**Real time non-instrumented clinical gait analysis as part of a clinical musculoskeletal assessment in the treatment of lower limb symptoms in adults: A systematic review**

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*Highlights*

* Real time observational clinical gait analysis is commonly recommended for musculoskeletal adult lower limb assessment
* This review found no systematic approach or evidence base relating to real time observational clinical gait analysis
* The use of such assessment is therefore open to question in terms of its reliability and validity
* Further work is required to establish if there is clinical worth or value of undertaking gait analysis without computerised or recording equipment

*Key Words*

Gait Analysis, Musculoskeletal, Lower limb, Clinical

*Abstract*

**Background**

The aim of this review was to evaluate and summarise the current evidence on non-computerised or non-recorded real time adult gait assessment conducted within the clinical musculoskeletal setting. It was hoped a protocol for best practice and a framework for further research could be developed from this search

**Research Question**

Can a protocol for best practice and a framework for further research be established from previous literature relating to non-computerised or non-recorded real time adult gait analysis in a musculoskeletal clinical setting.

**Methods**

A literature review with no limitation on date of publication was conducted on the 18th February 2017.

**Results**

The review found no significantly informative papers relating to the search

**Significance**

The lack of research on the accuracy, reliability and therefore worth of this highly recommended area of musculoskeletal assessment raises concerns over current assessment and treatment pathways. Further work to develop a method by which gait analysis can be routinely employed in musculoskeletal clinics as a diagnostic tool is required, with any new approach undertaking robust methodological testing.

*Introduction*

Clinicians are often recommended to conduct gait analysis as part of a general or lower limb musculoskeletal (MSK) adult patient assessment [1-9]. The analysis of gait may be conducted with or without the use of computerised recording analysis equipment with aims to aid in diagnosis, determine treatment goals and evaluate treatment outcomes [2,6,7,10].

The clinical use of gait analysis is thought to be highly variable [11] not only due to the perceived lack of supporting evidence, but also lack of availability, reimbursement and training [12]. Lower limb MSK clinics are suggested to place more value on the merit of gait analysis due to the increased incidence of literature relating gait dysfunction to lower limb injury and the obligatory use of the lower limb in normal gait [4,5,13,14]. Taro et al [15] investigated the status of National Health Service (NHS) physiotherapy gait analysis of children and adults within the UK. Their findings showed that although gait analysis made up a major aspect of physiotherapy outpatients practice, there was no systematic use of a standardised gait analysis tool or recognised methodology or protocol.

The gait of children with or without neurological disorders differs from adults and is also often assessed in more specialised paediatric clinics [16,17]. This sample is therefore seen as a separate group than that of adults assessed in a MSK clinical setting, and excluded from this review for this reason.

The terminology used to describe the clinical gait analysis may be misleading to the practitioner working in a therapeutic setting. ‘Clinical’ gait analysis could be interpreted to mean gait analysis ‘pertaining to a clinic’. Whittle [9] stated that ‘clinical gait analysis’ usually consists of videotape examination, measurement of gait parameters, kinematic analysis, kinetic measurement and electromyography. The term ‘clinical gait analysis’ therefore does not appear to reflect the assessment undertaken in the majority of therapy clinics or centres, but is more associated with assessments conducted in specialised gait laboratories [2,18]. The accepted definition seems counter intuitive and exclusive to the possible majority of MSK assessments conducted in a clinical setting. For clarity there appears a need for terminology to differentiate between ‘clinical gait analysis’ and ‘gait analysis conducted within most clinics’. For the purpose of this paper the term Clinical Gait Analysis (CGA) includes all gait analysis which requires computerised or videotaped recording or analysis, while Real Time Clinical Gait Analysis (RTCGA) pertains solely to gait analysis visually assessed and concluded upon without computerised or recorded aid.

In a systematic review published in 2011, Wren et al [12] concluded that the existing evidence, although sparse at higher levels of efficacy, supports the worth of CGA. They also state visual, or RTCGA, to be less efficacious than that using computerised gait assessment technology. The supposition is limited to just two investigations. Both of these use specific sample groups, either children with cerebral palsy or amputees [19,20]. These investigations were looking for specific markers to determine surgical approaches, and therefore limited to these sample populations and treatment options. Results may be different from a more general MSK patient population. However, these findings support the apparent consensus regarding RTCGA being the less valid and reliable of the methods available [2,21].

The aim of this systematic review was to evaluate and summarise the methods of RTCGA used in adult musculoskeletal clinics treating the lower limb. It was hoped from these findings a protocol of best practice in a clinical setting could be established and also provide a foundation for further work and investigation if required.

*Methods*

**Search Strategy**

Search criteria for the systematic review were identified using the Patient, Intervention, Comparison and Outcome (PICO) statement. The literature search was conducted to identify references for RTCGA in a symptomatic lower limb musculoskeletal adult sample with no neurological or amputation related injury or disorder. The data search was conducted on the 18th February 2017 by one reviewer (PH) and databases included were the DelphiS, AMED, CINAHL and MEDLINE. The Boolean operator ‘AND’ was used to combine terms and the Boolean operator ‘OR’ was used to link synonyms. The Boolean operator ‘NOT’ was employed to exclude key terms.

Overall search limitations were applied only to that of human participants. No historic date to results was set, as it was thought that older research (when technology was less readily available) may still hold valid results. If other than English language papers were found, translation would have been considered. Terms to exclude studies utilising computerised analysis or recording or playback equipment were not excluded at this stage. This is due to the possibility of such technology being used to research the validity of RTCGA. This database search methodology is shown in Figure 1.

**Figure 1** – Database Search. Conducted 18th February 2017

|  |
| --- |
| 1. Gait and Walking 2. Analy\* OR eval\* OR Assessment 3. 1 AND 2 4. Observation\* OR visual OR live OR “Real Time” 5. 3 AND 4 6. 5 AND adult 7. 6 NOT child\* NOT paediatr\* NOT pediatr\* 8. 7 NOT stroke NOT cerebr\* NOT CVA 9. 8 NOT amput\* NOT “muscular dystrophy” NOT sclerosis NOT “brain injury” NOT “spinal cord injury” NOT Alzheimer\* NOT neuropath NOT neurological NOT parkinson\* 10. “lower limb” OR “lower extremit\*” OR foot OR ankle OR shin OR leg OR knee OR thigh OR hip 11. 9 AND 10 12. Musculoskeletal OR orthopaedic\* OR orthopaedic\* OR therap\* OR physiotherap\* OR podiatr\* OR rehab\* OR outpatient\* OR doc\* 13. 11 AND 12 14. Injur\* OR pain\* or symptom\* or trauma\* 15. 13 AND 15 |

Hand searches of bibliographic references identified additional publications. Grey literature refers to publications on any format not controlled by commercial publishers nor necessarily peer reviewed. Grey literature was included based on an initial search using the terms Gait, walking and locomotion and rerun in conjunction with the terms analysis, assessment or examination to ensure the search had captured all relevant sources.

**Selection Criteria**

Study inclusion and exclusion criteria used to determine articles included in this review are shown in Table 1.

**Table 1** – Search inclusion and Exclusion Criteria

|  |  |
| --- | --- |
| Inclusion Criteria | Exclusion Criteria |
| Articles investigating visual un-instrumented walking gait analysis as part of a clinical musculoskeletal assessment in the treatment of lower limb symptoms | Methods dependent on the use of computerised analysis or recording and playback equipment\* |
| Adults | Assessments specific to amputation or neurological injury or disorder |
|  | Paediatric patients |

**\***Studies using the above techniques are excluded unlessused for validation of RTCGA

Potentially relevant articles were subject to abstract screening. If deemed suitable, full text screening was then undertaken. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist criteria [22] was used to extract data from identified literature.

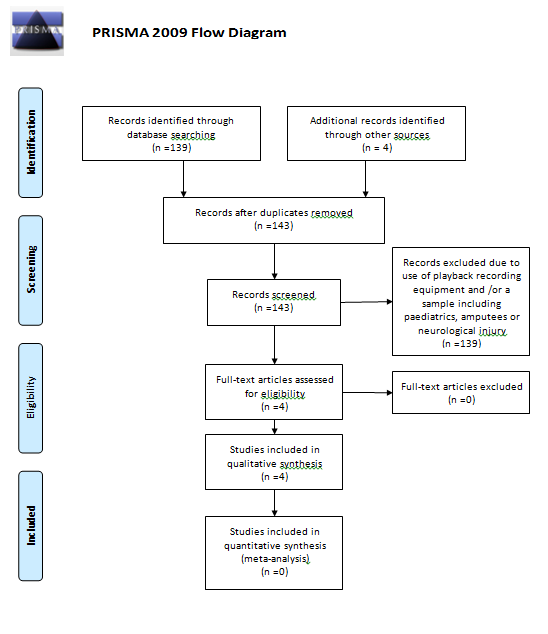
**Quality assessment**

The Critical Appraisal Skills Programme (CASP) tool was used to evaluate the included papers. The CASP tools are succinct and effectively cover the areas needed for critical appraisal of evidence [23]. Specific CASP checklists have been developed for reviews of randomized controlled trials, systematic reviews, qualitative, case control, diagnostic, cohort, economic designs, and clinical prediction rule [24]

*Results*

Papers were evaluated for inclusion following the PRISMA flow chart, shown in figure 2.

**Figure 2** – Search results demonstrated within the PRISMA flowchart



A total of 143 papers were identified as a result of the literature search. 139 were identified via electronic literature sources (DelphiS, AMED, CINAHL and MEDLINE) and 4 were from the grey literature or hand searches of bibliographic references. All of these 143 went directly to abstract screening, from which 139 were excluded for not meeting the selection criteria. The primary reason for exclusion was the use of CGA with no relation to validation of RTCGA. There was also a crossover with other exclusion criteria such as less common neurological disorders and also less common locomotion assessment such as walking backwards.

It was proposed the 4 remaining papers may relate to the research question and were worthy of full-text assessment for eligibility

The Gait Arms Legs and Spine (GALS) assessment Tool

2 of the remaining 4 articles related to the Gait Arms Legs and Spine (GALS) MSK assessment tool, one a validity study [25] and the other focussing on sensitivity and specificity of the tool [26].

The GALS was developed to assist in the detection of MSK abnormalities after Doherty et al [27], in a review of 200 patients in a non-acute hospital setting, found assessment of the locomotor system was frequently absent during medial clerking. It is used by consultants, general practitioners and primary healthcare professions [25]. RTCGA is the initial part of the physical assessment, but this is only 1 of 12 areas of examination and only 3 of the 29 total features assessed. The tool combines scores of separate assessments of the arm, legs and spine and so not specifically in relation to the lower limb or gait. Gait is assessed for symmetry and smoothness of movement, stride length and mechanics and ability to turn ‘normally’ and quickly. If or when an abnormality is observed, the health care professional records the result as ‘abnormal’ and then can note later the location and type of abnormality [25,26]. There is no guidance on a uniform or validated method to categorise these ‘abnormal’ findings further. No research or guidance is available into the details recorded clinically under the category of “abnormal”.

Validity was assessed for primary care use by comparing GALS tool scoring of family physicians with that of Rheumatologists. The coefficient of agreement (estimated Kappa) for the composite GALS score was 0.3675. The individual coefficient of agreement for the gait section was slightly higher at 0.49. This still may be classed as only a moderate agreement between both groups [28].

In a following paper utilising the GALS MSK assessment tool, Beattie et al [26] state family physicians and nurse practitioners appeared able to employ the GALS examination to screen for possible signs of Rheumatoid arthritis. Only the composite score was assessed, with no individual analysis of sections such as gait analysis.

Author designed assessment tool

Brunnekreef et al [10] published a paper on a structured gait analysis form used in the ‘observational gait analysis’ of patients with orthopaedic disorders. Although the study used videotaped analysis it was included as the abstract extrapolated upon the reliability of ‘Visual Gait Analysis’. It was therefore possible that the videotape element of analysis was used to assess the validity of a form used for RTCGA.

This was not the case. From this paper it is unclear as to whether the form is designed to be used for RTCGA, or just to aid in interpretation of CGA, but there was no comparison or evaluation of RTCGA.

The samples included were taken from videotapes of patients who were referred for gait treatment to an orthopaedic clinic and were assessed using freeze frame and slow-motion. Raters were allowed to watch the patient as many times as they wished. This can therefore be classed as CGA rather than RTCGA. The authors concluded their form had inter-rater reliability (ICC values) among experienced and inexperienced raters of 0.42 and 0.40 respectively.

Clinical Education Paper

A paper on gait and posture assessment for general practitioners working with MSK injuries was published by Sweeting and Mock in 2007 [29]. They propose 18 areas a general practitioner should assess during gait analysis, with no reference to detailed methodology, reliability or validity of any of these observations. The title and abstract is inappropriate to the content of the paper. The articles objectives, within the abstract, include assessment of gait and visual scanning of abnormal gait. The methods for neither are presented with the main text.

*Discussion*

Lack of Research

This review has found a lack of a standardised or systematic method of RTCGA in adults with a lower limb MSK injury.

The GALS MSK tool may be classed as ‘simplistic’ in its assessment of gait. In Beattie et als 2008 [25] paper, 9 out of the 10 patients who were classed as having an ‘abnormal gait’ were referred on for further gait investigation or assessment. It may be argued that GALS is more a tool used to identify the need for further referral for gait analysis rather than a gait analysis itself. Brunnekreef et al [10] studied the reliability of their own ‘orthopaedic gait analysis form’. The observed 30 patients had been classed by the authors at inclusion as showing an undefined ‘mild to severe’ gait deviation. This sampling bias towards more obvious gait abnormality reduces the ability to withdraw data relevant to a general MSK clinic. It is also unclear from the paper if Brunnekreek et al [10] recommend their orthopaedic gait analysis form to be used without the presence of recorded playback facility. Although no comments are directly related to this, they do conclude that “structured visual gait observation” is moderately reliable. If only this level of reliability was demonstrated while using a sampling bias of moderate to severe gait abnormality and assessed using video playback with freeze frame and pause capacity, it seems fair to conclude that even if findings could be migrated to RTCGA in a general lower limb MSK clinic then results would be poor.

On the basis of these results, it is difficult to predict the value, worth or even viability of including RTCGA in an MSK assessment. Coutts in 1999 [2] stated “currently observational analysis on its own is insufficiently reliable to be clinically acceptable”. Eighteen years later and there appears to be no further work available to change this conclusion. We do not even know the proportion of clinicians using RTCGA, why they use it, how they are undertaking it or in which situations.

Whether there is still a clinical worth in conducting RTCGA therefore remains highly controversial. To date, there is only evidence of categorisation of RTCGA patterns by researchers in the physical therapy and surgical communities for neurological disorders such as cerebral palsy, stroke or Parkinson disease [30,31]. Each of these assessment tools utilises observing gait markers which link to a particular gait dysfunction related to the specific disease process. Even in more specifically researched areas such as stroke patients, Taro et al [31] state a critical issue is the lack of a standardised method of gait classification. With this lack of research it would be expected that opinions on the use of RTCGA would remain balanced, but some authors still state that RTCGA is not only a powerful investigative tool, but even comparable to an X-ray or blood test [29]. Stating such a high level of worth, with no apparent evidence base, appears unfounded and potentially misleading to MSK clinicians.

The lack of research in an area of assessment with common clinical recommendation and possible use may be seen as both surprising and relatively alarming. Abnormal gait has been cited by many as the cause of MSK lower limb injury and yet there appears no reliable or systematic method by which the majority of clinicians can assess for it. It also leads to questions in relation to treatments which are used to improve gait dysfunction by clinicians without access to CGA. Without being able to ascertain the worth of RTCGA, can changes from treatments such as foot orthoses, footwear advice, taping and muscle balance correction be considered measurable in their outcomes? If improvement to gait is a goal to a treatment (while also ensuring treatment has no adverse effects and is not detrimental to gait), then it would seem compelling to consider such practices questionable at the least. Greater access to CGA for all clinicians may be a method to improve patient assessment and outcomes. However, although opinion and limited publications appear to state that CGA is more beneficial than RTCGA, this has yet to be determined within the general symptomatic adult MSK population. With no research or evidence based guidelines on RTCGA, there simply is no current method for the CGA to be compared against in this sample group.

**Terminology**

This paper has highlighted the possible confusion in terminology used with describing the assessment of gait in a therapeutic clinical setting. The authors propose the use of ‘Real Time Clinical Gait Analysis’ to specifically relate to the assessment of gait conducted live in health professionals clinics, without the use of any recording, play back or computerised equipment. The term ‘Clinical Gait Analysis’ has already been coined to describe gait analysis conducted with the use of recording and evaluation technology. This acceptance of differing terminology may help reduce some of the issues experienced within this search. Brunnekreef et al [10] used the terms observational gait analysis, videotaped observational gait analysis and visual gait observation without clear definition or separation. ‘Visual gait analysis’ has been used elsewhere to mean gait analysis conducted without technological aid [12]. It was unclear if Brunnekreef et als [10] abstract, using the term ‘structural visual gait observation’, related to its title of videotaped observational gait analysis or a conclusion obtained from this upon RTCGA, hence the papers inclusion.

**Further Work**

With such findings, it seems reasonable for explication of these results to include recommendations for further work. Further referral for more in depth analysis of gait is noted as an outcome in GALS research [25] and it is unclear if referral pathways in areas such as the NHS would have access to CGA. Development of an adult MSK RTCGA tool or protocol could be useful for clinical practice. If types or ‘patterns’ of gait can be recognised, then linking this to injury, aetiology, treatment and outcomes would be beneficial. The requirement for an easy to use RTCGA tool amongst physiotherapists working in the NHS has already been suggested [15]. Prior to the design of such a tool, investigations into the current use or requirements of RTCGA within the variety of lower limb MSK clinics needs to be established. A systematic approach has recently lead to the development and proposal of a static International Musculoskeletal Foot and Ankle Assessment (IMFAA) [32]. Such a method now needs to be employed for RTCGA. A RTCGA tool could be a worthy instrument for all clinicians treating adult lower limb MSK injury relating to gait dysfunction. These clinicians will have varied professional backgrounds and experience levels as well as working in multitudes of clinical settings. It is therefore essential that before further and possibly misleading information regarding RTCGA is passed onto MSK clinicians, the research into the validity, sensitivity and reliability of any RTCGA tool is assessed and presented with a balanced and clinically valid perspective.

*Conclusion*

This study has found a significant lack of justification into the use of RTCGA of adults with lower limb injury in MSK clinics. Although CGA may be more efficacious, it is assumed the methods by which this is conducted are not available for the majority of clinicians working with this patient group. A protocol for best practice could not be developed from this search. Further possible evolution in the role of RTCGA is proposed, but without additional guidance the current use of RTCGA as a part of this specific patient group analysis appears dubious at the very least.

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