2020

Dear Ms Bloom,

Study title:	**Understanding the early life and environmental determinants of bone strength and structure using participants from the Hertfordshire Cohort Study.**
REC reference:	**11/EE/0196**
Protocol number:	**8012**
EudraCT number:	**N/A**
Amendment number:	**Substantial Amendment 5**
Amendment date:	**28 May 2020**
IRAS project ID:	**80524**

The above amendment was reviewed at the meeting of the Sub-Committee held in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Non-validated questionnaire [Questionnaire for telephone interviews with older people COVID-19_v1 Intervention Group]	1.0	14 May 2020
Non-validated questionnaire [Questionnaire for telephone interviews with older people COVID-19_v2 Control Group]	1.0	14 May 2020
Non-validated questionnaire [HCS Nutrition and PA Study	1.0	14 May 2020

A Research Ethics Committee established by the Health Research Authority

Questionnaire 1 year FU]		
Notice of Amendment (non-CTIMP)	Substantial Amendment 5	28 May 2020
Other [REC Committee Response Letter]		18 June 2020
Research protocol or project proposal [Protocol HCS Nutrition and PA Study Tracked Changes]	2.0	18 June 2020

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

Working with NHS Care Organisations

Sponsors should ensure that they notify the R&D office for the relevant NHS care organisation of this amendment in line with the terms detailed in the categorisation email issued by the lead nation for the study.

Amendments related to COVID-19

We will update your research summary for the above study on the research summaries section of our website. During this public health emergency, it is vital that everyone can promptly identify all relevant research related to COVID-19 that is taking place globally. If you have not already done so, please register your study on a public registry as soon as possible and provide the HRA with the registration detail, which will be posted alongside other information relating to your project.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

HRA Learning

We are pleased to welcome researchers and research staff to our HRA Learning Events and online learning opportunities– see details at: https://www.hra.nhs.uk/planning-and-improving-research/learning/

11/EE/0196: Please quote this number on all correspondence

Yours sincerely

pp f. Slade

Professor Barry Hunt
Chair

E-mail: cambsandherts.rec@hra.nhs.uk

Enclosures: *List of names and professions of members who took part in the review*

A Research Ethics Committee established by the Health Research Authority

Copy to: *Dr Nichols Fuggle*
Diana Galpin

East of England - Cambridgeshire and Hertfordshire Research Ethics Committee

Attendance at Sub-Committee of the REC meeting on 29 May 2020

Committee Members:

Name	*Profession*	*Present*	*Notes*
Dr Mauro Buraglio	Independent Consultant in Clinical Pharmacology and Clinical Development	Yes	
Professor Barry Hunt	Pro-Vice Chancellor (International) (Retired)	Yes	Chaired the Meeting

Also in attendance:

Name	*Position (or reason for attending)*
Miss Faye Slade	Approvals Administrator

Appendix D NAPA study baseline questionnaire

Participant ID Number:	

Understanding the early life and environmental determinants of bone strength and structure: *The Hertfordshire Cohort Study Nutrition and Physical Activity Study*

Questionnaire

UNIVERSITY OF Southampton

MRC Lifecourse Epidemiology Unit

Today's date: | | | | | | | d d m m y y

Date of birth: | | | | | | | d d m m y y

SECTION 1: BACKGROUND

1. In terms of relationships, which of the following would best describe your current status? *Please tick one box*	
i. Single	☐
ii. Married	☐
iii. Divorced or separated	☐
iv. Widowed	☐
v. Cohabiting	☐
vi. Civil partnership	☐

2. Category of domicile *Please tick all that apply*	
i. Alone	☐
ii. Not alone (lives with friend/partner/family)	☐
iii. Sheltered/warden controlled flat	☐
iv. Other *(please specify)* _____	☐
If answer to category of domicile is "alone", how long have you lived alone? (Years. Months)	

3. Is your accommodation:	
i. Owned/mortgaged	☐
ii. Rented	☐
iii. Other *(please specify)* _____	☐

SECTION 2: NUTRITION AND DIET

4. DETERMINE Checklist
Circle the number in the 'yes' column for those that apply to you. For each 'yes' answer, score the number in the box. Total the nutritional score.

Item		YES
1	I have an illness or condition that made me change the kind and/or amount of food I eat.	2
2	I eat fewer than 2 meals per day.	3
3	I eat few fruits or vegetables or milk products.	2
4	I have 3 or more drinks of beer, liquor or wine almost every day.	2
5	I have tooth or mouth problems that make it hard for me to eat.	2
6	I don't always have enough money to buy the food I need.	4
7	I eat alone most of the time.	1
8	I take 3 or more different prescribed or over-the-counter drugs a day.	1
9	Without wanting to, I have lost or gained 10 pounds in the last 6 months.	2
10	I am not always physically able to shop, cook and/or feed myself.	2
	TOTAL	

5. Now I am going to ask you how often over the past 3 months you have eaten particular foods

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS									
		Never	Less than once/ month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
1.	White bread *(one slice)*	0	1	2	3	4	5	6	7	8	9
2.	Brown and wholemeal bread *(one slice)*	0	1	2	3	4	5	6	7	8	9
3.	Biscuits *e.g. digestive (one)*	0	1	2	3	4	5	6	7	8	9
4.	Apples *(one fruit)*	0	1	2	3	4	5	6	7	8	9
5.	Bananas *(one fruit)*	0	1	2	3	4	5	6	7	8	9
6.	Melon, pineapple, kiwi and other tropical fruits *(medium serving)*	0	1	2	3	4	5	6	7	8	9
7.	Green salad *e.g. lettuce, cucumber, celery*	0	1	2	3	4	5	6	7	8	9
8.	Garlic – *raw and cooked dishes*	0	1	2	3	4	5	6	7	8	9
9.	Marrow and courgettes	0	1	2	3	4	5	6	7	8	9
10.	Peppers – *cooked & fresh*	0	1	2	3	4	5	6	7	8	9
11.	Yogurt *(125g pot)*	0	1	2	3	4	5	6	7	8	9
12.	Eggs as boiled, fried, scrambled etc. *(one egg)*	0	1	2	3	4	5	6	7	8	9
13.	White fish *e.g. cod, haddock, plaice, sole (not in batter/crumbs)*	0	1	2	3	4	5	6	7	8	9
14.	Oily fish, *e.g. mackerel, tuna, salmon*	0	1	2	3	4	5	6	7	8	9
15.	Bacon and Gammon	0	1	2	3	4	5	6	7	8	9
16.	Meat pies, *e.g. pork pie, pasties, steak & kidney, sausage rolls*	0	1	2	3	4	5	6	7	8	9
17.	Boiled, mashed and jacket potatoes *(one egg size potato)*	0	1	2	3	4	5	6	7	8	9
18.	Chips	0	1	2	3	4	5	6	7	8	9
19.	Pasta *e.g. spaghetti, macaroni*	0	1	2	3	4	5	6	7	8	9
Which is the main spreading fat you have used for example on bread, toast or vegetables and how often do you consume this?											
20.	Spreading fat *(teaspoon)* Please name the spreading fat you use - _____	0	1	2	3	4	5	6	7	8	9

6. Please detail below the type of milk you have drunk over the last 3 months

7. And please state how much of this milk you have consumed

For questions 6 and 7 please complete table below

	25. Type of milk	Please tick	26. On average, over the past 3 months, how much milk have you consumed per day?
Example	*Whole*	✓	*0.5 pints or ½ pint per day*
1.	Whole pasteurised or UHT	☐	_____ pints per day
2.	Semi-skimmed pasteurised (include 1% milks) or UHT	☐	_____ pints per day
3.	Skimmed pasteurised or UHT	☐	_____ pints per day
4.	Other *(Please specify)* _____	☐	_____ pints per day
5.	None	☐	

8. Have you added sugar to tea and coffee or breakfast cereals in the past 3 months?	☐ Yes	☐ No
If no, go to question 10		
9. Approximately how many teaspoons of sugar have you added each day?		

10. My appetite is:	
i. very poor	☐
ii. poor	☐
iii. average	☐
iv. good	☐
v. very good	☐
11. When I eat I feel full after	
i. a few mouthfuls	☐
ii. a third of a meal	☐
iii. half of a meal	☐
iv. most of the meal	☐
v. I hardly ever feel full	☐
12. Food tastes	
i. very bad	☐
ii. bad	☐
iii. average	☐
iv. good	☐
v. very good	☐

13. Normally I eat		
i.	less than one meal per day	☐
ii.	one meal a day	☐
iii.	two meals a day	☐
iv.	three meals a day	☐
v.	more than three meals a day	☐

14. If appetite is poor or very poor:			
i.	Have you eaten in the past 5 days?	☐ Yes	☐ No
ii.	Are you likely to eat in the next 5 days?	☐ Yes	☐ No
15. How is your appetite now compared to one year ago?			
i.	unchanged	☐	
ii.	worse	☐	
iii.	better	☐	
iv.	don't know	☐	
16. Have you intentionally reduced the amount you eat in the past 3 months?		☐ Yes	☐ No

SECTION 3: PHYSICAL ACTIVITY			
17. Do you walk outside? *(explanation: with walking outside we mean walking to go shopping or doing other daily activities, like visiting someone. We do not mean: a walking tour)* *If no, please go to question 21*		☐ Yes	☐ No
18. Did you walk during the past two weeks? *If no, please go to question 21*		☐ Yes	☐ No
19. How many times did you walk in the past two weeks?			
20. How long did you usually walk for each time?			hr(s)
			mins
21. Do you cycle? *(explanation: with cycling we mean cycling to go shopping or doing other daily activities like visiting someone. With cycling we do not mean: a cycling tour)* *If no, please go to question 25*		☐ Yes	☐ No
22. Did you cycle during the past two weeks? *If no, please go to question 25*		☐ Yes	☐ No
23. How many times did you cycle in the past two weeks?			
24. How long did you usually cycle for each time?			hr(s)
			mins
25. Do you have a garden (including allotment) *If no, please go to question 31*		☐ Yes	☐ No
26. During how many months per year do you work regularly in your garden?			months
27. Did you work in the garden (or allotment) during the past two weeks? *If no, please go to question 31*		☐ Yes	☐ No
28. How many times did you work in the garden (or allotment) in the past two weeks?			
29. How long did you usually work in the garden (or allotment) for each time?			hr(s)
			mins
30. Did you dig the earth in your garden during the past two weeks?		☐ Yes	☐ No
31. Do you take part in any sporting activities? *(Sports include those activities listed in question 32)* *If no, please go to question 34*		☐ Yes	☐ No

32. Which sports did you take part in most during the past two weeks? *(Please tick box(es))*		How many times did you take part in this sport in the past two weeks?	How long, each time? hr(s)	mins
i. Distance walking				
ii. Distance cycling				
iii. Gymnastics				
iv. Cycling on a home trainer				
v. Swimming				
vi. Dancing				
vii. Bowling				
viii. Tennis, badminton				
ix. Running, fast walking				
x. Rowing				
xi. Sailing				
xii. Play billiards				
xiii. Fishing				
xiv. Playing soccer/basketball/hockey				
xv. Playing volleyball/baseball				
xvi. Skiing				
xvii. Other *(please describe)* _____, _____, _____				

33. How many times did you perspire while taking part in sport during the past two weeks?		
34. Do you do light household tasks? *Explanation: By light household tasks we mean washing the dishes, dusting, making the bed, doing the laundry, hanging out the laundry, ironing, tidying up and cooking meals.* *If no, please go to question **40***	☐ Yes	☐ No
35. How many days did you do light household tasks during the past two weeks?		
36. How long per day did you usually do light household tasks for?		hr(s)
		mins
37. Do you do heavy household tasks? *Explanation: By heavy household tasks we mean window cleaning, changing the bed, beating the mat, vacuuming, washing or scrubbing the floor, and chores with sawing, carpeting, repairing or painting.* *If no, please go to question **40***	☐ Yes	☐ No
38. How many days did you do heavy household tasks during the past two weeks?		
39. How long per day did you usually do heavy household tasks for?		hr(s)
		mins

40. You just told me about your usual activities in the past two weeks. Were the past two weeks normal as compared to the rest of the past year? *If yes, please go to question **42***	☐ Yes	☐ No
41. Why were the past two weeks not 'normal'?		
i. Disease	☐	
ii. Depression	☐	
iii. Bad weather	☐	
iv. Family occasion	☐	
v. Holiday	☐	
vi. Other (please specify) _____	☐	

SECTION 4: HEALTH, DISEASE AND MEDICATIONS

42. Have you been told by a doctor that you have any of the following conditions? *(possible examples/prompts are bracketed)*

☐ High blood pressure	☐ Vitiligo	☐ Osteoporosis
☐ Diabetes	☐ Depression	☐ Thyroid disease
☐ Lung disease *(asthma, COPD, emphysema, chronic bronchitis)*	☐ Parkinson's disease	☐ Stroke
☐ Rheumatoid arthritis	☐ Heart disease *(heart attack, angina, heart failure)*	
☐ Multiple sclerosis	☐ Peripheral arterial disease *(claudication)*	

☐ Cancer *(please specify below)*

_____

_____

_____

☐ Operations *(please specify below)*

_____

_____

_____

☐ Other serious illnesses *(please specify below)*

_____

_____

_____

_____

_____

43. Do you regularly take any medicines/tablets/eye drops/inhalers/dietary supplements etc.?

- *Using block capitals please copy the generic names from the labels on the bottles or boxes along with frequency and dosage.*
- *Use a new line for each medicine.*

Please include regular pain killers such as paracetamol and over the counter medicines such as glucosamine

Name of the Drug	Frequency	Dosage	Unit of Drug (e.g. mgs)

44. Many people find it hard to take all their medications. Do you find yourself miss any medications regularly? ☐ Yes ☐ No

If yes, which one, and why?

_____

_____

45. In the last year, have you had any falls?	☐ Yes	☐ No
If yes, how many falls?		
46. In the last year, have you had any fractures?	☐ Yes	☐ No
If yes, how many fractures?		
Can you recall the circumstance in which you fell or fractured?		
_____		
_____		
_____		

47. How would you rate the risk of you breaking your bones compared to other men/women?	
i. Much lower	☐
ii. A little lower	☐
iii. About the same	☐
iv. A little higher	☐
v. Much higher	☐

48. In the past 3-6 months, have you lost any weight unintentionally (i.e. not due to dieting or exercise)?	☐ Yes	☐ No	☐ Don't know
If yes, how much? (kg)			
What was your weight 3-6 months ago? (kg)			
49. Are you or your family concerned that you may be underweight or need nutritional advice?	☐ Yes	☐ No	☐ Don't know
50. Have you noticed that your clothes or rings have become loose recently?	☐ Yes	☐ No	☐ Don't know
51. Have you recently lost your appetite and/or interest in eating?	☐ Yes	☐ No	☐ Don't know

52. How often in the last week did you feel "everything I did was an effort" or "I could not get going?" *Please tick one box*	
i. Rarely or none of the time (less than 1 day)	☐
ii. Some or a little of the time (1-2 days)	☐
iii. A moderate amount of time (3-4 days)	☐
iv. Most of the time (more than 4 days)	☐

53. Do you or would you have any difficulty (or find it troublesome, exhausting or worrying) to do the following?	No	Yes, some difficulty	Yes unable to do alone
a. Washing down (whether in bath or not)	☐	☐	☐
b. Removing a jug, say, from an overhead shelf	☐	☐	☐
c. Tying a good knot in string	☐	☐	☐
d. Cutting toenails	☐	☐	☐
e. Running to catch a bus	☐	☐	☐
f. Going up/down stairs	☐	☐	☐
g. Going shopping and carrying a full basket of shopping in either hand	☐	☐	☐
h. Doing heavy housework	☐	☐	☐
i. Preparing a hot meal	☐	☐	☐
54. Do you have any long-term illness, health problem or disability, which limits your activities or the work you can do?		☐ Yes	☐ No

55. The following items are about activities you might do during a typical day.

Does your health now limit you in these activities? If so, how much?

		Not limited	Limited a little	Limited a lot
1.	**Vigorous** activities, such as running, lifting heavy objects. Participating in strenuous sports	☐	☐	☐
2.	**Moderate** activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	☐	☐	☐
3.	Lifting or carrying groceries	☐	☐	☐
4.	Climbing several flights of stairs	☐	☐	☐
5.	Climbing **one** flight of stairs	☐	☐	☐
6.	Bending, kneeling or stooping	☐	☐	☐
7.	Walking more than one mile	☐	☐	☐
8.	Walking half a mile	☐	☐	☐
9.	Walking one hundred yards	☐	☐	☐
10.	Bathing or dressing yourself	☐	☐	☐

56. Do you currently smoke?	☐ Yes	☐ No
57. Have you ever been a smoker? (at least once a day for one year or more)	☐ Yes	☐ No

58. Do you ever drink alcohol?	☐ Yes	☐ No
*If no, go to question **60***		
59. How often do you currently drink alcohol? (e.g.: wine/beer/lager/cider/port/spirits/liqueurs etc.) *Please tick one box*		
i. Never	☐	
ii. Once every 2-3 months	☐	
iii. Once a month	☐	
iv. Once a fortnight	☐	
v. 1-2 times per week	☐	
vi. 3-6 times per week	☐	
vii. Once a day	☐	
viii. More than once a day	☐	
When you drink these, how much would you normally have? Please document alcohol type and quantity (if a range is given then document the mid-point).	Beer/lager/cider (cans, bottles, pints...)	
	Wine (small/std/large glasses...)	
	Spirits/liqueurs (measures)	

SECTION 5: SOCIAL AND PSYCHOLOGICAL ASPECTS

60. Do you use any meal, activity or transport services? ☐ Yes ☐ No

If yes, how frequently?

	Type of service	Please tick	Frequency, ×per week
Example	*Hot meal delivery*	✓	*5 times per week*
1.	Hot meal delivery	☐	_____
2.	Frozen meal delivery	☐	_____
3.	Lunch club	☐	_____
4.	Dial-a-ride/similar	☐	_____
5.	Walking group	☐	_____
6.	Exercise group[1]	☐	_____

NB [1]for 'exercise group include dance, tai chi, yoga etc.

61. Please tell me how often you have taken part in the following activities in the last 12 months. *(Please tick)*

		Never	Less than monthly	Monthly	Weekly
1.	Religious activities/observance				
2.	Positions of office, school governor, councillor etc.				
3.	Involvement in clubs and organisations, voluntary or official				
4.	Courses and education/evening classes				
5.	Cultural visits to stately homes, galleries, theatres, cinema or live music events				
6.	Social indoor games, cards, bingo, chess etc.				
7.	Visiting friends and relatives				

8.	Going to pubs and social clubs				
9.	Individual occupations e.g. reading, listening to music				
10.	Household tasks e.g. DIY, maintenance, decorating				
11.	Practical activities, making things with your hands e.g. pottery, drawing etc.				
12.	Gardening				
13.	Using a home computer for leisure				

62. Lubben social network scale – 6 (LSNS-6)		
FAMILY: *Considering the people to whom you are related by birth, marriage, adoption, etc...*		
1.	How many relatives do you see or hear from at least once a month?	
2.	How many relatives do you feel at ease with that you can talk about private matters?	
3.	How many relatives do you feel close to such that you could call on them for help?	
FRIENDSHIPS: *Considering all of your friends including those who live in your neighbourhood*		
5.	How many of your friends do you see or hear from at least once a month?	
6.	How many friends do you feel at ease with that you can talk about private matters?	
7.	How many friends do you feel close to such that you could call on them for help?	

63. General self-efficacy *(Please tick one box per question)*					
		Strongly disagree	Disagree	Agree	Strongly agree
1.	I can always manage to solve difficult problems if I try hard enough				
2.	I can find a way to get what I want even if someone is trying to stop me				
3.	It is easy for me to stick to my aims and reach my goals				
4.	I am calm when things are difficult because I know I can cope				
5.	If I am in trouble I can usually find a way out				

SECTION 6: PATIENT REPORTED OUTCOMES

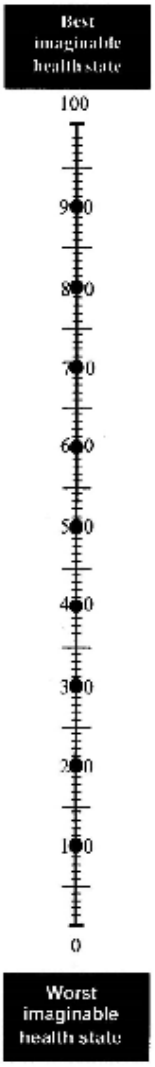
64. In terms of quality of life: *Please indicate which statement best describes your quality of life (Tick one box for each lettered section (a, b, c etc.)*	
a. Mobility	
i. I have no problems in walking around	☐
ii. I have some problems in walking around	☐
iii. I am confined to bed	☐
b. Self-care	
i. I have no problems with self-care	☐
ii. I have some problems washing or dressing myself	☐
iii. I am unable to wash or dress myself	☐
c. Usual Activities *(e.g. work, study, housework, family or leisure activities)*	
i. I have no problems with performing my usual activities	☐
ii. I have some problems with performing my usual activities	☐
iii. I am unable to perform my usual activities	☐
d. Pain/discomfort	
i. I have no pain or discomfort	☐
ii. I have moderate pain or discomfort	☐
iii. I have extreme pain or discomfort	☐
e. Anxiety/Depression	
i. I am not anxious or depressed	☐
ii. I am moderately anxious or depressed	☐
iii. I am extremely anxious or depressed	☐

65.

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked by 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is.

Your own health state today



SECTION 7: PHYSICAL EXAMINATION. TO BE COMPLETED BY RESEARCHER		
66. Height (m)		
67. Weight (kg)		
68. BMI (kg/m²)		
69. Balance tests (maximum stand for 10 seconds)		
a) Side-by-side stand (time in seconds)		
b) Semi-tandem stand (time in seconds)		
c) Tandem stand (time in seconds)		
70. Gait speed test (3m)		
a) Walk time 1 (in seconds)		
b) Walk time 2 (in seconds)		
71. Chair stand test a) Is patient able to stand up from sitting with arms folded? (Single chair stand test)	☐ Yes	☐ No
b) Time for five repetitions (seconds)		
72. Grip Strength (kg), always start with R hand, record to nearest kg:	R	L
a) First attempt		
b) Second attempt		
c) Third attempt		

If unable to complete aspects of the Short Physical Performance Battery Test, please note down the corresponding reason.		
Balance test	Side by side stand	
	Semi-tandem stand	
	Tandem stand	
Gait Speed Test	Walk 1	
	Walk 2	
Chair Stand Test	Single chair stand	
	Repeated chair stands	

Reasons:
1) Tried but unable
2) Participant could not stand/walk/hold position unassisted
3) Not attempted, you felt unsafe
4) Not attempted, participant felt unsafe
5) Participant unable to understand instructions
6) Other (Specify)
7) Participant refused

SECTION 8: ENVIRONMENTAL ASPECTS

73. Do you receive help with:		
Eating	☐ Yes	☐ No
Preparing food	☐ Yes	☐ No
Food shopping?	☐ Yes	☐ No

If yes, in the last 3 months, who usually provided you with help with these activities?
[For each activity, please rank all who provided help. Rank according to extent of help provided (from most to least help): most=1]

	Eating	Preparing food	Shopping
Partner			
Friend			
Family			
Carer			
Other *(please specify)* _____			

74. In the last 3 months could you please tell me the name and location of the shop where you (or the person in your household who does this) do most of your food shopping? Can you also include how often you shopped at that store and the approximate amount spent at each visit?
[The place where they buy most of their food from. If more than one shop is identified then ask which is store where the most food is bought]

☐	Aldi	☐	Iceland
☐	Co-op	☐	Marks & Spencer
☐	Lidl	☐	Sainsbury's
☐	Morrisons	☐	Sainsbury's local
☐	Tesco	☐	Waitrose
☐	Tesco express	☐	Internet shopping
☐	Asda	☐	Other *(please specify)* _____

1. Location _____
2. Frequency _____
3. Approximate spend per visit _____

75. What mode of transport do you (or the person in your household who does this) take to the store where you do most of your food shopping?
[If more than one option is provided, ask participant to rank them from most common method of transport to least: most=1]

☐	Car (I drive myself)	☐	Public transport/ taxi
☐	Car (I rely on a lift) [from partner/ friend]	☐	Not applicable (I do internet shopping)
☐	Walk	☐	Other *(please specify)* _____

76. Do you (or the person in your household who does this) experience any transport barriers to going food shopping?	☐ Yes	☐ No

If yes, which one(s)?

☐	No public transport	☐	No car
☐	Infrequent public transport	☐	Do not drive
☐	Public transport stops are too far away	☐	Other *(please specify)* _____

77. How much time do you (or the person in your household who does this) usually spend food shopping each week, including travelling to and from the stores?		hrs per week
		mins per week

78. Over the past 3 months, what other food shops have you (or the person in your household who does this) shopped at for groceries? Can you rank these in terms of next most used store down to the least? Can you also include how often you shopped at that store and the approximate amount spent at each visit?
[Places where food has been purchased for the household. Rank stores based on amount of food bought (from most to least): most=1]

☐ Aldi	☐ Iceland
☐ Co-op	☐ Marks & Spencer
☐ Lidl	☐ Sainsbury's
☐ Morrisons	☐ Sainsbury's local
☐ Tesco	☐ Waitrose
☐ Tesco express	☐ Internet shopping
☐ Asda	☐ Other *(please specify)* _____

	1	2	3	4	5	6
Location						
Frequency						
Approximate spend per visit						

Appendix E NAPA study 1-year follow-up questionnaire

Participant ID Number:

Understanding the early life and environmental determinants of bone strength and structure:
The Hertfordshire Cohort Study Nutrition and Physical Activity Study

Questionnaire – 1-year Follow-Up

UNIVERSITY OF Southampton

MRC Lifecourse Epidemiology Unit

Today's date: | | | | | | | d d m m y y

Date of birth: | | | | | | | d d m m y y

SECTION 1: BACKGROUND

1. In terms of relationships, which of the following would best describe your current status? *Please tick one box*	
i. Single	☐
ii. Married	☐
iii. Divorced or separated	☐
iv. Widowed	☐
v. Cohabiting	☐
vi. Civil partnership	☐

2. Category of domicile *Please tick all that apply*	
i. Alone	☐
ii. Not alone (lives with friend/partner/family)	☐
iii. Sheltered/warden controlled flat	☐
iv. Other *(please specify)* _____	☐
If answer to category of domicile is "alone", how long have you lived alone? (Years. Months)	

3. Is your accommodation:	
i. Owned/mortgaged	☐
ii. Rented	☐
iii. Other *(please specify)* _____	☐

SECTION 2: NUTRITION AND DIET

4. DETERMINE Checklist

Circle the number in the 'yes' column for those that apply to you. For each 'yes' answer, score the number in the box. Total the nutritional score.

Item		YES
1	I have an illness or condition that made me change the kind and/or amount of food I eat.	2
2	I eat fewer than 2 meals per day.	3
3	I eat few fruits or vegetables or milk products.	2
4	I have 3 or more drinks of beer, liquor or wine almost every day.	2
5	I have tooth or mouth problems that make it hard for me to eat.	2
6	I don't always have enough money to buy the food I need.	4
7	I eat alone most of the time.	1
8	I take 3 or more different prescribed or over-the-counter drugs a day.	1
9	Without wanting to, I have lost or gained 10 pounds in the last 6 months.	2
10	I am not always physically able to shop, cook and/or feed myself.	2
	TOTAL	

5. Now I am going to ask you how often over the past 3 months you have eaten particular foods

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS									
		Never	Less than once/ month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
1.	White bread *(one slice)*	0	1	2	3	4	5	6	7	8	9
2.	Brown and wholemeal bread *(one slice)*	0	1	2	3	4	5	6	7	8	9
3.	Biscuits *e.g. digestive (one)*	0	1	2	3	4	5	6	7	8	9
4.	Apples *(one fruit)*	0	1	2	3	4	5	6	7	8	9
5.	Bananas *(one fruit)*	0	1	2	3	4	5	6	7	8	9
6.	Melon, pineapple, kiwi and other tropical fruits *(medium serving)*	0	1	2	3	4	5	6	7	8	9
7.	Green salad *e.g. lettuce, cucumber, celery*	0	1	2	3	4	5	6	7	8	9
8.	Garlic – *raw and cooked dishes*	0	1	2	3	4	5	6	7	8	9
9.	Marrow and courgettes	0	1	2	3	4	5	6	7	8	9
10.	Peppers – *cooked & fresh*	0	1	2	3	4	5	6	7	8	9
11.	Yogurt *(125g pot)*	0	1	2	3	4	5	6	7	8	9
12.	Eggs as boiled, fried, scrambled etc. *(one egg)*	0	1	2	3	4	5	6	7	8	9
13.	White fish *e.g. cod, haddock, plaice, sole (not in batter/crumbs)*	0	1	2	3	4	5	6	7	8	9
14.	Oily fish, *e.g. mackerel, tuna, salmon*	0	1	2	3	4	5	6	7	8	9
15.	Bacon and Gammon	0	1	2	3	4	5	6	7	8	9
16.	Meat pies, *e.g. pork pie, pasties, steak & kidney, sausage rolls*	0	1	2	3	4	5	6	7	8	9
17.	Boiled, mashed and jacket potatoes *(one egg size potato)*	0	1	2	3	4	5	6	7	8	9
18.	Chips	0	1	2	3	4	5	6	7	8	9
19.	Pasta *e.g. spaghetti, macaroni*	0	1	2	3	4	5	6	7	8	9
Which is the main spreading fat you have used for example on bread, toast or vegetables and how often do you consume this?											
20.	Spreading fat *(teaspoon)* Please name the spreading fat you use - _____	0	1	2	3	4	5	6	7	8	9

6. Please detail below the type(s) of milk you have drunk over the last 3 months

7. And please state how much of this milk you have consumed

For questions 6 and 7 please complete table below

	25. Type of milk	Please tick	26. On average, over the past 3 months, how much milk have you consumed per day?
Example	*Whole*	✓	*0.5 pints or ½ pint per day*
1.	Whole pasteurised or UHT	☐	_____ pints per day
2.	Semi-skimmed pasteurised (include 1% milks) or UHT	☐	_____ pints per day
3.	Skimmed pasteurised or UHT	☐	_____ pints per day
4.	Other *(Please specify)* _____	☐	_____ pints per day
5.	None	☐	

8. Have you added sugar to tea and coffee or breakfast cereals in the past 3 months?	☐ Yes	☐ No
If no, go to question 10		
9. Approximately how many teaspoons of sugar have you added each day?		

10. My appetite is:	
i. very poor	☐
ii. poor	☐
iii. average	☐
iv. good	☐
v. very good	☐
11. When I eat I feel full after	
i. a few mouthfuls	☐
ii. a third of a meal	☐
iii. half of a meal	☐
iv. most of the meal	☐
v. I hardly ever feel full	☐
12. Food tastes	
i. very bad	☐
ii. bad	☐
iii. average	☐
iv. good	☐
v. very good	☐

13. Normally I eat		
i.	less than one meal per day	☐
ii.	one meal a day	☐
iii.	two meals a day	☐
iv.	three meals a day	☐
v.	more than three meals a day	☐

14. If appetite is poor or very poor:			
i.	Have you eaten in the past 5 days?	☐ Yes	☐ No
ii.	Are you likely to eat in the next 5 days?	☐ Yes	☐ No
15. How is your appetite now compared to one year ago?			
i.	unchanged	☐	
ii.	worse	☐	
iii.	better	☐	
iv.	don't know	☐	
16. Have you intentionally reduced the amount you eat in the past 3 months?		☐ Yes	☐ No

SECTION 3: PHYSICAL ACTIVITY		
17. Do you walk outside? *(explanation: with walking outside we mean walking to go shopping or doing other daily activities, like visiting someone. We do not mean: a walking tour)* *If no, please go to question 21*	☐ Yes	☐ No
18. Did you walk during the past two weeks? *If no, please go to question 21*	☐ Yes	☐ No
19. How many times did you walk in the past two weeks?		
20. How long did you usually walk for each time?		hr(s)
		mins
21. Do you cycle? *(explanation: with cycling we mean cycling to go shopping or doing other daily activities like visiting someone. With cycling we do not mean: a cycling tour)* *If no, please go to question 25*	☐ Yes	☐ No
22. Did you cycle during the past two weeks? *If no, please go to question 25*	☐ Yes	☐ No
23. How many times did you cycle in the past two weeks?		
24. How long did you usually cycle for each time?		hr(s)
		mins
25. Do you have a garden or allotment *If no, please go to question 31*	☐ Yes	☐ No
26. During how many months per year do you work regularly in your garden (or allotment)?		months
27. Did you work in the garden (or allotment) during the past two weeks? *If no, please go to question 31*	☐ Yes	☐ No
28. How many times did you work in the garden (or allotment) in the past two weeks?		
29. How long did you usually work in the garden (or allotment) for each time?		hr(s)
		mins
30. Did you dig the earth in your garden during the past two weeks?	☐ Yes	☐ No
31. Do you take part in any sporting activities? *(Sports include activities like those listed in question 32)* *If no, please go to question 34*	☐ Yes	☐ No

32. Which sports did you take part in during the past two weeks? *(Please tick box(es))*		How many times did you take part in this sport in the past two weeks?	How long, each time? hr(s)	mins
i. Distance walking				
ii. Distance cycling				
iii. Gymnastics				
iv. Cycling on a home trainer				
v. Swimming				
vi. Dancing				
vii. Bowling				
viii. Tennis, badminton				
ix. Running, fast walking				
x. Rowing				
xi. Sailing				
xii. Play billiards				
xiii. Fishing				
xiv. Playing soccer/basketball/hockey				
xv. Playing volleyball/baseball				
xvi. Skiing				
xvii. Other *(please describe)* _____, _____, _____				

33. How many times did you perspire while taking part in sport during the past two weeks?		
34. Do you do light household tasks? *Explanation: By light household tasks we mean washing the dishes, dusting, making the bed, doing the laundry, hanging out the laundry, ironing, tidying up and cooking meals.* *If no, please go to question 37*	☐ Yes	☐ No
35. How many days did you do light household tasks during the past two weeks?		
36. How long per day did you usually do light household tasks for?		hr(s)
		mins
37. Do you do heavy household tasks? *Explanation: By heavy household tasks we mean window cleaning, changing the bed, beating the mat, vacuuming, washing or scrubbing the floor, and chores with sawing, carpeting, repairing or painting.* *If no, please go to question 40*	☐ Yes	☐ No
38. How many days did you do heavy household tasks during the past two weeks?		
39. How long per day did you usually do heavy household tasks for?		hr(s)
		mins

40. You just told me about your usual activities in the past two weeks. Were the past two weeks normal as compared to the rest of the past year? *If yes, please go to question 42*	☐ Yes	☐ No
41. Why were the past two weeks not 'normal'?		
i. Disease	☐	
ii. Depression	☐	
iii. Bad weather	☐	
iv. Family occasion	☐	
v. Holiday	☐	
vi. Other (please specify) _____	☐	

SECTION 4: HEALTH, DISEASE AND MEDICATIONS

42. Have you been told by a doctor that you have any of the following conditions? *(possible examples/prompts are bracketed)*

☐ High blood pressure	☐ Vitiligo	☐ Osteoporosis
☐ Diabetes	☐ Depression	☐ Thyroid disease
☐ Lung disease *(asthma, COPD, emphysema, chronic bronchitis)*	☐ Parkinson's disease	☐ Stroke
☐ Rheumatoid arthritis	☐ Heart disease *(heart attack, angina, heart failure)*	
☐ Multiple sclerosis	☐ Peripheral arterial disease *(claudication)*	

☐ Cancer *(please specify below)*

_____

_____

_____

☐ Operations *(please specify below)*

_____

_____

_____

☐ Other serious illnesses *(please specify below)*

_____

_____

_____

_____

_____

43. Do you regularly take any medicines/tablets/eye drops/inhalers/dietary supplements etc.?

- *Using block capitals please copy the generic names from the labels on the bottles or boxes along with frequency and dosage.*
- *Use a new line for each medicine.*

Please include regular pain killers such as paracetamol and over the counter medicines such as glucosamine

Name of the Drug	Frequency	Dosage	Unit of Drug (e.g. mgs)

44. Many people find it hard to take all their medications. Do you find yourself missing any medications regularly? ☐ Yes ☐ No

If yes, which one, and why?

_____

_____

45. In the last year, have you had any falls?	☐ Yes	☐ No
If yes, how many falls?		
46. In the last year, have you had any fractures?	☐ Yes	☐ No
If yes, how many fractures?		
Can you recall the circumstance in which you fell or fractured?		
_____		
_____		
_____		

47. How would you rate the risk of you breaking your bones compared to other men/women your age?	
i. Much lower	☐
ii. A little lower	☐
iii. About the same	☐
iv. A little higher	☐
v. Much higher	☐

48. In the past 3-6 months, have you lost any weight unintentionally (i.e. not due to dieting or exercise)?	☐ Yes	☐ No	☐ Don't know
If yes, how much? (kg)			
What was your weight 3-6 months ago? (kg)			
49. Are you or your family concerned that you may be underweight or need nutritional advice?	☐ Yes	☐ No	☐ Don't know
50. Have you noticed that your clothes or rings have become loose recently?	☐ Yes	☐ No	☐ Don't know
51. Have you recently lost your appetite and/or interest in eating?	☐ Yes	☐ No	☐ Don't know

52. How often in the last week did you feel "everything I did was an effort" or "I could not get going?" *Please tick one box*	
i. Rarely or none of the time (less than 1 day)	☐
ii. Some or a little of the time (1-2 days)	☐
iii. A moderate amount of time (3-4 days)	☐
iv. Most of the time (more than 4 days)	☐

53. Do you or would you have any difficulty (or find it troublesome, exhausting or worrying) to do the following?	No	Yes, some difficulty	Yes unable to do alone
a. Washing down (whether in bath or not)	☐	☐	☐
b. Removing a jug, say, from an overhead shelf	☐	☐	☐
c. Tying a good knot in string	☐	☐	☐
d. Cutting toenails	☐	☐	☐
e. Running to catch a bus	☐	☐	☐
f. Going up/down stairs	☐	☐	☐
g. Going shopping and carrying a full basket of shopping in either hand	☐	☐	☐
h. Doing heavy housework	☐	☐	☐
i. Preparing a hot meal	☐	☐	☐

54. Do you have any long-term illness, health problem or disability, which limits your activities or the work you can do?	☐ Yes	☐ No

55. The following items are about activities you might do during a typical day.

Does your health now limit you in these activities? If so, how much?

		Not limited	Limited a little	Limited a lot
1.	**Vigorous** activities, such as running, lifting heavy objects. Participating in strenuous sports	☐	☐	☐
2.	**Moderate** activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf	☐	☐	☐
3.	Lifting or carrying groceries	☐	☐	☐
4.	Climbing several flights of stairs	☐	☐	☐
5.	Climbing **one** flight of stairs	☐	☐	☐
6.	Bending, kneeling or stooping	☐	☐	☐
7.	Walking more than one mile	☐	☐	☐
8.	Walking half a mile	☐	☐	☐
9.	Walking one hundred yards	☐	☐	☐
10.	Bathing or dressing yourself	☐	☐	☐

56. Do you currently smoke?	☐ Yes	☐ No
57. Have you ever been a smoker? (at least once a day for one year or more)	☐ Yes	☐ No

58. Do you ever drink alcohol?	☐ Yes	☐ No
*If no, go to question **60***		
59. How often do you currently drink alcohol? (e.g.: wine/beer/lager/cider/port/spirits/liqueurs etc.) *Please tick one box*		
i. Never	☐	
ii. Once every 2-3 months	☐	
iii. Once a month	☐	
iv. Once a fortnight	☐	
v. 1-2 times per week	☐	
vi. 3-6 times per week	☐	
vii. Once a day	☐	
viii. More than once a day	☐	
When you drink these, how much would you normally have? Please document alcohol type and quantity (if a range is given then document the mid-point).	Beer/lager/cider (cans, bottles, pints…)	
	Wine (small/std/large glasses…)	
	Spirits/liqueurs (measures)	

SECTION 5: SOCIAL AND PSYCHOLOGICAL ASPECTS

60. Do you use any meal, activity or transport services? ☐ Yes ☐ No

If yes, how frequently?

	Type of service	Please tick	Frequency, xper week
Example	*Hot meal delivery*	✓	*5 times per week*
1.	Hot meal delivery	☐	_____
2.	Frozen meal delivery	☐	_____
3.	Lunch club	☐	_____
4.	Dial-a-ride/similar	☐	_____
5.	Walking group	☐	_____
6.	Exercise group[1]	☐	_____

NB [1]for 'exercise group' include dance, tai chi, yoga etc.

61. Please tell me how often you have taken part in the following activities in the last 12 months. *(Please tick)*

		Never	Less than monthly	Monthly	Weekly
1.	Religious activities/observance				
2.	Positions of office, school governor, councillor etc.				
3.	Involvement in clubs and organisations, voluntary or official				
4.	Courses and education/evening classes				
5.	Cultural visits to stately homes, galleries, theatres, cinema or live music events				
6.	Social indoor games, cards, bingo, chess etc.				
7.	Visiting friends and relatives				

8.	Going to pubs and social clubs				
9.	Individual occupations e.g. reading, listening to music				
10.	Household tasks e.g. DIY, maintenance, decorating				
11.	Practical activities, making things with your hands e.g. pottery, drawing etc.				
12.	Gardening				
13.	Using a home computer for leisure				

62. Lubben social network scale – 6 (LSNS-6)		
FAMILY: *Considering the people to whom you are related by birth, marriage, adoption, etc…*		
1.	How many relatives do you see or hear from at least once a month?	
2.	How many relatives do you feel at ease with that you can talk about private matters?	
3.	How many relatives do you feel close to such that you could call on them for help?	
FRIENDSHIPS: *Considering all of your friends including those who live in your neighbourhood*		
5.	How many of your friends do you see or hear from at least once a month?	
6.	How many friends do you feel at ease with that you can talk about private matters?	
7.	How many friends do you feel close to such that you could call on them for help?	

63. De Jong-Gierveld short Loneliness Scale			
	No	More or less	Yes
Emotional loneliness			
1. I experience a general sense of emptiness			
2. I miss having people around me			
3. I often feel rejected			
Social loneliness			
4. There are plenty of people I can lean on when I have problems			
5. There are many people I can trust completely			
6. There are enough people I feel close to			

64. General self-efficacy *(Please tick one box per question)*

		Strongly disagree	Disagree	Agree	Strongly agree
1.	I can always manage to solve difficult problems if I try hard enough				
2.	I can find a way to get what I want even if someone is trying to stop me				
3.	It is easy for me to stick to my aims and reach my goals				
4.	I am calm when things are difficult because I know I can cope				
5.	If I am in trouble I can usually find a way out				

SECTION 6: PATIENT REPORTED OUTCOMES

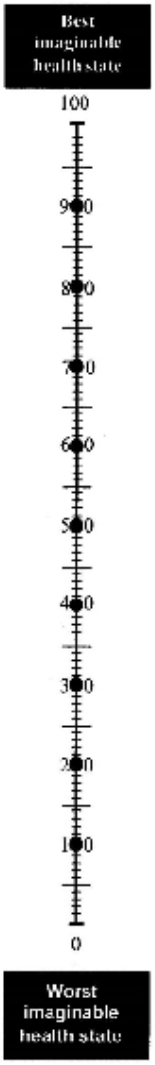
65. In terms of quality of life: *Please indicate which statement best describes your quality of life (Tick one box for each lettered section (a, b, c etc.)*	
a. Mobility	
i. I have no problems in walking around	☐
ii. I have some problems in walking around	☐
iii. I am confined to bed	☐
b. Self-care	
i. I have no problems with self-care	☐
ii. I have some problems washing or dressing myself	☐
iii. I am unable to wash or dress myself	☐
c. Usual Activities *(e.g. work, study, housework, family or leisure activities)*	
i. I have no problems with performing my usual activities	☐
ii. I have some problems with performing my usual activities	☐
iii. I am unable to perform my usual activities	☐
d. Pain/discomfort	
i. I have no pain or discomfort	☐
ii. I have moderate pain or discomfort	☐
iii. I have extreme pain or discomfort	☐
e. Anxiety/Depression	
i. I am not anxious or depressed	☐
ii. I am moderately anxious or depressed	☐
iii. I am extremely anxious or depressed	☐

66.

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked by 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is.

Your own health state today



SECTION 7: PHYSICAL EXAMINATION. TO BE COMPLETED BY RESEARCHER		
67. Height (m)		
68. Weight (kg)		
69. BMI (kg/m²)		
70. Balance tests (maximum stand for 10 seconds) a) Side-by-side stand (time in seconds)		
b) Semi-tandem stand (time in seconds)		
c) Tandem stand (time in seconds)		
71. Gait speed test (3m)		
a) Walk time 1 (in seconds)		
b) Walk time 2 (in seconds)		
72. Chair stand test a) Is patient able to stand up from sitting with arms folded? (Single chair stand test)	☐ Yes	☐ No
b) Time for five repetitions (seconds)		
73. Grip Strength (kg), always start with R hand, record to nearest kg:	R	L
a) First attempt		
b) Second attempt		
c) Third attempt		

If unable to complete aspects of the Short Physical Performance Battery Test, please note down the corresponding reason.

Balance test	Side by side stand	
	Semi-tandem stand	
	Tandem stand	
Gait Speed Test	Walk 1	
	Walk 2	
Chair Stand Test	Single chair stand	
	Repeated chair stands	

Reasons:

1) Tried but unable
2) Participant could not stand/walk/hold position unassisted
3) Not attempted, you felt unsafe
4) Not attempted, participant felt unsafe
5) Participant unable to understand instructions
6) Other (Specify)
7) Participant refused

SECTION 8: HOME AND COMMUNITY ENVIRONMENT INSTRUMENT (HACE)

74. Home mobility

a. What type of home do you live in?	
Single family	☐
Multi-family	☐
Apartment building or condominium complex	☐
Congregate housing or assisted living	☐
Nursing/rest home	☐
Other	☐
b. How many steps are at the main entrance of your home?	
None	☐
One or two	☐
Several	☐
Ten or more	☐
c. Is there a railing at the steps? ☐ YES ☐ NO	
d. Is there a ramp at the main entrance? ☐ YES ☐ NO	
e. Does the door at the main entrance open electronically or is someone available to open the door? ☐ YES ☐ NO	
f. How many steps are there from the main entrance of your building to your main living areas?	
None	☐
One or two	☐
Several	☐
Ten or more	☐
g. How many steps are there inside your main living area?	
None	☐
One or two	☐
Several	☐
Ten or more	☐
h. Is there a chairlift or elevator inside your main living area? ☐ YES ☐ NO	
i. Is there a chairlift or elevator inside your building? ☐ YES ☐ NO	

75. Community mobility

To what extent does your local community have:					
		A lot	Some	Not at all	Don't know
a.	Uneven sidewalks or other walking areas?				
b.	Parks and walking areas that are easy to get to and easy to use?				
c.	Safe parks or walking areas?				
d.	Places to sit and rest at bus stops, in parks, or in other places where people walk?				
e.	Curbs with curb cuts				

76. Basic mobility devices

Do you have?		
a. Manual wheelchair	☐ Yes	☐ No
b. Electric wheelchair or electric scooter	☐ Yes	☐ No
c. Walker	☐ Yes	☐ No
d. Cane or crutch	☐ Yes	☐ No
e. Bedside commode, raised toilet seat or grab bars near toilet	☐ Yes	☐ No
f. Grab bars or bench in tub or shower	☐ Yes	☐ No
g. Reachers	☐ Yes	☐ No
h. Dressing aids such as button adapters of zipper pulls	☐ Yes	☐ No
i. Eating aids such as built-up silverware or kitchen aids such as cutting boards that hold food or utensils that are designed to be used with one hand	☐ Yes	☐ No

77. Communication devices

Do you have?		
a. Aids to help you communicate with people such as boards or papers with pictures or telephones with big dials and hearing devices	☐ Yes	☐ No
b. Voice-output communication aids, such as voice generating computers	☐ Yes	☐ No
c. A computer	☐ Yes	☐ No
c. Access to the internet	☐ Yes	☐ No

78. Transportation factors

a. Do you have a car available to you at your home?	☐ Yes	☐ No
b. Do you drive?	☐ Yes	☐ No

c. To what extent does your local community have:

	A lot	Some	Not at all	Don't know
Public transportation that is close to your home				
Public transportation with adaptations for people who are limited in their daily activities, such as buses that lower to the ground and chairlifts for wheelchairs				
Adequate disabled people's parking				

79. Attitudes		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a.	People in your building have negative attitudes toward persons with limitations in daily activities					
b.	People in your building are willing to help persons with limitations in daily activities.					
c.	People in your community have negative attitudes toward persons with limitations in daily activities.					
d.	People in your community are willing to help persons with limitations in daily activities.					

Appendix F Healthy Conversation Skills guide - NAPA baseline home visits

Participant ID							

Date							Time				

Example script for Healthy Conversation at baseline visit – Intervention Group

- Note down an asterisk on the questionnaire for possible issues that arise during its completion
- Pick up on these issues during the subsequent Healthy Conversation
- In the conversation, focus on physical activity (e.g. walking) rather than specific exercises – have a few printouts of some ROS exercises on hand
- If the main issue identified is not physical activity or diet, focus on that (e.g. depression, alcohol issues…)
- Avoid: telling people what to do, making suggestions, offering solutions, signposting, and giving information or advice – UNLESS and UNTIL this seems to be appropriate and warranted as a result of the exploratory healthy conversation; asking closed questions to which the answer can just be "yes" or "no"; using 'why' questions that require the person to explain themselves; trying to persuade someone to do something.
- Support participant to make a SMARTER plan:
    - Try to set a small realistic goal. The participant might not set goals in the baseline visit, and might build up to it and then set a goal in follow-up telephone calls.
    - If too many issues, focus on one or two areas (especially diet and PA). How do they feel about adding these goals incrementally? Achieve one step at a time.

Now I'd like to have a chat to you about healthy living and lifestyle. Our chat should only take around 15 minutes, and if it is all right, I will time our talk to make sure that I am being consistent with other visits in this study. Is it all right if I audio-record our chat for quality control and research purposes?

While we were going through the questionnaire, I noticed that you said that … (issue related to diet, exercise) …

Or: What is your biggest concern at the moment?

How does that impact on you? How does that make you feel?

How important is it for you (on a scale of 1 to 10) to address this?

What do you think are the benefits of doing/consequences of not doing this? (If reluctant)

What do you think you could do differently?

SPECIFIC – What exactly would you like to change?

What do you think is a good first step to address this? What would you like to do?

MEASURABLE – How often do you want to do this?

How often/much/many … currently/future?

ACTION-ORIENTATED – What will you have to do to make this happen?

What actions do you need to take? How can you fit that into your daily routine?

What is the actual behaviour you are changing to achieve your goals?

REALISTIC – How confident are you (on a scale of 1-10) that you can achieve this change?

What do you think could get in the way, or what has been stopping you now?

How do you think you could get around this?

What support do you need to do this?

TIMED – When is a good time for you to start this plan (time/day)?

What is your time-scale for achieving your first goal/ultimate goal?

EVALUATED – When will you check your progress?

How will you know you've been successful?

How can you identify the things that went well and where you went off track?

REVIEWED – When will you review your plans and goals to see if you need to make any changes to these?

Who can support you with your Evaluation and Review?

What will you do next?

You will receive follow-up telephone calls with regards to our chat, at 1, 3, 6 and 9 months after this visit. I look forward to speaking to you again in 1 month to see how you're getting on in achieving your goal to change/improve … (e.g.: your diet, exercise).

(Adjust goal/strategies if necessary. If they are not achieving it, problem is with the goal, not with them. Social support is important.)

Appendix G Follow up Telephone Call Guide

Participant ID							

Date							Time				

Understanding the early life and environmental determinants of bone strength and structure: The Hertfordshire Cohort Study Nutrition and Physical Activity Study

Telephone guide

Semi-structured, example script for follow-up telephone calls.

When I visited you at home to complete the questionnaire and measurements/spoke to you last time on the phone, we also had a conversation about … (eg your diet, exercise) … and you identified a change you wanted to make. How are you getting on with that change?

GOOD:

What do you put that success down to?

How well did the plan we made work for you?

How are you feeling now you've done this?

How can you keep going with this change?

What if anything might get in the way?

What will you do if that happens in order to stay on track?

How confident on a scale of 1-10 are you that you can maintain this new behaviour (eg your diet, exercise)?

What will you do next?

NOT SO GOOD:

What has got in the way of you achieving the change in … (eg your diet, exercise)?

How can you overcome that?

What else could you try?

What else might get in the way?

What will you do if that happens in order to stay on track?

What changes do you need to make to the plan we made last time?

How confident on a scale of 1-10 are you that you can make this change in … (eg your diet, exercise)?

What will you do next?

I look forward to speaking to you again in … ?? months … to see how you're getting on in achieving your goal to change/improve … (e.g.: your diet, exercise).

Appendix H Process Evaluation: Follow up Phone call- Competency Coding Tool

Peer Support/Observation or Follow It is essential to evaluate the effectiveness of the training.

There are various levels of –**up Phone Call – Competency Coding Tool**

ID No: ☐☐☐

TO BE COMPLETED INDEPENDENTLY BY 1 or 2 CODERS AFTER THE CONVERSATION

Write example line numbers in the spaces below: Rate success from 0-4 – refer to the Competencies Rating Rubric (p37). Once completed, arrange to double-code and agree total score.

1 **Ask Open Discovery Questions**

eg

Rating: 0 1 2 3 4 ☐

2 **Reflect on own practice**

eg

Rating: 0 1 2 3 4 ☐

3 **More time spent listening than giving information**

Rating: 0 1 2 3 4 ☐

4 **Supported SMARTER goal-setting**

eg

Rating: 0 1 2 3 4 ☐

Coding Comments/Double-coding Quotes about agreed total training/HCS use: (out of 16): ☐

Competencies rating rubric
(0 = worst to 4 = best)
0 = No demonstration of HSC competency
4 = Strong demonstration of HSC competency

1 = Some demonstration of HSC competency
2 = Moderate demonstration of HSC competency
3 = Good demonstration of HSC competency

1 Asked Open Discovery Questions

0 No evidence of using Open Discovery Questions at all in conversations

1 Evidence of an awareness of the difference between Open Discovery Questions & other types of questions, though has not yet used Open Discovery Questions

2 **Limited** evidence of asking Open Discovery Questions, but **not** exploring context

3 **Some** evidence of asking Open Discovery Questions to explore context or plan change

4 **Substantial** evidence of asking Open Discovery Questions to explore context or plan change

2 Reflected on own practice

(Reflection = describes own practice & provides a rationale for, or impact of, that practice)

0 No evidence of reflecting on own practice

1 Evidence of reflecting on own practice, but doesn't include changes since the training

2 **Limited** evidence of reflecting on own practice, e.g. can say what they do well since the training

3 **Some** evidence of reflecting on own practice, e.g. can say what they do well & not so well since the training

4 **Substantial** evidence of reflecting on own practice, e.g. can clearly articulate their strengths & identify areas for improvement in using the skills from the course

3 More time spent listening than giving information

(When there's a lack of explicit evidence for either of these, look at the bigger picture)

0 Evidence they spend the whole conversation giving information rather than listening

1 Evidence they spend more time in conversations giving information than listening

2 Evidence they spend equal amount of time in conversations giving information as listening

3 Evidence they spend a little more time in conversations listening than giving information

4 Evidence they spend substantially more time in conversations listening than giving information

4 Supported SMARTER goal-setting

0 **No evidence of supporting planning**

1 **No evidence of supporting planning, but evidence that they would like to**

2 **Evidence of supporting planning by asking questions but not using the SMARTER technique OR**

Evidence of using SMARTER techniques, but not encouraging people to make their own plans.

3 **Evidence that they support SMARTER planning by asking questions to encourage people to come up with their own plans.**

4 **Evidence that they support SMARTER planning by asking questions to encourage people to come up with their own plans & has followed-up / intends to follow-up on those plans**

Appendix I : Process Evaluation of Healthy Conversation Skills Intervention in NAPA study

Participant ID: _____ Date of Process Evaluation: _____

1. Checklist for quick qualitative coding

Topics mentioned in the follow up telephone conversations (Tick if topic is mentioned)	**Date Baseline**	**Date 1 month FU**	**Date 3 Month FU**	**Date 6 month FU**	**Date 9 month FU**
Gardening					
Walking					
Household chores					
Leisure activities					
Societies					
Shopping (involving walking/carrying heavy bags)					
Any other form of physical activity					
General diet (e.g., eating a 'healthy' diet)					
Weight loss					

Sugar intake					
Mental health: mood, depression, anxiety					
Any other relevant topic (please specify)					
Additional comments (on topics mentioned), e.g. details about specific project/event such as for example, building something in their garden, going on a walking holiday.					
Assess changes made due to intervention (Yes/No/Don't Know)	**Date 1 month FU**	**Date 3 Month FU**	**Date 6 month FU**	**Date 9 month FU**	
Changes made to diet Indicator words/phrases of change could include: "change(d)", "more", "less", "improved", "better", "now", "before"					
Changes made to PA Indicator words/phrases of change could include: "change(d)", "more", "less", "improved", "better", "now", "before"					
Briefly report changes made to PA or diet from the different points (e.g. from walking weekly to daily)					
Additional comments on changes made:					

Appendix I

	Date Baseline	**Date 1 month FU**	**Date 3 Month FU**	**Date 6 month FU**	**Date 9 month FU**
Signs of resistance to intervention (Yes/No) Indicator statements of resistance could include: "don't talk to me about…" "don't remind me…", "I think I am fine…", "my daughter is looking out for me on that….so I'm okay"					
Additional comments on signs of resistance:					
COVID-19 had impact on: (Yes/No) Indicator words/phrases could include: mention of inability to attend usual social activities, do their own shopping, or venture out, e.g. into town or go for walks					
socialising					
accessing services					
going shopping					
performing physical activity					
diet					
Additional comment on impact of COVID-19:					

2. Relevant/interesting topics of discussion e.g., change in family circumstances – where helpful include short quotes (note down date, time in minutes of location in recording).

Appendix J : NAPA Case Report coding frame v1.3 – adapted from SPRING study

SPRING Case Report coding frame v1.3 – adapted for NAPA

Health behaviour discussed:

Please label 1 the topic that relates to the goal outlined in SMARTER; label all other topics consecutively, in order from most detailed to least.

Please note the labels:

1. Diet	6. Mental health
2. Exercise	7. Other
3. Smoking	
4. Alcohol	
5. Social engagement	

Supporting individual to set a goal: Use the free text information outlined in the boxes of the case report forms to code using the coding rubric below.

ID: 013/5529 17/12/2021

	0=not included	1=partly included	2=clearly included	Date: Baseline	Date: 1M FU	Date: 3M FU	Date: 6M FU	Date: 9M FU
Specific: (A behavioural goal e.g. walking; not an outcome or barrier e.g. joint pain)	No specific behaviour identified	General description of intention outlined (e.g. getting fitter or eating better)	Clearly specifies target behaviour related to topic (e.g. swimming as form of exercise)					
Measurable: (How much, how many, how long, how often)	No measurable aspects identified	Vague quantification of behaviour change (e.g. "more", "less") or only 1 aspect covered (e.g. specified how much/many OR how often)	Clearly quantifies at least 2 aspects of behaviour change (e.g. how much/many AND how often) NB: This may not always be possible with some topics e.g. social activities					
Action-orientated: (First step, what needs to be done to make change happen)	No clear action identified	Vague action only identified (e.g. thinking about where to swim/groups available, 'continuing' or 'trying' to eat fruit, or just stating 'as above')	Clearly identifies action for first step that will enable specified behaviour to happen (e.g. buy more fruit when doing shopping; make appointment to talk to someone – physio/ GP					

SPRING Case Report coding frame v1.3 – adapted for NAPA

Realistic: (Ensuring first steps/goal will work, e.g. how confident/ important, barriers/solutions)	No exploration of how difficult/easy achieving the behaviour will be in relation to barriers, solutions	Vague details about overcoming barriers to change: how difficult/easy achieving the behaviour will be. (e.g. 'done it before', 'I will get it done', 'ongoing', 'as above', 'enjoys exercise, keeps them motivated')	Clearly identifies barriers/solutions to achieving behaviour; scaling of importance or confidence in achieving the behaviour. (e.g. "how confident do you feel to … on a scale of 1-10?")					
Timed: (When will start, any sub-goal deadlines)	No details about timing	Vague description of timeframe to achieve behaviour (e.g. in the next week, currently/ continuing/ongoing; after holiday next week; when feeling better)	Clearly states when will start (e.g. time of day or day of the week) and/or target date for achieving goal or sub-goal					
Evaluated: (How to check progress, what success looks like, how they will feel)	No evaluation planned or undertaken	Vague description of evaluation plan, not clearly articulated (e.g. 'ongoing', 'same as last time', 'regularly', 'as above', 'as planned', 'continuing')	Clearly states how they will know behaviour has been achieved, how they will feel if (un)successful; describes level of achievement of previous measurable goal (e.g. 'swimming 30 lengths once a week, when had planned to go twice a week')					
Reviewed: (How they go forward, what they will do next)	No review planned or undertaken	Vague description of review plan, (e.g. at telephone call, 'regularly') but no details of possible outcomes/changes	Clearly states how goal will be/has been reviewed with someone (e.g. family/friend/ nurse); identifies any changes needed to goal or actions (e.g. revising swimming goal or actions to work for them)					

Appendix K Paper published in Calcified Tissue International: Is regular weight bearing physical activity throughout the lifecourse associated with better bone health in late adulthood?

Calcified Tissue International
https://doi.org/10.1007/s00223-022-00995-9

ORIGINAL RESEARCH

Is Regular Weight-Bearing Physical Activity Throughout the Lifecourse Associated with Better Bone Health in Late Adulthood?

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Abstract
We considered how weight-bearing physical activity (WBPA) through the lifecourse related to bone health in late adulthood in the Hertfordshire Cohort Study (HCS), a cohort of community dwelling adults born 1931–9, to identify sex-specific differences and periods critical for optimal bone health. Available questionnaire data from 258 participants (128 men and 130 women) included current reported lifestyle factors (including physical activity) and WBPA, coded as participation in WBPA aged < 18 years; aged 18–29 years; aged 30–49 years and aged ≥ 50 years. Responses were recorded as none/once a month/once a week/> once a week. Hip bone mineral density (BMD) was measured using a Lunar Prodigy DXA scanner. The mean age was 75.4 (SD 2.5) years in men and 75.7 (SD 2.6) years in women. Men reported significantly higher levels of past WBPA aged < 18 years ($p = 0.006$) and aged 18–29 years than women ($p < 0.001$). We observed greater BMD at total hip in women who reported regular WBPA at ages 18–29 years ($p = 0.02$) and 30–49 years ($p = 0.02$) compared with those who reported no WBPA ($p = 0.019$), after adjustment for confounders including current activity levels. In this cohort of older adults, recalled regular WBPA around the time of peak bone mass acquisition was less common in women than men, but associated with higher hip BMD in women in late adulthood.

Keywords Weight bearing · Physical activity · Lifecourse · BMD

Introduction

As a population, reduced physical activity is becoming increasingly common, and is associated with numerous adverse health consequences, including falls and fracture [1–3]. Physical inactivity was amongst the top 10 leading risk factors for disease burden in the 2010 Global Burden of Disease Study [4]. Recent data from World Health Organisation (WHO) highlight that 25% of adults and 80% of adolescents are insufficiently active [5], with current WHO guidance recommending that adults, including older people, undertake at least 150 min of moderate-intensity aerobic physical activity each week [5].

Previous studies have highlighted the benefits of weight-bearing activity for bone health [6–9] but much of this work is cross-sectional, with few studies describing activity profiles across the lifecourse, and associations with bone health in late adulthood. Studies involving children and adolescents have shown that regular participation in physical activity can have positive outcomes in bone structure in midlife [10, 11], whilst most research in older adults have shown those classified as active are more likely to experience a lower age-related decline in bone mineral density (BMD) [7, 8, 12], retain better balance and remain independent [13]. The few studies that have tracked physical activity from middle to later life have shown those who were active in their middle age were more likely to remain active in their older age [14]; that higher participation in physical activity was linked to better BMD [15] and lower bone loss [16]. Hence, few studies have considered relationships in both sexes, where lifecourse data are available.

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In this study, we used a well-characterised longitudinal cohort of older adults to perform a lifecourse analysis of recalled weight-bearing physical activity (WBPA) and bone health. We sought to consider (1) whether higher physical activity at a particular time point was of benefit and (2) whether the same relationships were seen in men and women.

Methods

Participants were recruited from the HCS [17], a study originally established to examine the relationship between growth in early life and adult diseases such as cardiovascular conditions and musculoskeletal diseases. The study design is described in detail elsewhere [17]. In brief, participants were born between 1931 and 1939, and were still currently living in Hertfordshire at the time of study. In this phase of the study, performed in 2011, 258 participants were recruited randomly selected from the total number, but all based in East Hertfordshire, 128 men and 130 women. Trained study nurses visited participants at home and administered questionnaires including, demographics, lifestyle and current physical activity levels. Lifestyle factors included smoking status (current or historical) and alcohol consumption (units consumed per week). Duration of current physical activity in the past 14 days was reported using the validated LASA Physical Activity Questionnaire (LAPAQ). Frequency and duration of activities over the past 2 weeks were recorded, including walking outside, cycling, gardening, a maximum of two sports and light/heavy household work. Anthropometry measurements including height and weight were measured, and Body Mass Index (BMI) was calculated. Height was measured to the nearest 0.001 m using a stadiometer. Weight was measured to the nearest 0.1 kg using a calibrated scale. Body mass index (BMI) was calculated as weight in kilograms divided by height in squared metres. Hip BMD was measured on participants using a Lunar Prodigy dual X-ray absorptiometry (DXA) scanner.

Personal recall of previous participation of WBPA was used in this study. Participants answered the following question: how often did you take part in sports and leisure time exercise involving weight-bearing activity? (e.g. running, racquet sports, football, rugby, hockey and dancing–not including walking, cycling or swimming) for each of four age groups. The age groups were as follows: < age 18 years, aged 18–29 years, ages 30–49 years and ≥ 50 years. Responses were categorised as none, once a month, once a week and more than once a week. The responses were scored as 0 for none, 1 for once a month, 2 for once a week and 3 for more than once a week to calculate a cumulative lifetime activity score.

The East and North Hertfordshire Ethical Committees granted approval for the study (10/H0311/590), and written informed consent was obtained from all participants.

Statistical Analysis

Cohort characteristics were summarised using mean and standard deviations (SD), median and interquartile ranges (IQR) or frequencies and percentages (%) as appropriate. Differences between men and women were assessed using Student's *t* tests, Mann–Whitney tests, $\chi 2$ tests or Fisher's exact tests. The BMD variables were transformed using the Fisher–Yates rank-based inverse normal transformation to create *z* scores. Relationships between BMD in later life and the frequency of past WBPA were examined using linear regressions. Analyses were conducted with and without adjusting for age, BMI, social class, smoker status, alcohol consumption, current physical activity and dietary calcium intake, and, additionally, for years since menopause and HRT use in women. Data analysis was carried out using Stata statistical software (Statacorp, Texas, USA).

Results

Data on past WBPA were available for 128 men and 130 women. The characteristics of these participants are summarised in Table 1. The mean age of participants was 75.4 (SD 2.5) years for men and 75.7 (SD 2.6) years for women. There were significantly more men who were current or ex-smokers than women (5.5% vs 0.8% and 56.3% vs 33.1%, respectively), and fewer men who had never smoked compared to women (38.3% vs 66.2%). Multimorbidity was common; 19.5% men and 28.5% women reported no co-morbidities; 39.1% men and 28.5% women reported 1 co-morbidity; 25.8% men and 23.1% women reported 2 co-morbidities, 8.6% men and 11.5% women reported 3 co-morbidities and lastly 7% men and 8.5% women reported ≥ 4 co-morbidities.

There was a modest difference between men and women's current physical activity at the time of study (median (IQR) activity time 194 (110–298) minutes per day for men, 206 (146–277) minutes per day for women). There were, however, statistically significant differences between men and women in the frequency of WBPA over the lifecourse (Table 2). Men reported a higher frequency of weight-bearing physical activity during their younger years with 53.4% of men reporting been active more than once a week up to 18 years of age, and 41.6% reporting being active more than once a week when aged 18–29, compared to 30.3% ($p = 0.006$) and 15.6% ($p < 0.001$) of women, respectively. For both men and women, the frequency of physical activity decreased as their age increased and sex differences became less marked; in

Appendix K

Table 1 Baseline characteristics of participants

	Men			Women			*p* value
	Total *N*	Mean	SD	Total *N*	Mean	SD	
Age (years)	128	75.4	2.5	130	75.7	2.6	0.27
Height (cm)	128	172.5	6.7	129	159.6	5.9	<0.01
Weight (kg)	128	81.5	11.4	130	72.5	13.2	<0.01
BMI (kg/m^2)	128	27.4	3.6	129	28.4	4.9	0.06
	Total *N*	Median	IQR	Total *N*	Median	IQR	*p* value
Daily dietary calcium intake (mg)	128	1237	(1005–1418)	130	1118	(941–1281)	0.01
Alcohol consumption (units per week)	128	7	(1.8–14.3)	130	0.8	(0.0–5.0)	<0.01
	Total *N*	*n*	%	Total *N*	*n*	%	*p* value
Smoker status	128			130			
Never		49	38.3		86	66.2	<0.01
Ex/Current		79	61.7		44	33.9	
Social class	122			130			
I-IIINM		56	45.9		68	52.3	0.31
IIIM-V		66	54.1		62	47.7	

Table 2 Past weight-bearing physical activity

	Men			Women			*p* value
	Total, *n*	*n*	%	Total, *n*	*n*	%	
Weight-bearing activity up to age 18	118			109			0.006
None		19	16.1		25	22.9	
Once a month		7	5.9		10	9.2	
Once a week		29	24.6		41	37.6	
More than once a week		63	53.4		33	30.3	
Weight-bearing activity aged 18–29	113			109			<0.001
None		19	16.8		26	23.9	
Once a month		13	11.5		29	26.6	
Once a week		34	30.1		37	33.9	
More than once a week		47	41.6		17	15.6	
Weight-bearing activity aged 30–49	114			112			
None		36	31.6		43	38.4	0.177
Once a month		22	19.3		25	22.3	
Once a week		29	25.4		30	26.8	
More than once a week		27	23.7		14	12.5	
Weight-bearing activity aged over 50	117			118			0.102
None		64	54.7		59	50.0	
Once a month		18	15.4		22	18.6	
Once a week		16	13.7		27	22.9	
More than once a week		19	16.2		10	8.5	

those aged 30–49 years, 23.7% men and 12.5% of women reported activity more than once a week ($p=0.18$). The rate decreased further in those aged 50 years or older, with 16.2% of men and only 8.5% of women performing WBPA more than once a week ($p=0.102$).

We next considered relationships between WBPA and BMD. No relationship was observed between WBPA and BMD in men at any timepoint. Relationships are shown in Figs. 1, 2, 3, 4. We observed an association between BMD at the total hip and WBPA at ages 18–29 years (regression

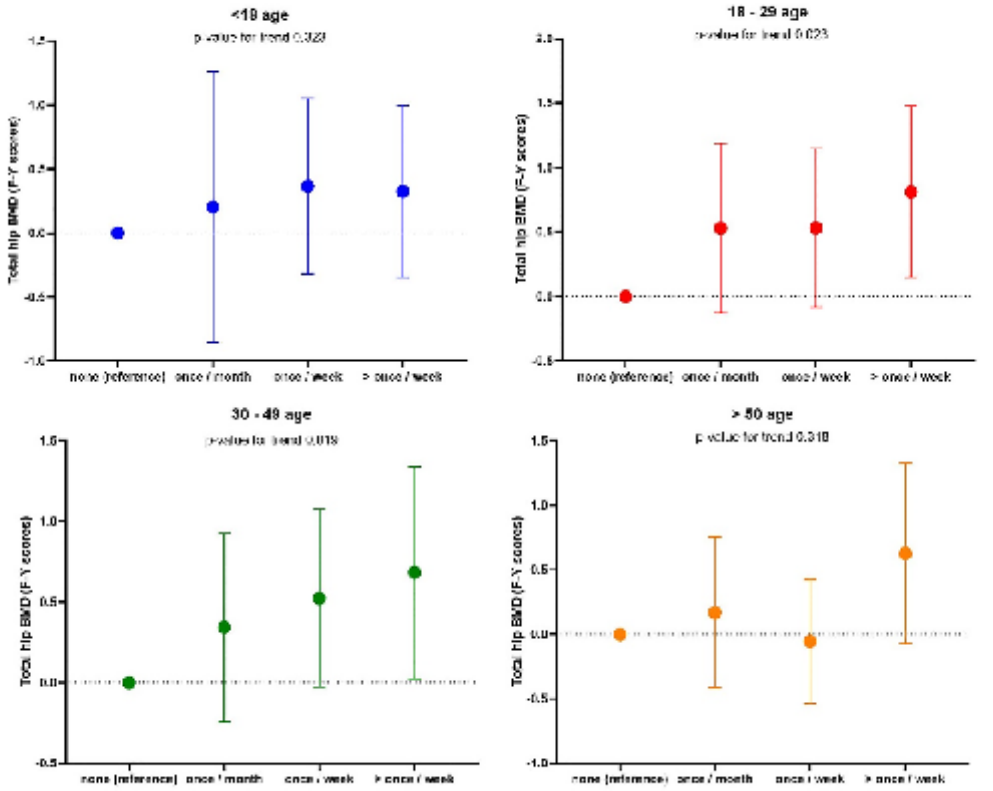

Fig. 1 Regression coefficients (and 95% CIs) for the associations between past WBPA at different ages and total hip BMD in women. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current physical activity, dietary calcium intake and for years since menopause and HRT use

coefficient (β) exercise weekly 0.72 z score (95% confidence interval (CI) 0.13, 1.31), $p=0.02$; β exercise more than once a week 0.83 z score (95% CI 0.20, 1.46), $p=0.01$), when adjusted for age, BMI, social class, smoker status, alcohol consumption, current physical activity, dietary calcium intake, years since menopause and HRT use, compared to those reporting no WBPA (Fig. 1). Similarly, there was also an association between total hip BMD and WBPA at ages 30–49 years (β exercise weekly 0.52 z score (95% CI 0.02, 1.02), $p=0.04$; β exercise more than once a week 0.78 z score (95% CI 0.15, 1.41), $p=0.02$), when adjusted for confounders. Furthermore, in women, there was a significant dose response between BMD at the total hip and WBPA at ages 18–29, p 0.023, and ages 30–49, p 0.019 when compared to those reported no activity (Fig. 1). A similar trend was also noted between BMD at femoral neck and WBPA, with ages 18–29 reaching statistical significance, p 0.033 when compared to those reported no activity (Fig. 2). In men, no such relationship was observed at total hip BMD (Fig. 3) nor femoral neck BMD (Fig. 4). A cumulative activity score was calculated to assess the impact of partaking WBPA across the lifecourse. A cut-off point of 8 was utilised, as on average the participant would have to partake in WBPA once a week or more than once a week at every time point; 65 (37.8%) achieved this threshold. Whilst the mean total hip BMD differences were not statistically significant ($p=0.46$), more regular PA through the lifecourse was associated with higher BMD.

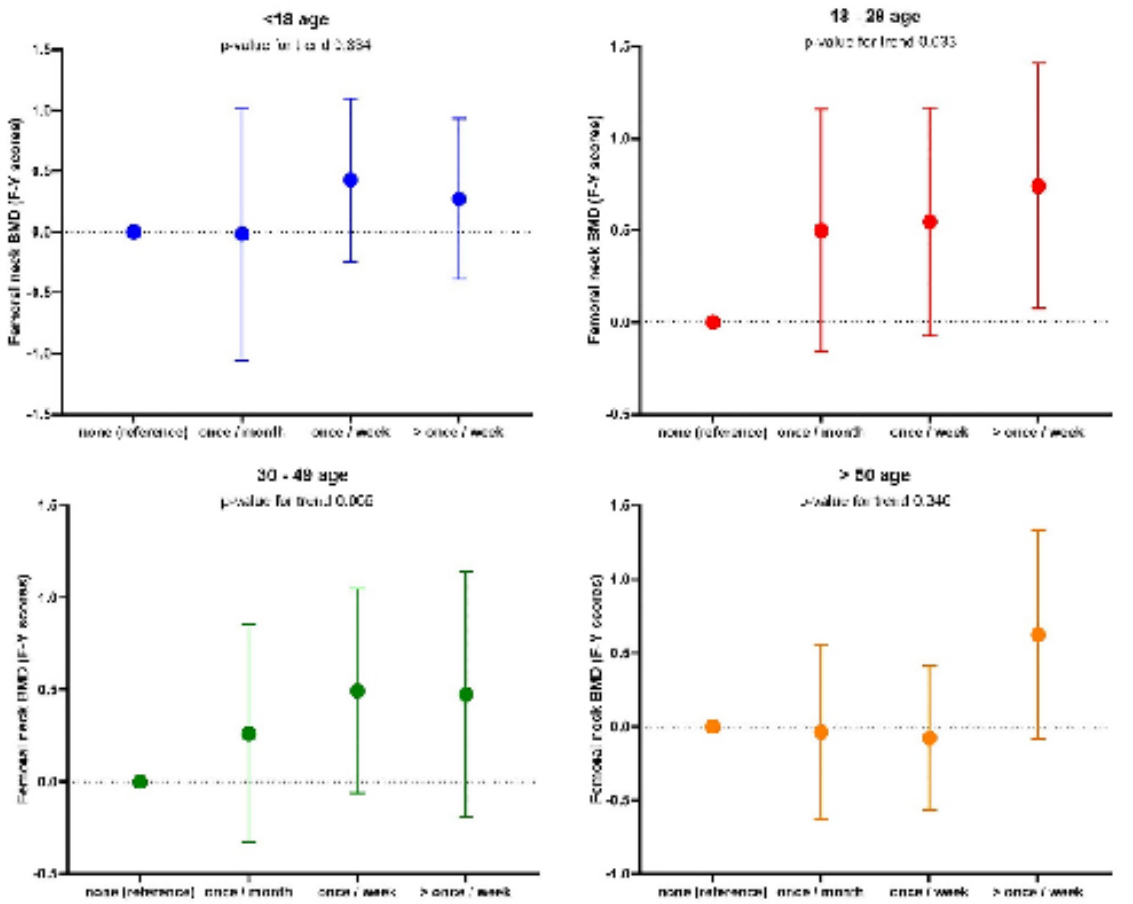

Fig. 2 Regression coefficients (and 95% CIs) for the associations between past WBPA at different ages and femoral neck BMD in women. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current physical activity, dietary calcium intake and for years since menopause and HRT use

Discussion

In this study, we have examined the relationship between recalled WBPA over the lifecourse and bone health in late adulthood. Men in our cohort group reported higher rates of participation in WBPA from 18 to 29 years, compared to women. However, the overall frequency of WBPA decreased as age increased in both sexes, and differences in WBPA between men and women became less pronounced with age. Indeed, the median time of current physical activity in older age was slightly higher in women than men, which may reflect the inclusion of household tasks in the LAPAQ questionnaire. We observed relationships between WBPA in women at the time of peak bone mass acquisition and BMD measured at later age, with a positive dose-related relationship between higher frequency of past self-reported WBPA at the age of bone acquisition observed and BMD at total hip and femoral neck in women. These relationships were robust to adjustment for current WBPA. This relationship was not seen in men.

There are of course limitations to our study; our cohort is based on a group of men and women recruited because they were born in Hertfordshire and still lived there in adult life. However, we have previously shown this group to be representative of the general UK population with regard to lifestyle characteristics such as body mass index and smoking [18]. Our sample size is modest, but perhaps the most significant limitation is the use of self-reported WBPA earlier in life, although current PA was validated in a subset of our cohort [19]. However, unless differential recall bias is operating, this should not affect the validity of our results. The type of physical activity asked in the questionnaire is

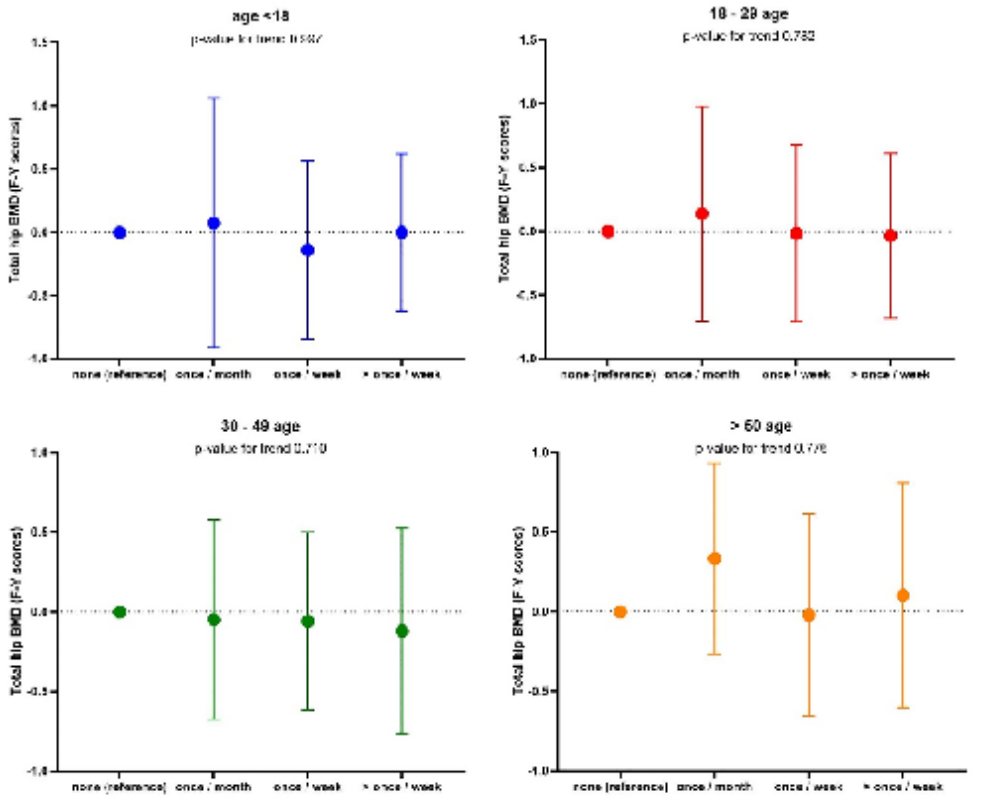

Fig. 3 Regression coefficients (and 95% CIs) for the associations between past WBPA at different ages and total hip BMD in men. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current physical activity and dietary calcium intake

weight-bearing physical activity, and therefore, there was no differentiation between sports-related or leisure-related activity. We also did not consider occupational activity specifically, although this may be less relevant in this cohort of women born in the 1930s.

In our study, we see a gender difference in physical activity participation. We hypothesise during the 1940s–1960s women will have a different physical activity profile compared to men. Several studies of nationally representative samples have shown men are more likely to participate in moderate-vigorous physical activity than women when younger [20–22]. However, women spend less time been sedentary than men in older adulthood [21, 22], and we observed the median time spent been active was higher for women than men. Previous work has highlighted the importance of peak bone mass in the risk of later osteoporosis [23] and our data reinforce this. In addition, recent data showed moderate to vigorous-intensity activity at adolescents (ages 12, 14 and 16) was associated with higher femur BMD, whereas light-intensity activity did not derived such benefit [24]. Whilst we did not observe strong relationships between being active throughout the 4 timepoints across the lifecourse, this may reflect small numbers of participants who reported regular weight-bearing activity, hence limiting our ability to consider this. Other studies have suggested that being active throughout the lifecourse is associated with better bone health later in life and the trends that we did observe were in accord with this [25, 26].

In line with the 1946 British Birth Cohort, we note a strong positive relationship between past WBPA at ages 18–29 and ages 30–49 and hip BMD at older adulthood in women; however, in the 1946 British Birth Cohort, the

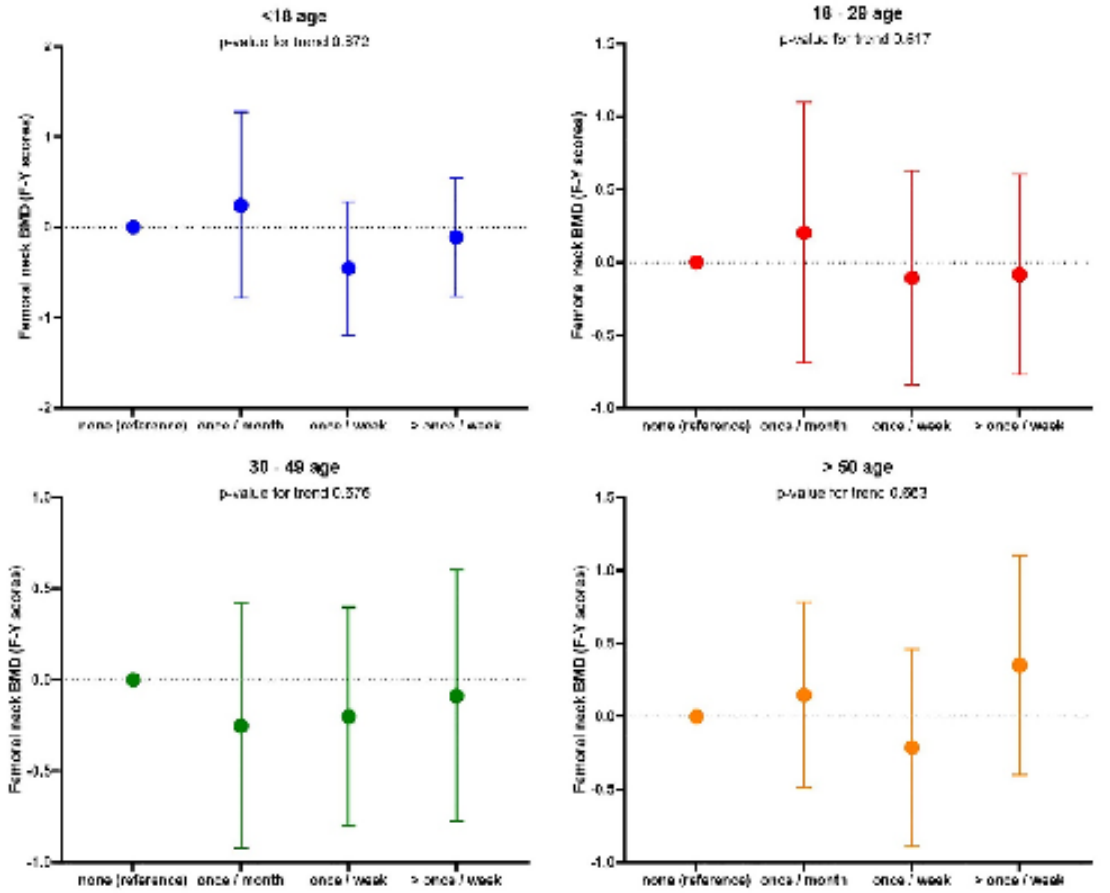

Fig. 4 Regression coefficients (and 95% CIs) for the associations between past WBPA at different ages and femoral neck BMD in men. Adjusted for age, BMI, social class, smoker status, alcohol consumption, current physical activity and dietary calcium intake

association was stronger in men than women [15]. This may reflect methodological differences between the two studies including the type of physical activity data collected. Specifically in the 1946 British Birth Cohort, researchers collected data on all leisure time physical activity, whereas our study focussed on WBPA only. In addition, although our own sample size was modest compared to the 1946 British Birth Cohort, we were able to consider WBPA at earlier time points from < 18 years compared with the 1946 British Birth Cohort which started at age 36. In other work, however, several authors have reported associations with WBPA and bone health in women consistent with our own findings [27, 28]. In the Northern Finnish cohort, high level of past physical activity over the lifecourse from 14 to 46 years of age was associated with larger vertebral cross-sectional area in women, whereas this association was not observed in men [28]. Finally, in recent work, in the Tromsø cohort, it was suggested the relationship between WBPA, and bone health may differ in male and female adolescents, with girls reporting high levels of PA having the best bone profiles [29].

In conclusion, we have highlighted differences in WBPA across the lifecourse using a historical cohort and reported a positive dose-related association between frequency of past WBPA and BMD in later life in women. This suggests we should encourage young women to participate in regular WBPA throughout the lifecourse, but particularly at the time of peak bone mass accrual, to reap the benefits for bone health later in life.

Author Contributions ED and CC designed the study and contributed to the field work of the study, NF and KAW contributed to the field

work of the study. CC is the guarantor. JZ, CP, KJ, CC and ED all contributed towards the statistical analysis of the data, and CP and KJ were responsible for statistical analysis of the data. JZ prepared the first draft of the paper. All authors revised the paper critically for intellectual content and approved the final version. All authors agree to be accountable for the work and to ensure that any questions relating to the accuracy and integrity of the paper are investigated and properly resolved.

Declarations

Conflict of interest Jean Zhang, Camille Parsons, Nicholas Fuggle, and Kate A. Ward have no conflicts of interest to declare. Cyrus Cooper has received lecture fees and honoraria from Amgen, Danone, Eli Lilly, GSK, Kyowa Kirin, Medtronic, Merck, Nestlé, Novartis, Pfizer, Roche, Servier, Shire, Takeda and UCB outside of the submitted work. Elaine Dennison has received consultancy or speaker fees from UCB, Viatris and Pfizer.

Ethical Approval The East and North Hertfordshire Ethical Committees granted approval for this study (10/H0311/590), and written informed consent was obtained from all participants.

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Appendix L Paper published in PLOS ONE: Understanding influences on physical activity participation by older adults: A qualitative study of community-dwelling older adults from the Hertfordshire Cohort Study, UK

PLOS ONE

RESEARCH ARTICLE

Understanding influences on physical activity participation by older adults: A qualitative study of community-dwelling older adults from the Hertfordshire Cohort Study, UK

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Data Availability Statement: The data are not freely available owing to data protection and consent restrictions, as data contain sensitive and potentially identifying participant information even after de-identification. The data may be accessed by collaboration with the HCS study team. Enquiries should be directed to the HCS steering committee (hcs@mrc.soton.ac.uk, https://www.mrc.soton.ac.uk/herts/contact/contact-general-enquiries/).

Abstract

Background

The health benefits of physical activity (PA) participation in later life are widely recognised. Understanding factors that can influence the participation of community-dwelling older adults in PA is crucial in an ageing society. This will be paramount in aiding the design of future interventions to effectively promote PA in this population. The main aim of this qualitative study was to explore influences on PA among community-dwelling older people, and the secondary aim was to explore gender differences.

Methods

Qualitative data were collected in 2014 by conducting focus group discussions using a semi-structured discussion guide with older people resident in Hertfordshire, UK. Discussions were audio-recorded, transcribed verbatim and transcripts analysed thematically.

Results

Ninety-two participants were recruited to the study (47% women; 74–83 years) and a total of 11 focus groups were conducted. Findings indicated six themes that appeared to affect older adults' participation in PA: past life experiences; significant life events; getting older; PA environment; psychological/personal factors; and social capital. Overall, the findings emphasised the role of modifiable factors, namely psychological factors (such as self-efficacy, motivation, outcome expectancy) and social factors (such as social support and social engagement). These factors exerted their own influence on physical activity participation,

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Competing interests: JZ, IB, KAW, SMR, and MB have no conflict of interest. EMD has received consultancy or speaker fees from Lilly, UCB and Pfizer outside of the submitted work. CC has received lecture fees and honoraria from Amgen, Danone, Eli Lilly, GSK, Kyowa Kirin, Medtronic, Merck, Nestlé, Novartis, Pfizer, Roche, Servier, Shire, Takeda and UCB outside of the submitted work. WL has received consultancy and speaker fees from Nutricia Ltd t/a Danone Specialised Nutrition outside of the submitted work. This does not alter our adherence to PLOS ONE policies on sharing data and materials.

but also appeared to mediate the effect of other largely non-modifiable background and ageing-related factors on participants' engagement with PA in later life.

Conclusion

In view of these findings, intervention designers could usefully work with behavioural scientists for insight as to how to enhance psychological and social factors in older adults. Our data suggest that interventions that aim to build self-efficacy, motivation and social networks have the potential to indirectly promote PA participation in older adults. This would be best achieved by developing physical activity interventions through working with participants in an empowering and engaging way.

Introduction

Regular physical activity (PA) in older adults, those aged ≥65 years old, is robustly promoted by the World Health Organisation (WHO) [1]. Plethora of research have shown physical activity leads to risk reduction in a wide variety of co-morbidities such as type 2 diabetes mellitus [2], breast [3, 4] and colon cancer [3], and hypertension [5]. The range of PA advocated includes muscle strengthening, improving balance and 150 minutes of moderate intensity aerobic activity throughout the week. The updated UK Chief Medical Officer's Physical Activity Guidelines published in 2019 echoes very similar messages to those of WHO [6]. However, given the emergence of new data indicating that a small amount of PA can show beneficial health effects [7, 8], the 2019 UK guideline has shifted away from recommending a minimum amount of time to exercise. In the section dedicated to people ≥65 years old, it emphasises "some physical activity is better than none: even light activity brings some health benefits compared to being sedentary" [6]. This shift in message may have a significant impact on how older adults view PA.

The level of PA participation in older adults is low; in 2016 the Health Survey for England reported that 67% of adults aged 19–64 years met the aerobic activity guidelines (71% of men; 63% of women) whereas only 44% of adults aged ≥65 years (48% of men; 41% of women) met the target [9]. Therefore, it is paramount to understand older adults' perspectives on participation in PA which then can aid us to develop interventions to promote PA, thus translating its benefits into practice. Previous qualitative research into older adults' perceptions of PA have tended to focus on structured PA, such as resistance training, balance and strength, and falls prevention programmes [10, 11] and has highlighted a number of influencing factors that can be largely categorised as: physical, social, environmental and psychological [10, 11]. Common facilitators include both physical and mental health benefits deriving from being physically active, and encouragement from peers, family and support networks [10, 11]. Frequently cited barriers to exercise include physical limitations due to pain or existing medical conditions [12, 13], and lack of motivation [13, 14]. A number of psychological factors have been strongly linked with higher levels of general PA and exercises in the older adult population, including high self-efficacy, positive thinking, and motivational internal thoughts [15–17]. In their review, Cavill and Foster focused on qualitative studies and previous reviews that investigated the barriers and facilitators to participation in strength and balance activities, having found specific motivators including reducing the risk or fear of falling, and preventing deteriorating and disability, and specific barriers including the perceived risk of a heart attack/stroke or death and fear of looking too muscular [10].

A UK qualitative study looked into older adults' experiences of successful PA interventions and what would influence exercise adherence at a population level and found PA being "enjoyable, sociable, affordable, accessible, flexible and seasonal were more important than the health benefits" [18]. Other qualitative studies on PA in community living older adults have focused on various influences such as the impact of neighbourhood deprivation in New Zealand including environmental influences, such as the local community and levels of traffic [19], or cultural influences in older Mexican women living in the US, for example in terms of gender expectations [20]. There have been some studies on older adults' perceptions of general PA, which can incorporate a wide spectrum of activities such as household chores, non-structured PA including walking, and hobbies [21–23]. In a recent systematic review of qualitative studies on older adults and PA, the principle finding suggests the biggest drive for PA is how it contributes to a purposeful and fulfilling life [24], rather than the health benefits. We had unique access to a group of UK community-dwelling older adults, i.e. older adults who were living in their own homes. The objective of this focus group study was to increase our understanding of factors that can affect older adults' general participation in all types of PA and to identify potential opportunities for effective intervention to promote PA in this age group; a secondary aim was to explore any gender differences in factors affecting PA participation.

Methods

Participants

Participants for this study were selected from an established cohort, the Hertfordshire Cohort Study, comprising individuals born in Hertfordshire between 1931–1939 [25]. This cohort has previously been shown to be broadly representative of the wider population of older adults in England [26]. In 1998–2003 at baseline, 3,225 men and women had agreed to be interviewed at home. In 2011, 592 of these participants were approached for follow-up, of whom 443 (75%) were re-assessed. Detail on the background characteristics that were assessed at baseline and in 2011 has been published elsewhere [25]. Of these 443 participants, 408 (still alive and taking part in the study) were approached and invited to attend a focus group for the present study. Of the 408 invited, 92 (23%) participants agreed to take part in the study. The remainder (n = 316) did not take part due to various reasons, including unavailability in the study time frame, non-response to invitation letter or unwillingness. Full details of participant recruitment and the study procedure has been described elsewhere [27].

Design

In brief, an invitation letter containing a participant information sheet and a reply slip were posted out to the participants. Telephone calls were then made to willing participants to arrange a convenient time to attend a focus group. The focus groups took place in a community venue in Hertford, UK between March and September 2014. Participants were reimbursed for their travel and refreshments were provided; no other incentive was offered. Each focus group was facilitated by one of the authors and was supported by another author acting as an observer, who made notes during the focus group discussions and debriefed afterwards with the facilitator (IB and WL). Both authors (female) had experience in qualitative methods. All groups were held separately for men and women in order to be able to explore gender differences, with the exception of one final group that combined men and women in order to fit with their availability. Ethical approval for this study was obtained from the NRES Committee East of England, Hatfield (REC reference: 10/H0311/59). The Hertfordshire Cohort Study had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and

Appendix L

the West Hertfordshire Local Research Ethics Committee. All participants gave written informed consent before discussions began.

The focus group discussions followed a semi-structured guide to facilitate discussion of the study topics (see Supplementary material for a copy of the guide–S1 File). Semi-structured discussions maintain the focus of the discussion but allow for freedom and flexibility for participants to express their views [28]. Discussions were audio-recorded and transcribed verbatim. Topics covered included diet and PA; findings of the diet-related data have been published previously [27], and this paper now reports the PA data.

Data analysis

PA data were analysed thematically [29] and independently of the analysis of the dietary data from the same participants [27]. The study adopted a critical realist position, assuming a realist ontology and a subjectivist epistemology, and thereby acknowledging that observations of reality and generation of knowledge are influenced by the theories and values that a researcher adopts [29, 30]. The transcripts were read, initial codes were identified to classify the data, and these were further organised into themes following the steps described by Braun and Clarke [29]. Initial codes were generated by double-coding of two transcripts; to give an example of how text was coded, a section of text talking about going dancing with friends would be coded under 'social capital/social engagement'. All transcripts were double-coded by the two authors. Researchers compared their coding, combined their codes and organized them into themes to create an initial coding framework. This was used to double-code all transcripts, while being refined to show the emerging themes and categories from the transcripts. The process used was inductive coding whereby data were coded into themes and categories without the constraints of a pre-devised structure [29]. Each theme was analysed by two authors who met regularly to agree upon any divergences in coding and the categorisation of codes under relevant themes, to agree upon the coding framework, to discuss the analysis process, and how the themes might link together to provide insight into participants' perspectives on PA and influences on their activity participation and habits. NVivo 12 qualitative data analysis software was used to assist with coding and data analysis.

Results

Focus group characteristics

Eleven focus group (FG) discussions were conducted with 92 participants, 47% were women, their mean age was 78 years, all were white British and living in their own homes. Table 1 shows the descriptive characteristics of the study participants, as assessed in 2011. Discussions lasted between 75–99 minutes (mean = 90 minutes).

Thematic analysis

Six overarching themes were identified through the process of thematic analysis: (1) past life experiences, (2) significant life events, (3) getting older, (4) physical activity environment, (5) psychological/personal factors and (6) social capital.

These themes are described below, with quotations offered as illustrative examples in Table 2. Quotations are labelled with the number of the focus group and M or W to indicate whether the speaker was a man or woman. We present the findings as they address the primary objective of the study which was to explore what influences physical activity (PA) participation among community-dwelling older people, and where applicable note differences between men and women.

Table 1. Descriptive characteristics of focus group participants (n = 92) (data collected in 2011).

	N	Mean	SD
Gait speed (m/s)[1]	91	0.78	0.16
Grip strength (kg)[2]	91	30.1	10.1
Height (cm)	91	167.2	8.5
	N	**Median**	**IQR**
Weight (kg)	92	78.3	71.5–86.9
BMI (kg/m^2)	91	27.7	25.4–30.8
Alcohol consumption (units per week)	92	3.5	0.8–10.7
Activity time in last 2 weeks (min/day)[3]	85	199	147–283
	Total N	**N**	**%**
Age left education (age at leaving full-time education)	92		
< = 14		14	15.2
> = 15		78	84.8
Social class	89		
I-IIINM (professional, managerial/technical and skilled non-manual occupations)		43	48.3
IIIM-V (skilled manual, partly skilled and unskilled occupations)		46	51.7
Smoker status	92		
Never		45	48.9
Ex		44	47.8
Current		3	3.3
Number of comorbidities[4]	92		
0		18	19.6
1		37	40.2
2		25	27.2
3		7	7.6
4 or more		5	5.4

[1] Gait speed was ascertained using the mean time from two 8ft gait speed tests.

[2] Grip strength was assessed three times for each hand using a Jamar dynamometer; the highest measurement was used for analysis.

[3] Level of physical activity was assessed using the Longitudinal Ageing Study Amsterdam Physical Activity Questionnaire (LAPAQ).

[4] Number of comorbidities out of: bronchitis, diabetes, ischaemic heart disease, hypertension, stroke.

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1. Past life experiences. Many participants spoke of PA habits or routines from previous life stages, e.g. early life or working life, continuing into older age (quotations 1 and 2). Others had stopped being active in the past for a variety of reasons such as busy lifestyles (e.g. work or raising a family), a new medical condition or event that impeded PA participation, and had not resumed their activity later in life, or because of they had aged (quotation 3).

2. Significant life events. This theme includes major events that are common in later life, which may present particular challenges to older people's daily routines and habits.

2.1. Retirement. In this cohort of older adults, men were more likely to mention retirement, than the women. This perhaps reflects the generation where the men tend to be the main earner for the family than the women. Therefore, it was noted the men were more likely to mention having more free time or freedom since retirement to participate in pursuits, take up new hobbies, join new organisations, or volunteer. They spoke of the importance of keeping going after retirement and maintaining a routine (quotation 4). Although some enjoyed a busy

Table 2. Quotations illustrating each of the six themes.

Themes	Quotations
1. Past life experiences	
Quotation 1	*'I've been used to all my life a fair amount of physical activity, an active life and I suppose it comes from a fairly hard working life. Since I retired many years ago I tried to expand that a little' (FG11MW)*
Quotation 2	*'Well I've got three dogs and I walk for an hour every day and I swim. I was a swimming teacher for 28 years, so I am pretty active. . .' (FG4W)*
Quotation 3	*'W1: . . . I used to play badminton 3 times a week and table tennis, as well as the swimming, I don't do as much now . . . it's made me too tired. . .* *W2: Haven't got the energy have we, like we used to have' (FG6W)*
2. Significant life events	
Quotation 4	*'M1: Once you've retired you gotta get out and do, you gotta go* *M2: You gotta keep going* *M3: I get up at the same time as when I went to work' (FG10M)*
Quotation 5	*'The moment I retired I had a terrific change in life because my job was 24/7 seven days a week and I left it all behind . . . I'm president of the sports club which runs three football teams, two cricket teams and I get involved in a lot of the village life . . .' (FG10M)*
Quotation 6	*'. . . I worked all my life seven days a week most of it, and then to suddenly stop work and you find . . . all the days are the same and you know, you get very lazy actually because 'oh I won't do it this morning I'll do it this afternoon'. . .' (FG5M)*
Quotation 7	*'I recently lost two friends, two brothers and a son-in-law, I think that has caused the depression.' (FG7W)*
Quotation 8	*'W1: . . . I then joined a women's club, things like that, to get myself out in the first place . . . being in the company of other people that are in the same position . . . must give you a bit of confidence really.* *W2: You do find that whereas we were . . . quite a bit, out and joining other couples, you did find that you weren't invited so much (noises of agreement)' (FG7W)*
3. Getting older	
Quotation 9	*'. . .I try to walk but I can't walk you know, since I had the heart operation' (FG6W)*
Quotation 10	*'. . . as we're getting older most of us have either got a bad knee or a bad hip. In my case I used to do a lot more walking than I do now, but I just can't do, it's too painful. . ." (FG5M)*
Quotation 11	*'It's through back and knees . . . but you know, I'm lucky I can still keep walking and . . . I think you learn to live with pain . . . I think there are very few old people who don't have pain, and I think it's the degree of it, but you just have to ignore it a bit' (FG9W)*
Quotation 12	*'Yes, I think I still do the same things but a little slower' (FG11MW)*
Quotation 13	*'I had a bit of blood pressure and I went to the doctor's and they said 'keep up the bowling, it's good exercise for you'. . . so I keep doing it' (FG3M)*
Quotation 14	*'The doctor said . . . 'you'll have to pack up working' I said 'I can't'. . . and I thought well I'm gonna prove you wrong . . . I had to talk the surgeon into doing two of mine at the same time, never done it he said before . . . Went back after six weeks . . . without crutches or walking sticks or anything and everybody was still on their crutches and they had one done, so he said 'how did you do that' I said 'determination' (FG10M)*
4. Physical activity environment	
Quotation 15	*'A tremendous variety of activities and one of them is the walks we go on once a month, but they have longer walks, they have eight mile walks, ten mile walks, fast walks, slow walks . . . ' (FG7W)*
Quotation 16	*'I mean an awful lot of people of our age group have never heard . . . 'U3A what is that' you know and I would've thought they would've at least heard of it . . .' (FG9W)*
Quotation 17	*'But these swimming pools . . . they don't make the time for the older people to have their time and you don't really want to go with youngsters splashing, you just want to go in and have swim and that's it, but you feel sometimes that they're not catering for our generation. . .' (FG6W)*

(Continued)

Table 2. (Continued)

Themes	Quotations
Quotation 18	*'. . . I know one or two people who actually, you know they get up in the morning and on goes the television and that's their day, because they can't really afford to do anything else' (FG10M)*
5. Psychological/ personal factors	
Quotation 19	*'Q So what motivates you to keep up that level of physical activity? [moderator's question is followed by discussion by participants] Q How do other people feel about that, about being busy? [answers are given by multiple participants]*
	A [I'm] up ladders and sticking windows up . . .
	A When you stop doing something then you never take it up again, so you got to keep doing what you've been doing all your life' (FG8M)
Quotation 20	*'[In the context of discussion prompted by moderator about what local services/support might be necessary to support people to undertake PA]*
	A You've got to stay healthy and fit. . .
	A I think our opportunities are quite good actually if you've got the motivation to go out and find them. . .' (FG1W)
Quotation 21	*'. . . I got this belief that if I'm doing the marathons . . . I'll still be able to do all the things that I do . . . the minute I slow down, and walk 'round Tescos with a trolley, then I won't be able to do the things, that's why I keep doing it. I sort of have got the belief that if I did it today, I can do it tomorrow and so I try and do it every day' (FG8M)*
Quotation 22	*'For me, a healthy lifestyle is being able to take part in things, still able to enjoy new activities and just generally not feel old actually (laughs) . . . people say 'Oh, you're doing very well for your age' and I say 'Well what am I supposed to be able to do at my age?' (laughs)' (FG4W)*
Quotation 23	*'If you didn't do any exercise it would seize up, wouldn't it, for good perhaps' (FG9W)*
Quotation 24	*'. . . I still get on the bike and also the treadmill but not as long as I should do' (FG5M)*
Quotation 25	*'. . .I'm not at all keen on this group thing, I'd rather do things on my own with my wife and family. . .' (FG5M)*
Quotation 26	*'I go line dancing twice a week, so that's my exercise, I would never go to a gym (laughs)' (FG9W)*
Quotation 27	*'. . . You feel as if you're not sort of educated enough to join the group, because . . . you find lots of very professional ex-headmistresses and that, you know what I mean, I feel inferior' (FG3M)*
6. Social capital	
Quotation 28	*'. . .So, you see other people's lifestyles and you think to yourself 'well they don't look quite as fit, so I need to keep going'' (FG3M)*
Quotation 29	*'I've got one or two friends with. . . Alzheimer's disease and Parkinson's and it worries me. . . that could be me one day. . . and I think at the back of your mind that you're trying to keep yourself in as good a shape as you can. . .' (FG2M)*
Quotation 30	*'. . .The dog insists on me taking it for a walk (noises of agreement) I'm not sure which one of us takes which (laughter). . .' (FG11MW)*
Quotation 31	*'. . .My wife who died eighteen months ago, she had to walk because she had a problem with her leg circulation. . .so that encouraged me to walk as well, so we did a lot of walking together' (FG5M)*
Quotation 32	*'My husband comes with me as well, he's 90, he does exercise, he's better than me (laughs)' (FG7W)*
Quotation 33	*'I've got two neighbours either side of me with young children . . . and they're great they're really' (FG1W)*
Quotation 34	*'I think the friends are very important. . .it's sometimes more important than family (noises of agreement) because you can't alter their lives, they've got their own lives to live' (FG7W)*
Quotation 35	*'I, for instance, have a friend. . . she and I both lost our husbands in the same year. . . I don't think I would've done half the things that I did if she wasn't there for company (noises of agreement) and I think if you can get two or three people who are alone together to go along things, rather than leaving them on their own' (FG7W)*

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schedule after having made a complete break from their working life (quotation 5), others had difficulty adapting to the lack of structure post-retirement (quotation 6).

2.2. Bereavement. For both men and women, adjusting to losing a partner included taking up activities that they previously had not done. There were some gender differences in this regard. Men spoke of doing new activities such as housework. For women, losing their husband led to more walking if they did not drive, or less if they used to walk together. Loss of a partner, pet, friend or family member also led to feelings of isolation and loneliness, with some suffering a loss of confidence, or depression (quotation 7); participants spoke of these aspects in the context of discussion around their views on a 'healthy lifestyle' and their PA habits, so it appeared likely that they affected their PA, even if in an indirect manner. Women highlighted the importance of having a supportive network, for example someone going through similar experiences (quotation 8).

3. Getting older. Debilitating health conditions, e.g. joint or heart problems, and the resultant medical events, e.g. hip or chest operations, impacted on activities, physical condition and loss of abilities such as driving or walking (quotation 9). Additionally, some medications caused side-effects like drowsiness. The decline in capability or ability to do certain activities, slowing down due to the natural ageing process and deconditioning of musculoskeletal health were important constraining influences on physical activity (quotation 10).

While some felt physically limited due to a heart condition, for instance, or a major medical event, others were determined to get back to their original capacity and not be prevented from doing the PA they wanted to do. In some cases, a medical condition or event had led them to do specific exercises or to adapt types of PA to suit their current condition (e.g. rehabilitation exercises). Pain and discomfort were barriers to doing PA, with some determined to 'walk through it' (quotation 11). Many spoke of maintaining activities despite being stiff and suffering general decline, of slowing down the pace but still continuing to complete the task (quotation 12). Interactions with medical professionals encouraged PA, including some wanting to prove medical professionals wrong (quotations 13 and 14).

4. Physical activity environment. *4.1. Availability of local services and facilities.* The discussions revealed varying knowledge with regards to availability of local facilities and activities, for example, some took advantage of regular activities such as walks, some had never heard of U3A (University of the Third Age) and for others it was an important part of their lives (quotations 15 and 16). The U3A is an organisation of locally-run interest groups around the UK that provide opportunities for members, usually individuals who are no longer in full-time work, to engage with others to undertake a broad range of activities together. Some women spoke of a lack of publicising of local organisations and facilities, and women were more likely than men to speak of reduced opportunities suitable for older people, as illustrated in quotation 17, where some felt there was a lack of certain facilities suitable for older people.

Having access to a suitable environment at home or nearby was a motivator for PA, e.g. having access to a garden, parks, and allotments. Some localities had greater availability of facilities than others, and there was mention of a loss of green spaces.

4.2. Accessibility. Availability of transport and having a bus pass offered freedom and pleasurable experiences. While some were reliant on a bus pass, others rarely used it. Some mentioned a lack of local transport, and how not being able to drive was restrictive. Affordability of activities and transport was an issue for some and could mean reduced participation in activities (quotation 18).

5. Psychological/personal factors. *5.1. Mental state.* For some participants, their mental well-being, low mood/depression and self-esteem appeared to be important aspects relating to the activities that they felt able to do. Participants also spoke widely of the enjoyment of activities, and the importance of keeping not only physically but mentally and socially active.

5.2. *Motivation and maintaining independence.* Discussions highlighted the importance of determination, discipline, positive thinking, motivation, independence, and self-efficacy (a belief in one's ability to undertake an action). There was a strong desire in some not to be restricted, and to keep going in order to remain independent; there was an awareness of ageing, with a fear of stopping being active as it might then be harder to restart (quotations 19, 20 and 21).

5.3. *Beliefs and self-awareness.* Many were determined to take part in things, to 'not feel old', and did not want to be perceived as incapable purely due to chronological age, and the importance of interacting with people of all ages as 'that keeps you young' (quotation 22). Some demonstrated 'outcome expectancy' (anticipation of future outcomes as a result of current actions) regarding PA being beneficial for long-term health or longevity (quotation 23). Some mentioned a lack of motivation, perceived as laziness, as a barrier to PA, acknowledging that they 'should' do more (quotation 24).

Personal preferences affected engagement with certain types of PA, such as disliking group settings or organised activities, and some suggested alternatives that they would prefer (quotations 25 and 26). Some men said they felt unworthy in some way of joining group activities (quotation 27).

6. Social capital. Many participants were involved in local or community groups and organisations (e.g. village committees, volunteering, U3A), although some of these were more mentally stimulating than physically challenging. Social aspects of PA and lifestyle more generally were important. Social comparisons were made with peers' health and PA behaviour. It appeared that behaviours were sometimes motivated by fear resulting from others' experiences or feeling fortunate to have relatively good health compared to others (quotations 28 and 29). Having a dog was an important motivator for some participants to do PA, particularly as it appeared to function as an incentive to go for walks on a regular basis (quotation 30); moreover, the social aspects of dog walking, including meeting other dog walkers and walking and talking together, appeared to be an important factor for engagement in this activity. Family, friends, and partners were important motivators (quotations 31 and 32) and as a source of social support. However, in some cases they could have a negative impact on PA due, for example, because their role as carers constrained their time. For both men and women, living alone was a potential barrier to social interaction and PA. Women were more likely than men to mention the importance of having helpful or supportive neighbours and community (quotation 33). For some this aligned with a desire to avoid being a burden on family which appeared to be a motivation to keep fit (quotation 34). The role of friends appeared to be particularly important for those who had lost their partner or lived alone, and there was suggestion that activities that are not just couple-oriented might be of importance (quotation 35).

Discussion

This study has highlighted six themes that might affect community-living older adults' participation in PA: past life experiences; significant life events; getting older; PA environment; psychological/personal factors; and social capital. The first three are largely non-modifiable as they tend to be events that have already happened or over which there is potentially limited or no control, however how an individual responds to these events could be modifiable. The opportunity to optimise the PA environment is likely to require a broader intervention approach and involvement of a multitude of stakeholders, such as local authorities, in order to make meaningful changes. Our analysis proposes the remaining two factors–psychological/personal and social capital partly determine how people respond to largely non-modifiable factors. For instance, those with higher levels of self-efficacy or determination, might be more

likely to respond positively to the consequences of ageing and medical events or conditions, by maintaining or increasing their PA. There was a gender difference in response to the loss or serious illness of a partner. Women who had access to and utilised their social network appeared to be more likely to remain engaged in PA. Whereas for men, the loss or serious illness, of a partner led to the need to carry out more household chores, but not to a specific interest in engaging with social activities. Despite approaching the PA data inductively, the same themes and relationships between the themes appeared to hold for the PA data as they did in the published diet findings in this group [27]. Unhealthy lifestyle behaviours including poor diet and low PA levels often co-occur in older adults [31, 32], and we can speculate that the motivations might be similar for both types of behaviour.

The role of psychological and social factors has been identified in previous quantitative studies that have shown leisure time PA to be significantly linked with self-efficacy [15] and improved social, physical, emotional and cognitional function [33]. Specifically, thinking more positively and having motivational internal thoughts have been extensively shown to be associated with increases in older adults' leisure time PA [15–17]. In a systematic review of 63 studies with adults aged ≥60 years [17], motivation and self-efficacy were the two psychological characteristics that were consistently associated with higher level of routine PA [17]. In our focus groups of community-dwelling older adults we observed variability in psychological and social factors that can affect the response of an older person to an event. This poses an interesting avenue for intervention targets, with health coaching using elements of motivation and self-efficacy to promote healthy behaviours. There is great heterogeneity in what constitutes health coaching [34]. It commonly consists of patient-centred approaches based on a behavioural change model that is delivered by a trained professional. The process often involves patient-determined goals, self-discovery and accountability. The effects of health coaching on level of PA participation in those aged ≥60 years have been found to be small but significant, compared to controls, and it is effective in both older adults with and without chronic conditions [35]. The use of "positive framing" has also been used in older adults in the context of walking; in one intervention study those exposed to "positive framing", where participants were informed of beneficial effects of walking, were found to walk more steps, after controlling for baseline number of steps walked, than those receiving "negative framing", where participants were informed of negative effects of not walking [36]. In a weight-loss trial, a motivation-focused programme that specifically targeted motivational factors showed comparable weight loss to the traditional skills-based weight loss programme [37].

The presence of physical limitations or health-related conditions has been found to be closely related with older adults' perceptions of being able to be physically active [11, 24]. Interestingly in our study we found polarising views on this matter. Some felt that their health-related issues were a barrier to being active, whereas others refused to let medical conditions be an impediment to their participation in PA, therefore making particular efforts to overcome obstacles. Halvarsson and colleagues interviewed older women (≥65 years), with a diagnosis of osteoporosis and either self-perceived fear of falling or who had experienced a fall within the past 12 months, after participating in a balance training programme [38]. The aim of the programme was to improve self-efficacy, balance and physical function [39]. The programme improved participants' self-perceived empowerment and self-efficacy, therefore resulting in the ability to approach activities of daily living with confidence and to employ risk-reducing strategies to avoid falls. However, the participants' assessment of risk still remained influenced by their own perception of fragility [38]. Aligning with our study findings, this reflects how some people's perception of their health is a barrier to be overcome, whereas for others it is insurmountable.

Strengths and limitations

One of the limitations of this study is the age range of 74–83 years, which was pre-determined by the age range in the Hertfordshire Cohort Study. This does not incorporate the full age range that is generally included in the older adults' category (i.e.: ≥65 years). Although data were collected in 2014, there is no reason to believe that findings would be different if we had conducted the research more recently. It should be noted that in the current context of the ongoing COVID-19 pandemic, increasing evidence indicates a decrease in PA levels of older adults due to related restrictions [40, 41]. Only white British adults participated in the focus groups, so we have no insight into any additional factors that could be relevant to other ethnic groups. However, a key strength of this study is the wide range of socio-economic backgrounds represented, therefore findings may be relevant to a large proportion of the UK older population.

We acknowledge that this study presents only one view, and other interpretations are possible. However, the analysis was conducted independently by two researchers through a rigorous process of double-coding, thereby reducing the probability of skewed views being presented. Throughout the study process, a multidisciplinary team approach was utilised, therefore minimising the probability of misrepresentation.

Implication for future research and practice

A variety of modifiable psychosocial factors, including self-efficacy, motivation, outcome expectancy, and social support and engagement, appeared to influence older adults' PA. Specifically psychological and social factors affected how older people overcame historical, environmental, medical and other ageing-related barriers, in order to incorporate PA in their lives. Therefore, this presents possible avenues for targeted interventions for older adults in encouraging PA.

Our findings regarding the importance of having a supportive network, including friends and neighbours, particularly for women who had lost their partner or lived alone, suggest that interventions to promote PA should take these aspects into account in their design, e.g. 'buddy-up' schemes to promote engagement with activities.

Furthermore, the physical environment was another modifiable element highlighted in our study; optimisation of the PA environment is important and without a facilitative infrastructure to propel meaningful progress, individual change can be challenging. Our study's findings suggest that involving older adults should be a key aspect of any intervention to enhance the local PA environment, as older adults could offer invaluable insights into local need and could work together with local councils to improve transport links and green spaces, for example.

This highlights the value of adopting participant-led approaches when designing interventions, emphasising the need to include older adults through user-led approaches, and be aware that a "one size fits all" approach would not be appropriate. Those who are likely to use such programmes are best placed to be able to provide insights into factors that are important to their age group [42, 43]. Co-production of interventions promotes a sense of ownership. These findings also emphasise the importance of involving behavioural scientists from the beginning of intervention programming. They understand not only theories of behaviour change, but can identify ways to (i) enhance self-efficacy (e.g. by providing mastery experiences), (ii) utilise effective behaviour change techniques (such as social support, goal-setting, prompts and cues, role models), (iii) increase sense of control (e.g. by involving older adults in public patient involvement), and (iv) motivate and empower using established programmes. More recent physical activity interventions have begun to incorporate the perspectives of the intended

users such as "The Move for Life Study" [44] and the "Osteoarthritis Physical Activity Care Pathway"[45].

Research is required to further explore how the COVID-19 pandemic has impacted community-living older people's health, well-being and PA behaviour. However, we believe that the data from the present study could still provide useful insights into how an ageing population view physical activity and how best to intervene to increase participation.

Conclusion

In an ageing population, healthy living is becoming a key concept and this has thrown up new challenges, thus to facilitate the adoption and maintenance of PA the inclusion of the intended users' perspectives is crucial. This study sought the viewpoints of a group of free-living community older adults who had not been recruited for specific PA related activities or programs. Consequently, PA in its broadest sense was discussed psychosocial factors emerged as key influences, suggesting that interventions that target factors such as self-efficacy and social engagement, might hold potential for promoting engagement in general PA. These findings would aid the development of future interventions and as well as local authority planning for the needs of older adults living in the community.

Supporting information

S1 File. Focus group discussion guide.
(DOCX)

S2 File. COREQ checklist.
(PDF)

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Understanding the early life and environmental determinants of bone strength and structure: The Hertfordshire Cohort Study Nutrition and Physical Activity Study

Information Sheet for Study Participants
Sheet 1

Nutrition and Physical Activity Study

Principal Investigator:
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MRC Lifecourse Epidemiology Unit

HCS

on the MRC LEU website and in the Hertfordshire Cohort Study News Letter. Details are included in 'Sheet 2 - Study Conduct Information'

Will I be reimbursed for my time?

There will be no reimbursement for time but your generous contribution is much appreciated.

Contact for further information

If you have any further questions then please contact Dr Ilse Bloom, Research Nutritionist or Dr Jean Zhang, Clinical Research Fellow, by phone on 023 8077 7624 or write to MRC Lifecourse Epidemiology Unit, Southampton SO16 6YD.

University of Southampton

V1.1, 24/09/2019, REC Reference -11/EE/0196

You are being invited to take part in a follow up for the above research study. Before you decide whether or not you wish to take part it is important that you understand why the research is being done and what it will involve. Please read this information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear, or if you would like more information. Take time to decide whether or not you wish to take part. Details about the conduct of the study are on another sheet (Sheet 2 -Study Conduct Information) and this should also be read before deciding whether or not you wish to take part.

What is the purpose of this study?
We want to find out more about the lifestyle of older people and how nutrition and physical activity can affect their musculoskeletal health. As part of the study, we wish to test different ways to support you in maintaining musculoskeletal health through changes in nutrition and physical activity.

Why have I been chosen?
You have been chosen because you have helped us with previous study visits. We are hoping to find about 200 individuals aged 80+ years old who are interested in taking part.

Do I have to take part?
No. It is up to you to decide whether or not to take part. If you do decide to take part, you then sign the contact sheet which is enclosed. You are still free to withdraw at any time without giving a reason.

What will happen to me if I take part?
If you return the contact sheet to us in the pre-paid envelope, you will then be contacted by a trained researcher via telephone to arrange a time at your convenience to be visited in your own home. Upon arrival, the researcher will show you an ID card to identify themselves. In this home visit, after a further explanation of the study where we will answer any remaining questions, you will then be asked to sign a consent form. A questionnaire will be administered and we would also like to measure:

a) your height and weight
b) how strong your hand muscles are
c) your balance and walking speed

You do not have to take off your clothes for these measurements. The home visit should take approximately up to 1.5 hours.

Some of you will receive a leaflet on healthy living, and some of you will have a conversation with the researcher about healthy living, which with your permission will be audio-recorded for quality control, and research purposes. You may receive follow up telephone calls with regards to the initial home visit, and they will take occur at 1, 3, 6 and 9 months after the home visit. Each call should be approximately 15-20 minutes. With your permission these telephone calls will be audio-recorded for quality control, and research purposes. If you do not wish to be audio recorded, you will still be able to participate in the study. At the end of the home visit you will be given an accelerometer which is a watch like device for you to wear for 7 days to monitor your level of physical activity. More information can be found in "GENEActiv physical activity monitor: participant information" sheet. You will be invited to be followed up a year later.

What are the possible benefits of taking part?
The results of your questionnaire will improve our understanding of how general lifestyle factors can affect our musculoskeletal health, and may be helpful to you and your family. We will use this information later to plan ways to improve health services for older people.

What are the possible disadvantages and risks of taking part?
The disadvantage of taking part is that it involves a time commitment to read the information and a home visit. There are no direct risks to taking part.

What will happen if anything goes wrong?
Any complaints you have about this study will be fully investigated. If you have a concern about any aspect of this study, you should contact Professor Elaine Dennison (Tel: 023 8077 7624, or write to MRC LEU, Southampton, SO16 6YD) who will do her best to answer your questions. If you remain unhappy and wish to complain formally, you can contact Research Integrity and Governance Manager on rgoinfo@soton.ac.uk or Tel: 023 8059 5058.

Will my taking part in this study be kept confidential?
Yes. All information that is collected about you during the course of the research will be kept strictly confidential. The details are included in 'Sheet 2 - Study Conduct Information' sheet.

What will happen to the study results?
Your questionnaire will be processed and analysed at the MRC LEU in Southampton.

The overall results may be presented at scientific meetings or published in a scientific journal. You will not be identified in any of these presentations or publications. A summary of the study results will be available

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