Inter and intra-rater reliability of rating criteria for the Floor Sitting Posture Screen

Matthias Houvenagel

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Declaration

Matthias Houvenagel:

This Research Project is submitted in partial fulfilment for the requirements for the Unitec degree of Masters of Osteopathy

Candidate's Declaration

I confirm that:

This Research Project represents my own work;

The contribution of supervisors and others to this work was consistent with the Unitec Regulations and Policies.

Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.

Research Ethics Committee Approval Number: 2010-1136

Candidate Signature: Date:

Student number: 1288306

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Introduction to Thesis

In contemporary society a large proportion of daily activity is spent seated using various forms of furniture (eg office chair, dining chair, vehicle seating, couch). Beach (2008a), hypothesises that the amount of time spent seated in chairs may negatively influence musculoskeletal health and decrease our ability to achieve various floor sitting postures such as squatting or straight leg sitting (Beach, 2008a). Beach's hypothesis is based on an evolutionary perspective on health and posits that, as a species humans have not had sufficient time to adapt to the relatively recent introduction of elevated sitting using furniture.
Beach has described a selection of floor postures (see Appendix A) and suggested that they may be useful in clinical assessment and treatment of the musculoskeletal system (Beach, 2008a). To be able to utilise the floor sitting postures as a screening protocol, practitioners need to be reliable in judging the performance of the presented postures. Recently, Hargovan (2012) produced a visual rating protocol named "Floor Sitting Posture Screen" for a sub-group of six of the postures presented by Beach (Appendix A). However, to ensure the screening protocol is clinically useful, it must first be shown to be reliable and valid.

Reliability and validity of physical examination and diagnostic procedures are imperative for the subsequent development of further research as well as the development of appropriate treatment plans (Lucas & Bogduk, 2011). Limitations of validity and reliability may result in patients with the same signs and symptoms being diagnosed and treated differently by different practitioners, potentially leading to different therapeutic outcomes. Due to the early stages of development and obvious novelty of the Floor Sitting Posture Screen, reliability and validity studies are necessary to evaluate the characteristics of the protocol before its application in practice.

Extensive research in the field of visual assessment screening in musculoskeletal healthcare has been undertaken because visual observation enables practitioners to broadly investigate their patients' musculoskeletal system with rapid, inexpensive and non-invasive procedures (Watson & Mac Donncha, 2000; Fedorak, Ashworth, Marshall, & Paull, 2003; Moran & Ljubotenski, 2006; Aitken, 2008). However, based on the available evidence it appears that more research within the field of visual observation is needed to improve the reliability of many visual rating protocols. Consequently the aim of the study reported in this thesis was to evaluate the inter and intra-rater reliability of the Floor Sitting Posture Screen.

This thesis is arranged in three sections.

Section 1 is a literature review that introduces the on-going debate about the validity of the Postural Structural Biomechanical model. This model supposes a positive correlation between patients' physical findings (such as bony and soft tissue symmetry, muscle tone, texture, or joint range of movement) and patients' physical impairments (such as back or neck pain). The outcome of this debate is important because it influences the utility of physical examination for the musculoskeletal system. This review then briefly introduces the ideas of Philip Beach, an osteopath and author, about the possible usefulness of floor sitting postures in assessing and managing musculoskeletal impairments that are prevalent in contemporary society. In a subsequent section, current research on the reliability of practitioners using static and dynamic visual physical examination protocols is reviewed. Finally, the review will introduce the recently developed visual examination protocol "Floor Sitting Posture Screen", and present a rationale for investigation of reliability in support of its possible adoption into clinical process.

Section 2 of the thesis reports a study that investigated the inter and intra-rater reliability of the Floor Sitting Posture Screen. The section is formatted as a journal manuscript in accordance with submission requirements of the *Manual Therapy* journal (Appendix H for Instructions for Authors).

Section 3 (Appendix) contains ethics documentation and other additional information.

SECTION 1: LITERATURE REVIEW

Literature search methods

The literature search for this literature view was performed using online databases: Science Direct, EBSCO host, PubMed (Medline). The combinations of keywords included: posture, reliability, visual evaluation, observation, assessment, examination, anthropology, low back pain, postural structural biomechanical model, osteopathy, manual therapy, physiotherapy, chiropractic.

1. THE POSTURAL STRUCTURAL BIOMECHANICAL MODEL

1.1 Introduction of the Postural Structural Biomechanical model

In considering optimal health of the musculoskeletal (MSK) system it is necessary to understand the causes and processes that lead to its impairment. Musculoskeletal therapists (eg chiropractors, manual and manipulative physiotherapists, osteopaths) have been trying to produce theories and data to model the MSK system. In this regard, musculoskeletal therapists have been primarily focused on what has become known as the "Postural Structural Biomechanical (PSB) model" (Lederman, 2011). This model aims to explain, through application of biomechanical principles, why tissues may be a source of nociception and impairment (Solomonow, 2006). The PSB model draws on the basic laws of Newtonian physics to understand MSK biomechanics. This model states, for example, that when musculoskeletal asymmetries are present, compensation of workload will need to occur (Ward et al., 2003, p. 583) and when soft tissue capacity is overwhelmed by the increase in workload then failure and mechanically and chemically mediated nociception may occur.

To introduce the PBS model in a clinical practice context, practitioners generally aim to identify physical abnormalities using clues such as asymmetry of bony landmarks, altered muscle length and tension, detection of altered tissue texture during palpation, or observation of altered joint ranges of movement (Ward et al., 2003; Porter, 2008; Souda, 2009). Visual observation is a key assessment approach used by musculoskeletal therapists to identify dysfunction of the musculoskeletal system, and subsequently direct treatment planning with the aim of restoring function.

1.2 Uncertainty of the Postural Structural Biomechanical model

Although the PSB model is based on biomechanical principles, there appears to be some uncertainty about the extent to which the PSB model explains some common MSK complaints, such as in the case of low back pain. In this section (1.2.1), several studies that support the PSB model will be reviewed before a subsequent section (1.2.2) reviews studies that challenge the PSB model.

1.2.1 Data that support the Postural Structural Biomechanical model

Does the degree of thoracic kyphosis influence the mechanical loading of spinal structures?

A study by Briggs et al found that an increased thoracic kyphosis enhances loading force on spinal structures (Briggs et al., 2007). Briggs et al measured the thoracic kyphosis of 44 subjects (1 male, 43 female; mean age of 62.3±7.1years) using lateral standing radiographs and photographs.The 44 subjects were then classified into two groups according to their degree of thoracic kyphosis ('high' and 'low' kyphosis). The degree of kyphosis was then introduced into a biomechanical model to calculate loading forces. Results show that the high kyphosis group had greater segmental normalized flexion moments from Tl -L5 spinal level with a percentage difference ranging from 1.1%to 65.6% in comparison to the control group. In addition, the mean segmental shear forces of the high kyphosis group were greater than those of the low kyphosis group by a percentage difference ranging from 8.3% to 193%. The high kyphosis group also had greater mean compression from T7-L5 spinal level with a percentage difference ranging from 2% to 14.4%. Furthermore a strong correlation existed between thoracic curvature and net segmental loads (canonical r=0.85 to 0.93) and between thoracic curvature and muscle forces (canonical r=0.70 to 0.82). This study illustrates that,at least in this sample, increased kyphosis will enhance loading forces on spinal structures. Briggs et al (2007) concluded that increases in thoracic kyphosis are likely to accelerate degenerative process. Unfortunately no analysis was reported to investigate if subjects with high level of kyphosis had more spinal degeneration than the low kyphosis group. This is unfortunate because radiological findings may have provided information on degenerative processes of exposed dense structures (eg osteophyte formation and other spondylytic changes). Furthermore, the ionising radiation exposure and the price (fiscal cost and time) incurred in performing an x-ray examination should have encouraged researchers to analyse all the data collected.

Is there a correlation between musculoskeletal traits and low back pain?

The degree of thoracic kyphosis is not the only MSK trait that may predispose to MSK impairments. A study by Al-Eisa, Egan, and Wassersug (2004) found a strong correlation between the symmetry of eight physical anatomical traits and the presence of low back pain (LBP). Al-Eisa et al (2004) measured a number of physical traits such as hand lengths, tibia lengths and pelvic asymmetry in two different groups of participants; a LBP group (n=17 males and 27 females; mean age =34.9 ±7.1 years) and a control group (n=17 males and 34 females; mean age = 29.3 ± 5.6 years). The most interesting result was that the LBP group had a higher relative pelvic asymmetry index (PAI) (PAI= 0.068 ± 0.04; p=0.005) than the control group (PAI= 0.046 ± 0.03; p=0.005).

This study presents data that measurable asymmetries can positively correlate with MSK impairments. Other research has also found that soft tissue asymmetries (strength and flexibility) of the MSK system can predispose individuals to MSK impairments (Knapik, Bauman, Jones, Harris, & Vaughan, 1991; Tyler, Nicholas, Campbell, & McHugh, 2001). Knapik et al (1991) found that discrepancy of strength of more than 15% between right and left knee flexors was a predisposing factor for injury. Similarly, the same authors also identified that discrepancies between right and left flexibility of hip extensor will also predispose to injury. A more recent study by Tyler et al (2001) found that professional ice Hockey players were 17 times more likely to sustain adductor muscle strain if their adductor strength was less than 80% of his abductor strength.

Is there a correlation between some lifestyle factors and musculoskeletal impairments?

In addition to asymmetry, how the human body is used also seems to influence MSK health, for example heavy lifting in the workplace has been shown to be strongly associated with LBP (Waddell & Burton, 2001). Furthermore, Ariens et al (2007) found that the amount of sitting time positively correlated with neck. Similarly, Dankaerts et al (2006) found that sitting postures are associated with non-specific chronic LBP. These lifestyle factors (eg heavy lifting, sitting time, and sitting postures) imply that the MSK system is affected by how we are mechanically loading our MSK system. Even though these studies do not demonstrate a correlation between PSB factors (such as bony and soft tissue symmetry, tone, texture, or joint range of movement) and MSK impairments, they still suggest that the type and amount of mechanical load that is applied to the MSK system will contribute to MSK impairments.

1.2.2 Data that challenge the Postural Structural Biomechanical model

In contrast to studies that support the PSB model, a number of authors have questioned the value of the model to explain some MSK impairments. For example, interesting research produced by Dieck et al (1985) and Poussa et al (2005) report data that shows a lack of association between postural spinal asymmetry, degree of thoracic kyphosis and lumbar lordosis in teenagers and developing LBP in adulthood. Furthermore, a systemic review by Christensen et al only found studies that show no association between sagittal spinal curves and any health outcomes including spinal pain (Christensen & Hartvigsen, 2008). These data challenge the power of the PSB model to explain MSK impairments. With the combination of data fromBriggs et al, Poussa et al (2005) and Dieck et al (1985), we could conclude that a theoretical and reasonable increased load on a particular structure due to postural spinal asymmetry or increased spinal curves do not adequately explain soft tissue injury or MSK impairment.

In considering these unexpected findings, some commentators have suggested that the MSK system may contain a reserve capacity to accommodate for loss and imperfection without pain or impairment (Fryer, 2011). This idea is illustrated in the case of leg length discrepancy, where evidence suggested that 90% of the population has leg length discrepancy (Knutson, 2005). However this physical factor has been shown to correlate with lower back pain only when the leg length discrepancy (difference between left and right) reaches approximately 20mm or more (Knutson, 2005). Perhaps the idea of 'critical level' and 'reserve capacity' to accommodate minor physical irregularity needs to be quantified for other physical factors to guide practitioners while using the PSB factors. One commentator, Australian osteopath and researcher Gary Fryer (Fryer, 2011), believes that any physical findings must be placed in context with clinical history (for example, lifestyle, history of injury, age, body morphology), or in other words: physical findings need to be considered within the broader biopsychosocial framework. Fryer also recognises that the importance of PSB factors was probably overstated in the past, but still considers that biomechanical findings are useful guides for patient management. Fryer's position probably reflects the majority view of musculoskeletal therapists who draw heavily on biomechanical principles in undergraduate and postgraduate education and clinical training (Fryer, 2011).

1.2.3 Possible consequences of research methodologies

A possible explanation for the relatively small amount of supporting evidence in regard to the PSB model, is that the methodology used by some researchers fails to identify causation that does exist (a Type II error). For example, a number of studies on lower back pain (LBP) do not sub-classify lower back pain patients (Battié et al., 1990; Esola, McClure, Fitzgerald, & Siegler, 1996; Ferguson, Marras, & Burr, 2004). Failure to undertake subgroup analysis in back pain studies is likely to introduce methodological bias asrecent research has found that within a LBP population certain subgroups of different types of back pain have been identified (Wand & O'Connell, 2008; Slater et al., 2012). Different types of back pain are known to respond differently to different treatment approaches (Fritz, Thackeray, Childs, & Brennan, 2010). Recently, Hoffman et al (2012) found subgroups of people with LBP have symptoms that are associated with different movement directions (eg pain present on spinal flexion or extension). This difference of LBP symptoms will lead to different physical limitations between different people with LBP (eg limitations of flexion compared to extension) (Hoffman et al., 2012). Consequently, research which fails to consider the directional movement preferences of study participants, may mask or dilute treatment effects because of different responses effectively ‘cancelling out’. The results of these types of studies eg (Battié et al., 1990; Esola et al., 1996) suggest that ROM is not different between symptomatic lower back pain patients and asymptomatic controls, however, they fail to consider the possible influence of subgrouping. Measures of dispersion (such as standard deviations) were not presented in the Battie et al (1990) and Esola et al (1996) reports which is unfortunate because a greater degree of deviation within the LBP group may provide clues as to the possible presence of sub-groups within their samples. Lack of sub grouping of LBP patients is an example of methodological bias that may falsely leads to conclusions that PSB factors do not explain MSK impairment. Hannon (2011) believes that LBP is more complex than previously thought. Hannon claims that some designs used to investigate LBP are not appropriate for the complexity of the LBP impairments, and therefore lead to biased findings (Hannon, 2011). As a result, there have been calls in the literature to improve methodological standards in regards to all MSK impairments not only LBP (Cook, 2009; Hannon, 2011).These methodological issues could potentially explain why research has failed to demonstrate the apparent associations between MSK impairment with PSB factors, commonly described by musculoskeletal practitioners in practice. The lack of sub-classification or grouping of LBP patient has also affected randomised control trials for treatment of LBP, however, many recent randomised controlled trials investigating LBP are now applying a methodology of sub-grouping patients, and are producing clearer findings (Cook, 2009; Fritz et al., 2010; Kumar, Sharma, Shukla, & Dev, 2010; Lehtola, Luomajoki, Leinonen, Gibbons, & Airaksinen, 2012).

1.2.4 Explanation of musculoskeletal complaints using genetic factors

In addition to a PSB approach to explain MSK impairments, other models have been proposed to explain MSK complaints. One of these models states that genetic factors could predispose people to MSK pain and impairment. One study of identical twins as subjects identified that 47% to 66% of spinal degeneration was due to hereditary factors and shared environmental factors, whereas only 2% to 10% of the degeneration could be explained by resistance training and occupational physical loading (Videman et al., 2006). This finding is consistent with findings reported by

Paassilta et al (2001) who on the basis of case control data argue that physical degeneration is primarily linked to variation in collagen and immune repair rather that biomechanical factors. The influence of genetic factors on musculoskeletal impairments has not yet been researched extensively, although recent development of genetic techniques may see more studies searching this particular topic.

1.2.5 Effect of biopsychosocial factors of musculoskeletal complaints

Musculoskeletal impairment is not only affected by BSP and/or genetic factors it also appears to be influenced by a combination of other biopsychosocial factors. The impact of MSK impairment can affect individuals differently, based on various biological, psychological and social factors. Such factors can greatly influence the chronicity and perceived level of disability for impairments. 'Burnout', anxiety, depression, post-traumatic stress reactions, and poorer coping capacity have been associated with higher durations of sick leave, using more pain control medication, using more somatic treatment care (eg manual and physical therapy), and reporting higher pain intensity (Grossi, Soares, Ängeslevä, & Perski, 1999). Denison et al (2004) found that self-efficacy was a strong predictor for MSK disability (Pearson's $r=0.73$; $p<0.001$). Fear avoidance (Pearson's $r=0.47$; $p<0.001$) and pain intensity (Spearman's $r=0.34$; $p<0.001$) were also found to be positively associated with MSK disability but to a lesser extent than self-efficacy (Denison et al., 2004). In contrast, gender, age, and pain duration have not been found to be related to levels of disability (Linton., 2000; Linton, 2001; Pincus, Burton, Vogel, & Field, 2002; Denison et al., 2004; Linton., 2005). This data suggests that psychological factors can influence the presentation of MSK pain and disability. However psychological factors alone cannot account for the entire problem and Linton et al (2000) concludes that back pain is perhaps best explained by a multidimensional, biopsychosocial approach, a view that does not appear to have changed in the last decade.

To summarise, it is now generally accepted by most musculoskeletal practitioners that MSK impairments are not only influenced by PSB factors but also by other factors including genetic and biopsychosocial factors. It is important to clarify that even though some researchers are debating the value of the PSB model, no alternative model has yet been comprehensively adopted in practice of musculoskeletal therapy or in undergraduate education curriculum to replace the BSP model. As a result, the PSB model is still mostly considered as the primary model to explain the MSK system and pain or impairments even though its importance is the subject of an ongoing debate amongst musculoskeletal practitioners.

2. PHYSICAL EXAMINATION

2.1 The application of the PSB model in practice

To employ the PSB model and gather PSB factors within the clinical setting, the majority of musculoskeletal therapists will undertake a physical examination. Most musculoskeletal practitioners usually commence physical examination with a general visual observation and/or a screening assessment (Petty & Moore, 2001, p. 36; Seidel., Ball., Dains., & Bennedict., 2003, p. 53; Chila & Association., 2011). Screening assessments typically respond to the question: “Is there a problem within the musculoskeletal system that deserves additional evaluation?”(Greenman, 2003). Screening systems are usually organised as a series of movements and/or postures that enable practitioners to assess, using visual observation, PSB factors. Screening assessments enable the practitioner to collect a broad range of information about their patients MSK system prior to more specific assessment which is then used to define specific MSK impairments. Unfortunately, many screening or specific examination procedures used to evaluate the MSK system lack adequate reliability and validity. For example, a systematic review by Hestboek and Leboeuf-Yde (2000) found that many of the tests evaluated (eg motion palpation of the lumbar spine and sacroiliac joints, measurement of leg-length, sacro-occipital technique, muscle tension, palpation for misalignment, and visual inspection) demonstrate poor levels of reliability and validity. A more recent systemic review by Van Trijffel et al (2005) on the reliability of passive assessment of inter vertebral motion in the cervical and lumbar spine demonstrate an overall level of reliability ranging from Poor to Fair. Furthermore, a systematic review by Hollerwoeger (2006) on the reliability of manual assessment of cervical dysfunction concluded that studies of appropriate methodological quality demonstrate that “reliability manual assessment of cervical dysfunction is questionable”. Moreover, a systematic review by May, Littlewood, and Bishop (2006) on the reliability of commonly used physical examination procedure on non-specific LBP patients concluded, that most of these procedures demonstrate low reliability. In contrast, some other physical examinations have demonstrated adequate reliability and validity, including palpation and nomination of lumbar spinal levels (Downey, Taylor, & Niere, 1999), passive straight leg raise (SLR) test (Hunt et al., 2001), visual assessment of the lumbar lordosis posture (Moran & Ljubotenski, 2006),a combination of neck physical examination (De Hertogh, Vaes, Vijverman, De Cordt, & Duquet, 2007), classification system for patients with non-specific low back pain (Vibe Fersum, O'Sullivan, Kvale, & Skouen, 2009), a groups of shoulder girdle physical examination procedures (Nomden et al., 2009), and the Functional Movement Screen (Minick et al., 2010; Onate et al., 2012).

This uncertainty in regards to the reliability and validity of some physical assessment procedures implies that practitioners need to weigh the value of each test to come to a conclusion, which again increases the degree of subjectivity. The often modest levels of specificity and sensitivity of physical examinations can also lead therapists to diagnostic uncertainty. The possible uncertainty and difficulties that practitioners face in employing valid and reliable clinical assessment methods highlights the need for more research into MSK system assessment.

2.2 Introduction to floor sitting postures

A number of researchers and commentators are discussing the possibility that our modern lifestyle could predispose us to a number of health disorders (Cordain, Eaton, Miller, Mann, & Hill, 2002; O'Keefe, Vogel, Lavie, & Cordain, 2010). A group of researchers suggest that the human body has evolved in response to selective pressures which are now dramatically different in most contemporary lifestyles compared to those of early humans. This hypothesis is based on the premise that the human genus slowly evolved over 84,000 generations in responses to a hunter-gatherer lifestyle (Cordain et al., 2002; O'Keefe, Vogel, Lavie, & Cordain, 2011). During this era of hunter-gatherers, technological advancements were minimal in comparison to the rate of advancement made in the most recent 350 generations that separate our modern era and the hunter-gather era (Cordain et al., 2002; O'Keefe et al., 2011). The life style changes caused by technological advancement are even more obvious within the last 30 years with the digital revolution where sedentary activities are becoming the norm. The same group of researchers (Cordain et al., 2002; O'Keefe et al., 2011) believes that the human genus was not able to genetically adapt in such a short time. Consequently, in order to understand the lifestyle of our ancestor hunter-gatherers and to apply this understanding to our modern lifestyle with a view to improving modern health, a number of researchers have aimed to identify the physical activities, resting behaviours and dietary patterns of human ancestors, particularly those of the hunter-gatherer humans. It has been proposed that the resting postures used by our ancestors were on the ground (sitting, squatting etc) and are in obvious contrast to the contemporary resting postures using elevated seated positions and furniture (Beach, 2007, 2008a, 2008b). One of the theories that arose from Beach's observation is that our MSK system is not adapted to spending so many hours in modern seated posture. As a result, Beach argues that the contemporary elevated seated posture may be a predisposing and/or causative factor for modern MSK impairments (Beach, 2008a). Unfortunately, there appears to be an absence of epidemiologic or anthropologic to investigate if a lower incidence of MSK complaints occurs in cultures who sit on the floor in comparison to those who predominantly use elevated seating using furniture . Beach further found that when people presenting with back pain were asked to assume the same floor seated postures used by human ancestors, these postures were reported to be very challenging and exposed impaired levels of basic physical function (Beach, 2007, 2008a, 2008b). Based on these clinical observations, Beach considers that the visual observation of patients performing the floor sitting postures may enable an efficient and broad assessment of a number of PSB factors (Beach, 2007, 2008a, 2008b). Consequently Beach proposed that these postures could be used as an alternative approach to the current assessment processes of the MKS system. Beach's ideas have been formally presented to MSK practitioners through the descriptive journal articles, books and conference presentations. However, the numbers of MSK practitioners who are currently using the floor sitting posture is not known . The rationale of this study is to continue the work done by Beach and Hargovan, with the aim of establishing measurement tools (rating system) to enable future research on Beach's hypothesis (Hargovan, 2012).

3. THE RELIABILITY OF VISUAL POSTURAL ASSESSMENT

This section primarily aims to introduce the subject of visual rating protocols and reliability studies to inform reader on the current and previous work performed in the field of visual assessment of posture. Furthermore, the section will present a rationale for the use of the "Floor Sitting Posture Screen" to evaluate physical function.

3.1 Visual postural assessment without rating protocol

Greenman's screening protocol (Greenman, 2003) and the Unities model of diagnosis (Dummer, 1999) are two well defined approaches that have been described within the field of osteopathy, and are included within undergraduate curriculum for osteopaths (R. Moran, Personal Communication, June 03, 2012). Due to these protocols, or component parts, being used in practice (Peace & Fryer, 2004) it was decided to presented these protocols in this section.

3.1.1 Greenman's screening protocol

Greenman's protocol consists of 12 steps that evaluate the movement patterns, symmetry and the range of movement of the entire MSK system (Greenman, 2003). Although Greenman describes possible findings that can be interpreted from these tests, a clear definition of whether a finding is positive or negative (or some other grading system) has not been articulated. It appears that Greenman's protocol is a subjective assessment and the interpretation of the practitioner is used to decide if a finding is relevant or not. This method of assessment is easily criticized because it is based solely on subjective evaluation which leads to variation of practitioner decision making. On the other hand, this subjective approach enables practitioners the flexibility to adapt their judgment according to the patient's age, lifestyle, physical fitness or history of trauma. Unfortunately the subjectivity of this method does not promote clear communication between practitioners, as no consensus in regard to notation and rating of findings has been completed. Also, because of the lack of objectivity or grading, this method is not able to objectively evaluate change in patients. In other words, this protocol enables practitioners to evaluate patients in a comprehensive manner but at the same time, introduces subjectivity which may compromise its clinical usefulness.

Although the reliability of Greenman's 12 Step Screening exams has not been investigated as a whole system, some physical tests used in this screening protocol are common orthopaedic tests which have been investigated. For example, in the case of Greenman's Upper Extremity Screen, which requires patients to actively fully abduct both of their arms, so that the dorsal aspects of their hands are touching together above their head (Greenman, 2003).This movement is the same movement used in the orthopaedic test known as 'The Painful Arc' (Cleland, 2005). However, the interpretation of the tests differs. For example, with Greenman's protocol a positive finding is considered when asymmetry is present, on the other hand, a Painful Arc is considered positive when pain is reported within an arc between 60° and 100° of abduction (Cleland, 2005). The Painful Arc test is used to screen for subacromial impingement and other shoulder pathologies in comparison to Greenman's Upper Extremity Screen which is used to broadly consider the presence of dysfunction of the upper extremity (Greenman, 2003; Cleland, 2005). Due to these differences of purpose, it is not appropriate to compare or generalise findings or reliability between these techniques. A similar conclusion can be made while comparing Greenman's Hip Screen with the orthopaedic 'FABER' Test, or Greenman's Hamstring Length assessment and the orthopaedic Straight Leg Rise. To date, it appears that no studies have evaluated Greenman's individual screening procedures or the overall screening protocol in terms of reliability or validity.

3.1.2 Unities model of diagnosis

The Unities model of diagnosis aims to identify dysfunction within the musculoskeletal system by evaluating the body using inspection (static and dynamic), and palpation (static and dynamic) (Dummer, 1999, p. 166). A dysfunction can range from minor restriction of joint range to an orthopaedic pathology. The Unities approach divides the body into three regions (Unity 1: lumbar spine, pelvis and lower limbs; Unity 2: neck and upper limbs; Unity 3: thoracic spine and rib cage). The diagnostic procedure starts with a Unities General Screening protocol that evaluates the body dynamically and statically within different positions. The Unities General

Screen enables practitioners to choose which body regions need further investigation (Dummer, 1999, p. 165). Again, to date it appears that no studies have yet evaluated the 'Unities protocol' in terms of reliability or validity. In summary, the Unities protocol enables practitioners to evaluate patients in a comprehensive manner but like Greenman's 12 Step Screen, introduces subjectivity that may compromise its clinical usefulness.

3.2 Visual postural assessment with rating protocols

Different rating tools have been developed to assess various aspect of standing posture, this sub section will present five different protocols with different formats. Inter-rater and intra-rater reliability studies for each of the five protocols will also be presented and briefly reviewed.

3.2.1 Assessment Criteria for posture deviation using a three point rating scale

Watson and Mac Donncha (2000) produced the Assessment Criteria for Posture Deviation; a three-grade scale protocol to visually evaluate 10 different aspects of standing posture (ankle posture, knee interspace, knee hyperextension/flexion, lordosis, kyphosis, scoliosis, round shoulders, abducted scapulae, shoulder symmetry, forward head) (Watson & Mac Donncha, 2000). These criteria were produced by observing the posture of randomly selected males (n=117 age range: 15-17 years) from two high schools. Four photographs of different views were taken for each participant. Then, individual photographs were selected to represent each category; "good posture", "moderate defect" and "severe defect" (three-point ordinal scale) of the visual assessment. In addition, Watson and Mac Donncha (2000) performed an intra and inter-rater reliability study with 30 randomly selected participants and two raters. The level of apparent of intra and inter-rater agreement was high, with percentage agreement between 73% to 100% for the intra-rater reliability and 96% to 100% for the inter-rater reliability. The criteria for rating each body posture were described using a diagram, which enabled raters to be guided while using the criteria. This explicit protocol minimises subjectivity and by consequence probably explains the high level of rater percentage of agreement. Although the protocol was well defined, there is one limitation in the design and one major weakness in data analysis. The choice of raters (one of the authors and an experienced assessor) limits our ability to generalise their results, because their expert status results in greater agreement than might be typical in musculoskeletal therapists owing to their experience with the rating scales. Watson and Mac Donncha (2000) used the percentage of agreement during their statistical analysis, which is not the preferential method of analysis with reliability data between pairs of rating (inter or intra). Analysis of percentage agreement does not account for chance agreement. Kappa coefficients would be more appropriate due to its ability to account for chance agreement which is important when raters are only rating scales with a small number of increments (eg when using a 4-point scale would expect chance agreement to be 25%). The formula to calculate kappa subtracts the proportion of agreement that could be expected by chance alone from the observed percentage of agreement, and can therefore avoid inflating the level of agreement and avoiding conclusions that agreement is good, when in fact it may simply be due to chance (Meeker & Escobar, 1998). Watson and Mac Donncha (2000) results include a high level of percentage of agreement that cannot be explained purely by chance, however, a more appropriate method of statistical analysis (eg Kappa) would strengthen their conclusions.

3.2.2 Visual assessment of cervical and lumbar lordosis using a three point rating scale

Fedorak et al (2003) investigated visual assessment of cervical and lumbar lordosis with the aim of determining if raters of different health professional training will influence the level of raters reliability. Raters were asked to visually evaluate cervical and lumbar lordosis while using a three-point rating scale "normal, increased or decreased lordosis" (Fedorak et al., 2003). Twenty raters were recruited from different health professions (chiropractors, physical therapists, physiatrists, rheumatologists, and orthopaedic surgeons) to evaluate the postures of photographed subjects. Thirty-six participants were recruited (LBP group n=17, control group n=18, with a total mean age of 41-years. Mean intra-rater reliability was Kappa = 0.50 (95% CI 0.20 – 0.98) and mean inter-rater reliability was Kappa = 0.16 (95% CI 0.00 – 0.48) which correspond respectively to 'moderate agreement' for intra-rater and 'poor agreement' for inter-rater reliability according to Landis et al (1977) interpretation of Kappa values (Landis & Koch, 1977). There was no statistically significant difference existed among the five groups of clinicians or between the evaluation of the subjects with and without back pain. The authors conclude that clinicians should be aware of the limitation of visual assessment and encouraged clinicians to use a combination of postural assessment tools. It is important to note that raters were not provided with any definitions of a standard normal, increased or decreased lordosis. The lack of clarification (operational definition of 'normal', 'increased' or 'decreased') in regard to how to use the rating protocol could partially explain this limited reliability that was observed.

3.2.3 Visual Analogue Scale as an assessment protocol for posture

Moran and Ljubotenski (2006) and Aitken (2008) both used a continuous visual analogue scale (VAS) to rate lumbar lordosis and forward head posture, rather than a categorical scale (eg three point rating scale) as Watson and Mac Donncha (2000) and Fedorak et al (2003).

Moran and Ljubotenski (2006) evaluated the intra- and inter-rater reliability of 13 raters while rating the lumbar lordosis of 60 participants. Raters were asked to rate the patient's lumbar lordosis using a 100mm (VAS) with the terminal anchors of the line representing "maximum lordosis" and "minimum lordosis". The mean intra-rater reliability of the 13 raters was Very high with an ICC of 0.71; 90% CI 0.47 to 0.86). The mean inter-rater reliability of the thirteen raters was Moderate with an ICC of 0.53; 90% CI 0.29 to 0.70). Additional investigation of the data showed that rater reliability decreased for participants with a high Body Mass Index (BMI), and also that the level of experience for the raters influenced reliability. Four groups of raters were defined according to the experience of the raters: Year 1 osteopathic students; Year 5 osteopathic students; new graduate osteopaths (less than 5 years in practice) and experienced osteopath practitioners (15 or more years in practice). The results indicate that Year 5 osteopathic students and new graduates had higher intra- and inter-rater reliability than the two other groups. The authors (Moran & Ljubotenski, 2006) hypothesised that the higher reliability of Year 5 osteopathic student and new graduates could be explained by their current or recent common education compared to the diverse education of the more experienced raters (Moran & Ljubotenski, 2006).

A similar study by Aitken (2008) evaluated the reliability of visual assessment of forward head posture. Seventy eight raters were recruited (lay people n=16; osteopathic students n=40; and osteopathic practitioners n=22). A VAS was used to grade the participants' forward head posture. Sixty participants (male n=42, neck pain group n=36) were recruited for the study. The posture of the 60 participants was video recorded. However, a sample of video clips from 21 participants was used for the reliability study for statistical weighting purpose. The videos were presented to the rater with the help of a computer program that did not enable slow motion. The result of the intra-rater reliability showed None to poor agreement agreement (kappa = 0 to 0.19). The mean inter-rater reliability was Fair for the three main categories of raters (Laypeople (kappa=0.38), Students (kappa=0.38), Practitioners (kappa=0.32)) (Aitken, 2008).

Both Moran and Ljubotenski's (2006) study and Aitken's (2008) study had a similar research design, with a similar sample of rater and participant populations as well as use of the same basic rating instrument (VAS). However, the two studies arrive at different conclusions in regard to level of rater reliability. The main difference between the two studies is the different body site (lumbar lordosis versus forward head posture). By looking at these two studies we could conclude that ratings of lumbar curvature are more reliable than those of forward head posture, and therefore the reliability of a visual assessment method may vary across different body regions being evaluated.

3.2.4 Functional Movement Screen dynamic visual assessment using a four point rating scale

The Functional Movement Screen (FMS) is introduced to this review even though it assesses movements rather than static postures, primarily because it uses an ordinal 4-point rating scale and specific guidelines. Furthermore, the FMS has been evaluated in terms of rater reliability by several recent and well conducted methodological studies.

The recently developed FMS aims to evaluate the quality of seven movements in a physically active population. The FMS has been evaluated in terms of reliability and validity by a number of researchers (Anstee, Dochertym, Gansneder, & Schultz, 2003; Kiesel, Burton, Cook, & Mattacola, 2004; Kiesel, Burton, & Cook, 2005; Cook, Burton, & Hoogenboom, 2006a, 2006b; Kiesel, Plisky, & Voight, 2007; Minick et al., 2010; Onate et al., 2012). The purpose of the FMS is to demonstrate and rate limitations and movement asymmetries in healthy individuals by evaluating their ability to perform a set of movements. According to the developers (Cook et al., 2006b, 2006a) of the FMS approach the seven movements were selected according to their ability to show limitation or asymmetry in this population. Furthermore, the FMS has been used to identify athletes at risk for injury in pre-season or pre-participation screening and also as an assessment for training outcomes (Cook et al., 2006b, 2006a). A practical 4-point scale and descriptive criteria was developed to rate each movement.

The inter-rater reliability of the FMS has been evaluated by Minick et al (2010). The population used to test inter-rater reliability was made of asymptomatic young athletic university students (n=23 female, 17 male; mean age 20.8 years) (Minick et al., 2010). In this study two experts and two novices were used to evaluate the inter-rater reliability (Minick et al., 2010). Percentage of agreement and weighted Kappa statistical analysis was used to evaluate the level of inter-rater reliability between the two novice raters, the two expert raters and the combined score of the two novices and the combined score of the two experts. The reliability results ranged from Moderate to Excellent depending on which raters, or movement, were being contrasted.

The inter-rater reliability of the Functional Movement Screen was also assessed in the study by Onate et al (2012), however, the rating procedure was made in real-time rather than using video recordings. The intersession reliability was also assessed in the study of Onate et al (2012). Subjects consisted of 19 volunteer civilian (female n=7; male n=12), and two raters; one considered as a novice and one considered as an experienced FMS rater. The reliability was calculated using weighted Cohen's Kappa statistical analysis for the categorical raw data of each movements and an ICC for the continuous data of the total FMS score (Onate et al., 2012). Onate et al (2012) demonstrate that the level of inter-rater reliability while using the FMS protocol ranges from Good to High for the movements, except for the "hurdle step" movement which demonstrated Fair reliability. The ICC of the total FMS score of the two raters shows High reliability (ICC=0.98 SEM=0.25). An important finding of this study is that it provides evidence that the FMS protocol can achieve a similar level of inter-rater reliability in a real time assessment as when conducted from a videotape assessment. Furthermore with this methodology (real time assessment), the inter-session reliability study evaluated two significant reliability values; it evaluated bias that can be caused by daily variation (biological reliability) and intra-rater reliability.

To summarise, the results of both reliability studies investigating Functional Movement Screening Minick et al (2010) and Onate et al (2012) demonstrate that the level of expertise of raters had a minor effect on the reliability results, which is a particularly positive aspect of the FMS since even novice raters can produce useful clinical information. These results also confirm the fair reliability of the "hurdle step" movement. Furthermore these results demonstrate that the FMS can be used in a real time setting which supports its use outside of a laboratory setting. A number of additional studies have investigated aspects of the FMS demonstrating promising results in regards to its validity and clinical relevance (Anstee et al., 2003; Kiesel et al., 2004; Kiesel et al., 2005; Cook et al., 2006a, 2006b; Kiesel et al., 2007). At this stage the FMS protocols appear to be reliable in terms of intra and inter-rater reliability, however, there is yet to be a study that involves a study with more than four raters.

In the recent literature, visual measuring protocols with four- or three-point scale have often been chosen for static standing posture and movement assessment (Watson & Mac Donncha, 2000; Fedorak et al., 2003; Chmielewski et al., 2007; Tidstrand & Horneij, 2009; Weir et al., 2010). According to Watson and Mac Donncha (2000) "the use of any more categories made distinction between categories difficult and reduced the reliability of the procedure". It also seems that four- or three-point scales enable a compromise between appropriate validity, practical use, and adequate reliability.

3.3 Computer assisted postural assessment

Visual assessment of posture is not the only option to evaluate patients' posture, some recent technological advancements open interesting possibilities to evaluate posture such as the PosturePrint® computer system.

Normand et al (2007) evaluated the intra and inter-examiner reliability of the PosturePrint® computer system which analyses neutral upright human posture. Forty student participants (male n=10, female n=30; combined mean age = 24.4 ± 1.9 years), and three examiners were recruited. In their study, the examiners were required to position markers on 13 anatomical landmarks on each participant, and then three photographs (left, right lateral view and antero-posterior view) were taken. On the digital photographs, examiners identified an additional 16 points. With these points the computer program evaluates and reproduces participants standing posture.

This procedure was repeated two days later for each examiner and participant. Inter- and intra-examiner reliability was calculated. Results for inter-examiner reliability were excellent ranging from ICC=0.88 (95% CI 0.81 to 0.93) to ICC=0.95 (95% CI 0.92 to 0.97) depending on the measurements. Results for intra-examiner reliability were also excellent ranging from ICC=0.85 (95% CI 0.64 to 0.88) to ICC=0.97 (95% CI 0.91 to 0.97) depending on the measurements. However, it is important to note that the research design had some limitations, for example; the test-retest study was performed with an interval of only 24-hours. This short period may have introduced a memory bias (recollection of the location of the markers between sessions) for the examiners. In addition the high level of homogeneity of participants and the small sample size of examiners limits the generalisability of the findings. Furthermore, two of the six authors were examiners and one of the authors declared financial involvement with the computer program used. Finely, these excellent levels of reliability need to be considered in light of several clinical limitations of the protocol. Firstly, the authors reported that it took 3 to 6 minutes for each examiner to apply the 13 markers, however, the time needed to apply the 16 other markers and the time needed to evaluate the result was not presented. The time to undertake the assessment is not reported and suggests doubtful practical application in the clinical setting.

Secondly, the authors do not address the possible unwillingness of patients in a clinical setting to have pictures taken although this is probably not a major concern given the privacy rules in place for clinical practitioners. A broader limitation could also arise with the cost of the equipment and the training necessary to competently operate the technology, which was not presented in the study. To summarise, this computer assisted postural assessment shows strong reliability, but other limitations particularly in relation to accessibility to the technology may limit its utility for a majority of musculoskeletal therapists.

4. PRESENTATION OF THE FLOOR SITTING POSTURE SCREEN

It appears form a general point of view that physical examinations generally lack adequate rater reliability (see section 2.1). More specifically, previously developed visual rating protocols lack rater reliability and/or have other clinical limitations (see section 3). Consequently, the presentation of Beach's hypothesis, which argues that certain floor seated postures may enable an efficient and broad assessment of the MSK system, led Hargovan (2012) to the development of a visual rating protocol for six specific floor seated postures.

Hargovan (2012) developed a visual screening rating protocol with the aim of quantifying the ability of participants to assume six of the floor sitting postures described by (Beach, 2007, 2008b, 2008a). The screening protocol was produced using video recordings of healthy participants (n=33, female=23, male=10) performing the six postures six times within two sessions at an interval of 7-14 days. The finalised protocol evaluated six different floor postures (Normal Squat, Variant Squat, Straight Leg Sit, Cross Legged Sit, Low Kneel and High Kneel posture). The criteria are rated using scales ranging from two to five points depending on the complexity of the posture being evaluated (see Appendix A).

The consistency of subjects attaining the same postures between sessions (7-14 day interval) was also measured. Subjects (female n=17; male n=8) were marked on specific anatomical land-marks. A still image of each posture from the recorded video enabled the measurement of angles and distances (26 measures in total for the six postures) between the marked anatomical landmarks using video analysis software. Data analysis using intra-class correlation coefficients (ICC) showed Very high (ICC = 0.87; 95% CI 0.71 to 0.94) to Nearly perfect (ICC = 0.97; 95% CI 0.94 to 0.99) reliability for 4 of the 6 postures. The Straight Leg Sit postural angle of dorsiflexion and the Low Kneel postural angle of hip flexion respectively demonstrated Moderate reliability (ICC = 0.67; 95% CI 0.25 to 0.85; and ICC = 0.71; 95% CI 0.37 to 0.87) (Hargovan, 2012). To summarise, it appears that subjects were entering most postures with consistency, which is a necessary feature if these postures are to be used clinically. The participant inclusion and exclusion criteria enabled the inclusion of subjects with chronic MSK impairments and asymptomatic subject. Participants with acute pain and serious medical conditions were excluded from the study (Hargovan, 2012). These inclusion and exclusion criteria resulted in a sample of participants that were likely to be typical of those who would be assessed using the protocol in a clinical setting. The visual screening rating protocol needs to be assessed in terms of inter and intra-rater reliability and validity before its use within a clinical setting. This is the first version of the floor setting posture screen, and although the consistency of achieving postures appears to be acceptable, further development work may result in improvements.

CONCLUSION

Although the Postural Structural Biomechanical model has lost some credibility in explaining musculoskeletal impairments in light of the emergence of the idea that the complex interaction of many biopsychosocial factors can influence musculoskeletal dysfunction and impairment, the Postural Structural Biomechanical model still appears to be widely employed by musculoskeletal therapists. Nevertheless, the methods of assessment inherent in a Postural Structural Biomechanical approach demonstrate a range of rater reliability and validity. This is particularly so in the field of static visual assessments, where research has shown inconsistent results from investigation of rater reliability.

Based on the premise that the human genus may not be adapted to a modern predominantly sedentarily lifestyle and based on clinical observations, Philip Beach hypothesised that the floor seated postures used by our ancestors may enable an efficient and broad musculoskeletal assessment (Beach, 2007, 2008a, 2008b). This promising hypothesis and the absence of criterion standards for visual evaluation of the musculoskeletal system, encouraged Hargovan (2012) to develop a rating criteria to enable more objective evaluation of these floor seated postures. Hargovan (2012) developed a set of rating criteria named Floor Sitting Posture Screen for visual assessment of six specific floor seated postures. However, the Floor Sitting Posture Screen has yet to be tested for intra and inter-rater reliability. Subsequently, the aims of the study reported in the Section II of this thesis are to evaluate the inter and intra-rater reliability of the Floor Sitting Posture Screen.

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SECTION 2: MANUSCRIPT

Note:

This manuscript has been prepared in accordance with the Guide for Authors for the journal Manual Therapy [See Appendix H for Guide for Authors]. For the purposes of completion of this thesis some guidelines from Manual Therapy have not been followed. The instructions require a limit 3500 words. This limit has been exceeded here to allow full and evaluative discussion of the results in this thesis.

Inter and intra-rater reliability of rating criteria for the Floor Sitting Posture Screen

Abstract

Background: Visual assessment of posture and movement is commonly used by musculoskeletal therapists. Postures have historically been assessed using subjective criteria. Recently, however, a number of new rating protocols have been produced with the aim of enhancing the reliability and objectivity of visual assessments. The Floor Sitting Posture Screen (FSPS), a recently developed visual assessment protocol, could be of clinical value however it is yet to be evaluated in terms of inter and intra-rater reliability. The Aims of this study were to evaluate the level of inter- and intra-rater reliability while using the FSPS.

Methods: A blinded test-retest design was used to examine the level of inter- and intra-rater reliability while using the FSPS. Inter-rater reliability was investigated by comparing results of 12 raters (n=11 senior osteopathy students; n=1 osteopath) while rating pictures of 7 subjects (n=5female; n=2 male). The intra-rater reliability was investigated by having raters rate images of 7 subjects (female n=5) on two occasions one week apart.

Results: Inter-rater reliability of each criterion (n=17) of the FSPS ranged from Poor to Good. The majority of the criterion (n=11) demonstrated Moderate to Good inter-rater reliability, with only one criterion demonstrating poor reliability. Intra-rater reliability of individual criterion could not be calculated using Cohen's Kappa, due to the sample size and the homogeneity of raw data. However, intra-rater percentages of agreement were above 81%for 10 of the 12 raters. The ICC of the combined criteria score of the FSPS was Almost perfect (ICC=0.93; 95% CI= 0.88-0.95).

Conclusions: The level of inter and intra-rater reliability and percentage of agreement of some criterion demonstrate promising results. Some criteria need further development before the FSPS can be applied into practice or prior to any further reliability and validity studies.

Keywords: Reliability; Visual assessment; Floor sitting posture

1. INTRODUCTION

Physical examination of the musculoskeletal system is an important part of the clinical process undertaken by musculoskeletal practitioners (e.g. chiropractors, manual and manipulative physiotherapists, and osteopaths) because it informs diagnosis and treatment selection. Consequently, physical examination may influence therapeutic outcome. Visual observation of posture and movement is a central component of physical examination and musculoskeletal therapists employ a range of evaluative procedures and orthopaedic tests to identify relevant musculoskeletal dysfunction. Each test generally aims to evaluate the integrity of one or more tissues. On some occasions a 'battery' of tests is interpreted collectively to increase the utility of the assessment. Comprehensive physical examination can be time consuming and musculoskeletal therapists in typical commercial clinical settings need to employ the most efficient clinical processes. Consequently, due to time constraints, it may be pragmatic for practitioners to focus on assessing isolated joints or particular regions of the musculoskeletal system rather than undertaking a comprehensive analysis of whole body function.

Using isolated joint assessment is discordant with osteopathic principles relating structure and function of the body as a complex system of inter-related sub-systems (Ward et al., 2003, p. 583). It is believed that a dysfunctional but asymptomatic distal region may affect a proximal symptomatic tissue (Bullock-Saxton, Janda, & Bullock, 1994; Nadler et al., 2002; Scott, 2002). This concept has been described in the physical therapy literature as "regional inter-dependence" and has been used as a rationale for evaluation and treatment of related body regions (Bullock-Saxton, Janda, & Bullock, 1994; Nadler et al., 2002).

Several physical assessment systems have been developed to screen regions or all the musculoskeletal system (Dummer, 1999; Greenman, 2003; Beach, 2008a; Minick et al., 2010). These assessment systems are all composed of various movements and postures to be assumed in sequences that enable practitioners to collect comprehensive information of functionally related body regions.

Recently, Phillip Beach, a New Zealand osteopath and author, presented a defined set of floor sitting postures and hypothesised that the visual observation of these postures may enable an efficient and broad assessment of the musculoskeletal system (Beach, 2007, 2008a, 2008b, 2010). Beach's ideas are grounded in an evolutionary biology framework and he posits that human anatomy has not had sufficient time to adapt to the recent introduction of the elevated seated posture using furniture (e.g. office chair, dining chair, vehicle seating, couch). As a result, Beach argues that the contemporary elevated seated posture may be a predisposing and/or causative factor for a wide range of musculoskeletal impairments observed in modern cultures in which furniture use is routine (Beach, 2008a). Furthermore, Beach has observed that some floor seated postures used by people without access to furniture are particularly challenging to many people who routinely use chairs and maintain relatively sedentary lifestyles and these floor sitting postures may serve to expose dysfunctional structures and functions (Beach, 2007, 2008a, 2008b). Consequently, Beach considers that the visual observation of patients performing the floor seated postures should be considered as an assessment for the musculoskeletal system (Beach, 2007, 2008a, 2008b).

Subsequent to Beach's work, Hargovan (2012) developed a visual rating protocol named "Floor Sitting Posture Screen" (FSPS) for six of the postures presented by Beach (Appendix A). The FSPS is intended to enable practitioners to use the floor seated postures in clinical practice as a physical assessment procedure. Hargovan (2012) has investigated the reliability of participants' to enter the FSPS postures, and reported moderate reliability (ICC = 0.67; 95% CI 0.25 to 0.85) to nearly perfect reliability (ICC = 0.97; 95% CI 0.94 to 0.99) for the six postures. Prior to more widespread use of the FSPS it is necessary to investigate inter- and intra-rater reliability of the rating scale. Establishing rater reliability is important for clinical evaluation tools because poor diagnostic reliability implies that decisions about therapeutic interventions could differ between practitioners, consequently leading to dissimilar therapeutic outcomes (Lucas & Bogduk, 2011). Therefore, the aim of the present study is to investigate the inter and intra-rater reliability of the FSPS.

2. METHODS

2.1 Study Design

A repeated measures, test re-test reliability design was used to investigate the inter-rater and intra-rater reliability of the FSPS. A schematic of the design is shown in Figure 1.

Phase 1 video recording

Subjects assessed for eligibility (n=28)

Excluded (n=2)
Not meeting inclusion/exclusion criteria

Video recording of subjects (n=26) performing the six floor sitting postures.

Image compilation:
Extraction of subjects pictures from videos to produce images for the rating procedure.

Phase 2 rating procedure using the FSPS

Raters assessed for eligibility (n=15)

First rating session for raters (n=15)
Subjects (n=7*) were rated using the PowerPoint document.

* Only 7 subjects were rated from the initial 26 subjects due to raters' lack of availability (maximum of 2 hours)

Raters excluded (n=3)
Not available during second rating session

Second rating session* for raters (n=12)
The same subjects (n=7) were re-rated in a different order of presentation.

* The interval between sessions was 7 days.

Figure 1: Flow chart of methodology

2.2 Ethics

The study was approved by the Unitec Research Ethics Committee, and all participants gave their written informed consent prior participation (UREC Approval No: 2010-1136).

2.3 Participant recruitment

2.3.1 Subjects

Posters, advertising using an online participant recruitment service (http://www.getparticipants.com) and word-of-mouth were the main methods of recruitment. Males and females 18 years of age or older were eligible to participate. Exclusion criteria were: inability to walk without the help of mobility aids; known diagnosis of any systemic malignant, neurological, or haematological condition; pregnancy; clinical signs of infection, or fracture. In addition, people were excluded from data analysis if they had distinguishing body features, such as tattoos, birthmarks, or scars, which may have introduced bias for the intra-rater reliability study.

2.3.2 Raters

Osteopathic students and registered osteopaths were recruited through word-of-mouth and poster advertisements. Raters were required to be enrolled in the Master of Osteopathy program, or hold a current osteopathy annual practicing certificate.

2.4 Venue and Materials

A room with a plain white background was used for the purpose of video recording of subjects performing the postures. Two digital cameras mounted on tripods were directly linked to a computer with a video card and Siliconcoach motion analysis software (http://www.siliconcoach.com). The software simultaneously recorded the two views (anterior and left lateral view) (See Appendix C).

2.5 Subjects Data Collection Procedures

During the video recording session**,** subjects were introduced to the postures by watching a video demonstrating the performance of the six postures. Subjects were asked to disrobe to their underwear and height and weight was measured. Anatomical landmarks were marked using self-adhesive stickers and fin markers (Appendix B). These landmarks were: left lateral malleolus; bilateral tibial tuberosity; left fibular head; left greater trochanter; left acriomio-clavicular joint; and spinous process of spinal levels L5, T12 and T1. The markers were used as this reliability study was conducted in collaboration with the Hargovan (2012) study which required these markers.

To ensure accurate video recording, subjects were asked to perform six postures at a specific location marked on a foam mat positioned on a hard floor. Subjects were guided to perform the postures by a researcher who provided standardised verbal instructions (Hargovan, 2012). Subjects were video recorded while performing the postures. If attainable, each posture was statically maintained for 3 seconds.

2.6 Image Processing and Compilation

Two slide show presentations (PowerPoint; Microsoft 2010) for each rating procedure were produced showing static images of each subject performing the six postures. The two slideshows were identical except for the order of images which were randomised. The order of images presented within the slideshows was randomised using an online randomisation service (http://www.randomizer.org/form.htm). Each slideshow contained a different order of images so as to minimise the risk of recall bias in the intra-rater reliability data. The duration of time where subjects maintain each posture (three seconds minimum) enabled researchers to pause the video when the subject was statically holding the position. Screen shots from the video were extracted from the video to produce static images and image manipulation software (SnagIt v10, 2010) used to blur the face of each subject for blinding and confidentiality purposes.

2.7 Rating Procedure

Raters were asked to meet in a lecture room and each rater used a separate laptop connected to a wireless network. Raters were given the FSPS in paper form (Appendix A) and introduced to the screening protocol. The slideshow was presented to the raters by the lead researcher using a retro-projector on a screen. To orient raters to the task and the rating system, practice images from 3 subjects were presented and discussed to provide guidance on how to use the rating criteria. During this session raters were encouraged to openly discuss their observations and ask questions about the use of the rating system. Following presentation and discussion about rating for approximately 20min, the first formal rating session commenced. Raters were not permitted to discuss their ratings with each other or ask questions of the lead researcher. Raters recorded their rating for each subject on a unique web based form (Google docs, Google, Mountain View, CA). Each subject rating began on a fresh form without access to previous ratings. This enabled raters to rate each subject individually without the possibility of comparing between-subject ratings. A new set of images for each subject was introduced when all raters had finished, and there was no time restriction.

Treatments on a weekly basis are commonly used in clinical practices by musculoskeletal therapists, consequently, the second rating session was scheduled 7-days after the first session. The procedure began with two sets of practice images, however, raters were not guided through the use of the FSPS. Ratings from practice images were excluded from the data analysis, and the subject images used for practice purposes were not shown in the main slideshow.

2.8 Data Analysis

The raw data were exported into an Excel spreadsheet. The data from the Excel sheet was then uploaded to an online statistical website to calculate Cohen's and Fleiss Kappa to evaluate intra-rater and inter-rater reliability respectively (http://stattools.net/CohenKappa_Pgm.php). Cohen's Kappa was used to calculate intra-rater reliability (within each rater) because of the categorical data and because this statistical method would discount for chance agreement (Lucas & Bogduk, 2011). Fleiss's Kappa was used to calculate the overall inter-rater reliability from multiple raters. The interpretation of both Cohen's and Fleiss' kappa coefficients followed the descriptors of Landis and Koch (1977) (see Table 1).

Raw percentage of agreement of raters between sessions for each criterion was also calculated for intra-rater reliability in order to give Kappa statistical context as encouraged by Lucas and Bogduk (2011). The percentage of agreement within raters was calculated from frequency of agreement between sessions.

An intra class correlation coefficient (ICC) calculation was used to calculate overall rater reliability for the combined criteria score of the FSPS. Combined scores have previously been used with visual rating tools. For instance, the FMS has used and evaluated the reliability and the validity of the FMS combined scores (Plisky, & Voight, 2007). With the actual raw data, the validity of the combined PSPS scores can not be analysed. However, the evaluation of its level of reliability can encourage future research to undertake validity studies. It is important to note that combined scores are significantly limited, since a same combined score can be potentially obtained through different individual's postural limitations. Consequently, a combined score has limited interpretation, and raters should be aware of this particular limitation.
An ICC was also performed for each combined criteria score for the two squatting postures (Normal and Variant squat). The ICC of the squatting postures was performed to evaluate if one of the posture had greater reliability as a combined score in the aim to select the most reliable rated squatting posture.

A custom spreadsheet was used for the ICC calculation, suggested by Hopkins on the Sport Science site: Hopkins WG (2011). Precision of measurement. In: A New View of Statistics (newstats.org/precision.html).

Table 1. Interpretation of Kappa coefficients by Landis and Koch (1977)

Range	**Interpretation**
< 0	No agreement
0 - 0.19	Poor agreement
0.20 – 0.39	Fair agreement
0.40 – 0.59	Moderate agreement
0.60 – 0.79	Good agreement
0.80 – 0.99	Very good agreement
1.0	Perfect agreement

Table 2. Interpretation of intra class correlation coefficients by Hopkins (2000)

Range	**Interpretation**
0 – 0.1	Trivial, very small, tiny
0.1– 0.3	Small, low, minor
0.3 – 0.5	Moderate, medium
0.5 – 0.7	Large, high, major
0.7 – 0.9	Very large, very high
0.9 – 1	Nearly, practically, or almost perfect

3. RESULTS

3.1 Characteristics of Subjects and Raters

Images from 7 subjects, a total of 63 images (9 per subject) were rated (Table 3). Eleven Master of Osteopathy student osteopaths (n=11, Year 4 n=5, and Year 5 n=6) and 1 registered osteopath were recruited as raters (n=5 male; n=7 female).

Table 3: Descriptive characteristics of subjects

	Total (n=7)	Female (n=5)	Male (n=2)
Age (years)	41 (16)	42 (17)	38 (12)
Height (m)	1.68 (0.10)	1.63 (0.06)	1.80 (0.06)
Weight (kg)	69.6 (11.6)	64.9 (10.5)	81.6 (0.4)
Body Mass Index (kg/m²)	24.69 (3.61)	24.46 (4.13)	25.25 (1.55)

Notes: Values are presented as Mean (Standard Deviation)

3.2 Inter-Rater Reliability

Table 4: Inter-rater reliability with Fleiss's Kappa for each criterion of Floor Sitting Posture Screen.

Postures	Criteria	Fleiss's Kappa	SE	95% CI Lower	Upper	Descriptors*
Normal Squat	Femur angle	0.65	0.03	0.60	0.71	Good
	Convergence	0.44	0.03	0.38	0.50	Moderate
	R tibial alignment	0.39	0.03	0.33	0.45	Fair
	L tibial alignment	0.21	0.03	0.15	0.26	Fair
	Head position	0.53	0.04	0.46	0.61	Moderate
Variant Squat	Femur angle	0.56	0.02	0.51	0.60	Moderate
	Convergence	0.67	0.03	0.61	0.73	Good
	R tibial alignment	0.22	0.03	0.16	0.27	Fair
	L tibial alignment	0.23	0.03	0.16	0.29	Fair
	Head position	0.69	0.04	0.61	0.77	Good
Straight Leg Sit	Straight leg sit	0.33	0.03	0.27	0.39	Fair
Cross Legged sit	Right	0.59	0.03	0.54	0.65	Moderate
	Left	0.66	0.03	0.60	0.71	Good
Low Kneel	Low knee	0.25	0.04	0.17	0.32	Fair
High Kneel	Buttock heel contact	0.70	0.03	0.63	0.77	Good
	Ankle dorsi-flexion	0.45	0.03	0.39	0.51	Moderate
	Toes extension	0.11	0.04	0.03	0.19	Poor

Notes: SE (Standard Error), CI (Confidence Interval)

* Descriptor according to Landis et al (1977) interpretation of Kappa.

The level of inter-rater reliability of each criterion ranged from Poor to Good according to descriptor recommended by Landis and Koch (1977) (Table 4). 10 of 17 criteria demonstrated Moderate to Good inter-rater reliability. 7 of 17 criteria ranged from Poor to Fair with one criterion (High Kneel: Toes Extension) demonstrating Poor inter-rater correlation.

3.3 Intra-rater Reliability

The intra-rater reliability results with Cohen's Kappa statistic calculation for the 17 criteria can be seen in (Appendix G)

Table 5: Intra-rater percentage of agreement for each criterion

Posture	Criterion	Rater												
		1	2	3	4	5	6	7	8	9	10	11	12	Criterion Mean (SD)
Normal Squat	Femur angle	86	86	86	100	100	71	100	100	86	71	71	100	88 (12)
	Convergence	86	100	71	43	100	71	71	57	71	43	86	86	74 (19)
	R tibial alignment	86	71	100	100	86	57	71	57	86	86	57	86	79 (16)
	L tibial alignment	100	71	86	71	71	71	71	71	71	86	100	86	80 (12)
	Head position	71	86	86	86	86	100	86	100	86	86	86	86	87 (7)
Variant Squat	Femur angle	100	100	100	100	71	86	100	71	100	57	100	71	88 (16)
	Convergence	100	100	100	57	71	71	86	100	71	71	100	86	85 (16)
	R tibial alignment	100	57	100	71	71	71	71	71	71	86	100	86	80 (14)
	L tibial alignment	71	100	71	71	57	29	71	86	71	29	71	86	68 (21)
	Head position	86	86	86	100	86	100	100	86	100	100	100	100	94 (7)
Straight Leg Sit	Straight leg sit	86	57	57	57	71	71	86	86	86	71	29	57	68 (17)
Cross Legged sit	Right	29	100	100	100	100	0	86	86	86	86	71	71	76 (31)
	Left	29	86	100	86	71	100	86	100	86	100	100	86	86 (20)
Low Kneel	Low kneel	71	86	57	100	71	86	86	100	86	86	100	100	86 (14)
High Kneel	Buttok heel contact	100	100	100	100	100	86	86	100	100	100	100	100	98 (5)
	Anckle dorsi-flexion	100	71	86	71	86	29	57	86	71	86	100	71	76 (20)
	Toes extension	86	43	57	57	100	100	57	71	71	71	71	86	73 (18)
	Rater Mean	82	82	85	81	82	71	81	84	82	77	85	85	

The intra-rater percentage of agreement for the criteria and raters ranged from 0% (R Cross Legged Sit, rater 6) to 100% (eg Normal Squat: Femur Angle, rater 4) (Table 5). For the majority of criterion (10 of the 17) the mean intra-rater percentages of agreement are above 80%. Furthermore, 10 of 12 raters mean intra-rater percentages of agreement were above 81%.

3.4 ICC of the Combined Criteria Score

The ICC of the combined criteria (n=17) score of the FSPS was Almost perfect (ICC=0.93; 95% CI 0.88 to 0.95). The ICC of the combined criteria (n=5) score of the two different squats (Normal and Variant) was Very large (ICC=0.86; 95% CI 0.79 to 0.91) and Almost perfect (ICC=0.91; 95% CI 0.86 to 0.94) respectively.

4. DISCUSSION

4.1 Overview

This study was conducted to evaluate the level of inter- and intra-rater reliability of Osteopaths using newly developed rating criteria. The Good to Moderate level of inter-rater reliability of the 10 of 17 criteria, the high level of percentage of agreement for intra-rater for all 17 criteria, and the Very large to Almost perfect agreement of the combined criteria score between raters demonstrates that reliability of the majority of the FSPS criteria are acceptable for clinical use. However, the Poor and Fair level of inter-rater reliability of 6 criteria suggests that modification of these specific criteria are needed before the FSPS can be applied into practice or further reliability and validity studies. It is also important to note that the relatively small sample of raters and subjects limits the generalisability of these findings beyond this sample and further development work is required before general clinical use.

4.1.1 Comparison of Results with Previous Reliability Studies

The level of inter- and intra-rater reliability of the present study can be compared with other similar studies.

Floor Sitting Posture Screen Versus Assessment Criteria for Posture Deviation
Watson and Mac Donncha (2000) developed the Assessment Criteria for Posture Deviation; a three-grade scale protocol to visually evaluate 10 different aspects of standing posture of male adolescents (age 15-17). The protocol is comprised of three diagrams that enable the classification of each category for each of the 10 criteria (Watson & Mac Donncha, 2000). Comparing the findings of Watson and Mac Donncha (2000) with the present study, it appears that, generally, the Assessment Criteria for Posture Deviation achieved a slightly higher level of intra-rater reliability (ranging from 73% to 100%) than the present study (68% to 98%). It is important to note that the present study has better generasability than Watson and Mac Donncha (2000) due to it greater number of raters (12 raters in present study versus 2 raters in Watson and Mac Donncha (2000) study.

Floor Sitting Posture Screen Versus visual assessment protocols with no guidelines Fedorak, Ashworth, Marshall, and Paull (2003) investigated the inter- and intra-rater reliability of visual assessment of the cervical and lumbar lordosis in a standing position in the general population by different health professionals. Moran and Ljubotenski (2006) and Aitken (2008) evaluated the inter- and intra-rater reliability of those visually assessing subjects' lumbar lordosis and forward head posture respectively. When comparing similarly analysed results from these studies with those from the present study, those found from the present study appear to demonstrate greater reliability. Unlike the present study the Fedorak et al (2003), Moran and Ljubotenski's (2006) and Aitken's (2008) did not provide raters with a rating guideline. This may explain why reliability of raters using visual observation in these previous studies is less than those obtained in the present study.

Floor Sitting Posture Screen Versus Functional Movement Screen The rating protocol of the Functional Movement Screen (FMS) is similar to that of the FSPS (they both use, writing, diagrammatic guidelines and categorical scale). The foremost dissimilarity between the rating protocols is that the FMS claims to rate dynamic movements whereas the FSPS rates static postures. The FMS uses a 4-point ordinal scale to evaluate 7 different movements. Each movement is categorised into the 4-point format according to a set of specific rating criteria explained with the help of diagrams and written instructions (Minick et al., 2010). Previous studies evaluating the inter- and intra-rater reliability of the FMS (Minick et al., 2010; Onate et al., 2012) used similar designs to the present study. The main methodological difference is that Onate et al (2012) had raters rate subjects in real-time rather than using video, as done by Minick et al (2010), or 2-dimensional (2D) photographic images as used in the present study. The inter- rater reliability results for the FSPS obtained in the present study appear to have similar levels of reliability to the FMS (Minick et al., 2010; Onate et al., 2012), where a majority of criteria achieved Moderate to Good inter-rater reliability, and a minority achieved Poor to Fair inter-rater reliability. Similarly, the ICC of the FSPS combined score (ICC=0.93; 95% CI 0.88 to 0.95) and the FMS combined score (ICC=0.98 SEM=0.25) can both be interpreted as Almost perfect agreement according to the criteria of Hopkins (2000).

Overall, it appears that rating protocols which use specific guidelines such as detailed written instructions and diagrams or only diagrams persistently are associated with higher inter- and intra-rater reliability (Watson & Mac Donncha, 2000; Minick et al., 2010; Onate et al., 2012) over those that use no guidelines (Fedorak et al., 2003; Moran & Ljubotenski, 2006; Aitken, 2008). Reliability is paramount for an examination procedure, however, reliability is not the only factor needed for an examination procedure to be clinically relevant. By consequence more studies that evaluate the validity, specificity, and sensitivity of visual assessment tools for target disorders such as spinal dysfunction are also needed.

4.1.2 Effect of terminology and subject Body Mass Index on raters reliability

Effect of terminology and sentence structure on raters reliability

After the second rating session raters were invited to provide anonymous feedback on the FSPS. A number of comments described the confusion raters felt while assessing particular postures (Straight Leg Sit, Low Kneel, High Kneel: Toes Extension). It was hypothesised that the terminology and sentence structure of each criterion of the present study may partially explain raters' confusion and some of the discrepancy between criteria results. Ute (2011) specified the importance and possible consequence of terminology and sentence structure in a diagnostic assessment. In the present study the comparison of two criteria exposed the effect of terminology on raters reliability. High Kneel: Buttock to Heel Contact criterion illustrated the highest level of inter-rater reliability (Kappa=0.70; CI 0.63 to 0.77) of the screening protocol and used terminology that could be objectively identified. Raters simply had to identify if two body parts made contact or not (Appendix A). Conversely, the High Kneel: Toes Extension criterion illustrated the lowest level of inter-rater reliability (Kappa=0.11; CI 0.03 to 0.19) and used terminology that required subjective interpretation. Raters had to choose between two options:

> "1) Toes have minimal extension"
> "2) Toes are considerably extended" (Appendix A).

Unfortunately, the protocol did not clearly define the terms *"minimal"* or *"considerably"*. Furthermore, the different sentence structure of the options of the criterion may have caused confusion to raters. A similar sentence structure between the options of the criteria may have increased inter-rater reliability according to Ute (2011), for example:

1) Toes are minimally extended
2) Toes are considerably extended

Effect of subject Body Mass Index on rater reliability

Confusion arising from criterion terminology alone probably does not explain the Fair inter-rater agreement associated with the "Straight Leg Sit" and "Low Kneel". An interesting finding reported by Moran and Ljubotenski (2006) was that the higher the Body Mass Index (BMI) of the subjects, the lower the raters' reliability for the task of rating standing lumbar posture from a lateral view. The BMI correlation could be explained by the fact that from a lateral view, soft tissue body contours may affect the visibility of the lumbar lordosis. Moran and Ljubotenski (2006) evaluated subjects in a standing posture, so their conclusion may not necessarily be generalised to the present study which evaluated subjects posture in different sitting positions. The small sample size of the present study did not permit a correlation between raters' reliability and subjects BMI. It is not possible to analyse the influence of subject BMI on the reliability of ratings but this should be considered in further work.

4.1.3 Recommendation for visual assessment protocol

When comparing results reported by Watson and Mac Donncha (2000), Fedorak et al (2003), Moran and Ljubotenski (2006), Aitken (2008), Minick et al (2010) and Onate et al (2012) with those of the present study, a number of recommendations for future visual assessment protocols can be suggested with the aim to enhancing rater reliability.

- Clear and specific written and illustrative guides for the rating protocol to clearly define criterion scoring levels
- Criteria which involve body features that are clearly observable and minimally affected by subjects BMI
- Terminology and rating criteria that minimises subjectivity
- Consistency of sentence structure when defining criteria levels

4.2 Difference between the two squatting postures

Hargovan (2012), author of the FSPS, added the Variant Squat (see Appendix A) to enable evaluation of which squatting posture, either "Normal" or "Variant Squat", was more reliable. From the present study results, no clear differences in level of inter-rater reliability between the "Normal" and "Variant Squat" were demonstrated. However, this finding is limited by the sample size. Research into the validity and interpretive value of each variation is also needed to determine if one posture is more meaningful than the other. Nevertheless, the general levels of reliability of the criteria for the two squats achieved in the present study provide encouraging results.

4.3 Instability of Cohen's Kappa

In the present study Cohen's Kappa was used to evaluate the intra-rater reliability, however two unexpected negative statistical phenomena arose during the analysis.

One of the phenomena led to Kappa values of zero, or inability to calculate (Appendix G). Cohen's Kappa becomes unstable when the raw data is homogenous and consequently produces these values (Lantz & Nebenzahl, 1996).In the present study, 5 of the 17 criteria (Variant Squat: Head position, Low Kneel, High Kneel: Buttock to Knee, High kneel: Ankle Dorsi-Flexion, High kneel: Toes extension) were associated with this phenomena. The homogenous data may be due to a lack of sensitivity in the rating criteria to detect subtle differences in subject's abilities to enter the postures. Based on the variation of measures between angles reported by Hargovan, it is known that there are differences between participants (eg up to 32 degrees difference between subjects for the angle between femur and lumbar spine in Low Kneel posture) (Hargovan, 2012), however, these differences were not detected by the subjective rating with the FSPS. Consequently we could argue that these five criteria lack sensitivity.

The second unexpected phenomenon that arose while calculating the inter-rater reliability with Cohen's Kappa affected the calculation of confidence intervals (CI). Most criteria from the present set of data had an unusually wide CI (Appendix G). This phenomenon has previously been described by Tractenberg, Yumoto, Jin, and Morris (2010) and is believed to be due to an insufficient sample size of subjects rated. Tractenberg et al (2010) suggest that a minimum 20 rated subjects were needed before the CI of Cohen's Kappa is interpretable. Therefore the present CI of Cohen's Kappa obtained from seven rated subjects lacks precision and should be interpreted cautiously.

Due to the instability of Cohen's Kappa with the present set of data, raw percentage of agreement (Table 5) was calculated and presented to provide statistical context as encouraged by Lucas and Bogduk (2011). The raw percentage of agreement does not account for chance, which is an important limitation when raters are only rating scales with a small number of increments. Therefore, the raw percentage of agreement should be considered only as a broad estimation of the agreement. Further studies should address issues of sample size and subject homogeneity.

4.4 External validity

The present study was not performed within a typical musculoskeletal clinical setting. The presence of anatomical markers and the use of video recording are the main two limitations.

4.4.1 Limitation caused by markers on anatomical landmarks

One methodological bias in this study was that rated subjects had markers on a number of anatomical landmarks (Appendix B). For example when the raters were rating subjects' Tibial Alignment of Normal and Variant Squats (Appendix B), the subjects' tibial tuberosities were clearly indicated with yellow round markers. These markers were present because the images of subjects used for this reliability study were collected concurrently with the Hargovan (2012) study but the markers would not be routinely used in a typical clinical setting. The presence of markers makes visual judgement easier and the level of agreement reported in this study may be biased upwards compared to making judgement without the benefit of anatomical markers.

4.4.2 Limitation of two-dimensional pictures

This present study used two-dimensional (2D) pictures to make judgements upon a three-dimensional object (the subject's posture) during the rating procedure. This approach is useful because it ensures that the postures were identical between rating sessions thereby controlling for biological variability between sessions. Therefore, any variation between measures can only be explained by variations in the rating procedure and not to variation in the stability of the trait being measured between sessions. Unfortunately the utilisation of images rather than real time observation introduces some difficulties linked to judging images that differ from real time observation. Therefore, the use of images may limit the generalizability of results. The use of 2D images seems to have caused specific difficulties to raters while rating one particular criterion. Five of the 12 raters of this study expressed that it was difficult to apply the “Tibial Alignment” criteria of the two squatting postures (Appendix A). Raters noted that it was difficult to visually distinguish if the imaginary vertical line passing through the tibial tuberosity was also passing through the second toe (Appendix B). It is possible that the criterion itself asked raters to rate something that was not clearly distinguishable on an image that would be visualised more easily in real time observation. However, it seems more likely that the method of presentation (2D pictures in frontal and sagittal planes) did not permit raters to alter their perspective and distance from the subject consequently limiting raters ability to accurately use the rating criterion. Reliability designs using real time observation, or the use of higher quality images would address this issue.

4.5 Application to clinical practice and future researches

The FSPS was developed to categorise the ability of people to enter a number of floor sitting postures. The postures were hypothesised to screen the function of the musculoskeletal system with an emphasis on the trunk and the lower extremities. Hargovan (2012) demonstrated that their sample of subjects had High to Almost perfect consistency while entering the six floor postures depending on the posture (ranging from ICC = 0.67; 95% CI 0.25 to 0.85 to ICC = 0.97; 95% CI 0.94 to 0.99). Although the sample size limited the strength of the present study, it does provide some preliminary evidence that clinically acceptable levels of reliability may be achievable in future studies using the FSPS. The results of these two studies encourage further research related to the hypothesis of Beach (Beach, 2007, 2008a, 2008b) and the FSPS. The clinical relevance of being able to perform these postures has yet to be investigated but this study provides useful data from which to further consider issues of rating reliability and subsequently issues of validity.

Conclusion

The present inter- and intra-rater reliability study of the Floor Sitting Posture Screen demonstrated promising results for 10 of the 17 criteria. Nevertheless, findings indicate that 7 of 17 criteria require further development before the Floor Sitting Posture Screen can be applied into practice or prior to any further reliability or validity studies. Even though methodological limitations limit generalization of findings, the current research has identified issues and provides recommendations for future research.

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SECTION 3: APPENDIX

Appendix A: Floor Sitting Posture Screen

Grading Criteria For Floor Sitting Postures

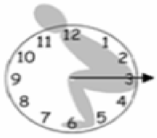
1. SQUAT and SQUAT VARIATION

A) Femur angle from vertical

*Rate the **angle of the femur** according to the hours of the clock in a clockwise direction. Middle of the clock positioned mid-knee. Rate to the nearest number and rate down numerically if the femur appears to be half way between the numbers on the clock.*

Squat Criteria:

1. Femur appears to be at 1 o'clock
2. Femur appears to be at 2 o'clock
3. Femur appears to be at 3 o'clock
4. Femur appears to be at 4 o'clock
5. Femur appears to be at 5 o'clock



3. Femur appears to be at 3 o'clock

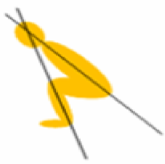
B) Torso–tibial relationship in terms of convergence

*Convergence is the intersection of the extrapolated lines from the angles of the **tibia** and **torso***

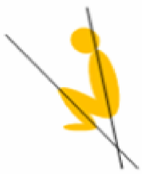
Convergence Criteria:

1. Convergence above pelvis
2. Convergence below pelvis
3. No obvious convergence, the torso and tibia appear parallel

Examples of convergence:



Convergence above



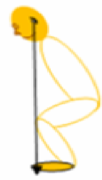
Convergence below

C) Head Position

Head position: Vertical line from mid-ear to floor

Head Position Criteria

1. Vertical line from mid-ear falls outside of the foot
2. Vertical line from mid-ear falls within the foot



Example of head position:
2. Vertical line from mid-ear falls within the foot

D) Tibial tuberosity and 2nd toe

Description: Location of the tibial tuberosity in relation to the toes in the frontal plane.

Tibial Tuberosity and 2nd Toe Criteria

1. Vertical line from the tibial tuberosity does not bisect any of the toes
2. Vertical line from the tibial tuberosity bisects any of the toes except the 2nd toe
3. Vertical line from the tibial tuberosity bisects 2nd toe

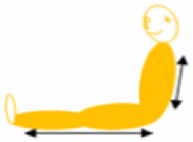
Example of Tibial Tuberosity and 2nd toe:

Right leg- Grading 3
Left leg- Grading 1

3. STRAIGHT-LEG SIT

Straight-Leg Sit Criteria

1. Knees are bent with calf not in contact with the floor and/or curved back
2. Straight legs with back straight but not vertical
3. Straight legs with back straight and vertical



Example of Straight Leg Sit:

2. Straight legs with back straight but not vertical

4. CROSS-LEGGED SIT

Grading in reference to the distance of the superior aspect of the knee of the top leg from the floor. Foot length in this criterion refers to a measurement between 20-30 centimetres.

Cross-Legged Sit Criteria

1. Can't do posture, knee is more than a foot length high from the floor
2. Knee held noticeably above lower leg less than a foot length high from the floor, and legs are not in contact
3. Legs appear to be in contact with top leg rested on lower limb

Example of Cross legged sit:

2. Knee held noticeably above lower leg less than a foot length high from the floor, and legs are not in contact

5. LOW KNEEL

Low Kneel Criteria

1. Buttock does not rest on heels and/or gap present under the ankle
2. Buttock rests on heels but without a straight and vertical back
3. Buttock rests on heels with a straight and vertical back

Example of Low kneel:

2. Buttock rests on heels without a straight and vertical back

6. HIGH KNEEL

A) Buttock to Heel contact

Thigh-calf contact is in reference to proximal calf

High Kneel Criteria

1. Minimal to no thigh-calf contact, no buttock-heel contact
2. Mid-thigh and calf in contact, with no buttock-heel contact
3. Buttock on heels

Example of buttock to heel contact:

2. Mid-thigh and calf in contact, with no buttock-heel contact

B) Angle of ankle flexion – angle of planter surface of foot and floor

Angle of Ankle Criteria

1. Planter surface of foot is less than 90° from the floor
2. Planter surface of foot is vertical (90°) to the floor
3. Planter surface of foot is more than 90° from the floor

Example of the Angle of ankle flexion:

1. Planter surface is less than 90° from the floor

C) Extension of toes

Extension of toes Criteria

1. Toes have minimal extension
2. Toes are considerably extended

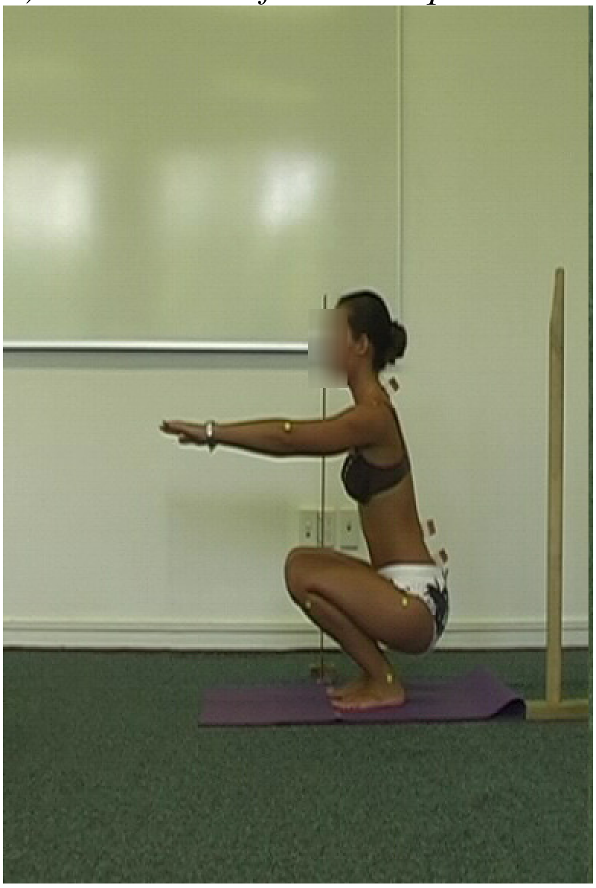
Example of Extension of toes:

2. Toes are considerably extended

From: Hargovan, B. (2012). *The development of grading criteria and investigation of test-retest reliability of selected floor sitting postures.* Master of Osteopathy, Unitec Institute of Technology, Auckland.

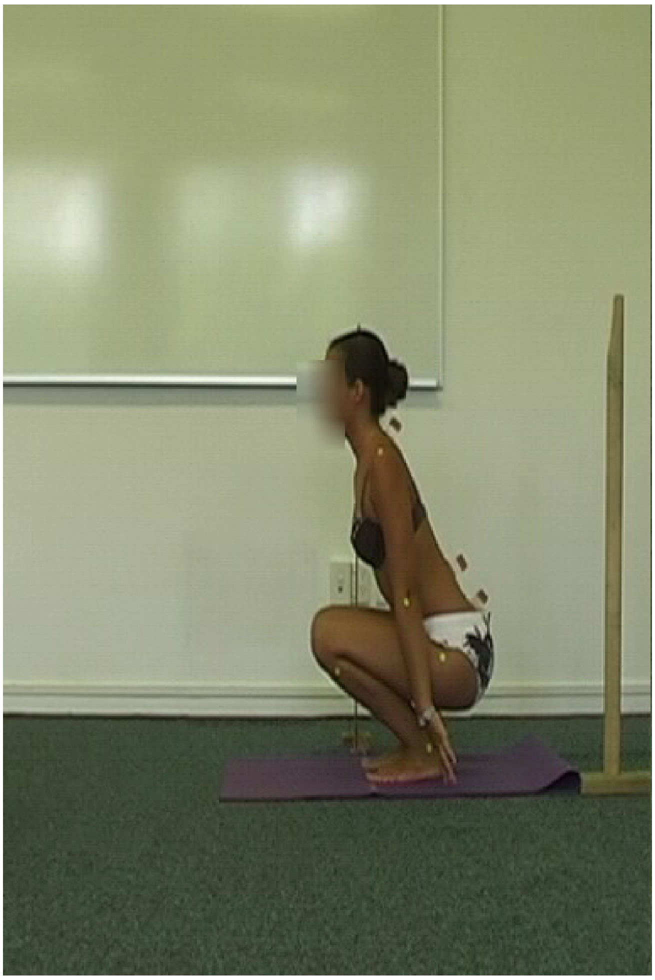
Appendix B: Sample of picture rated

A) Lateral view of Normal squat



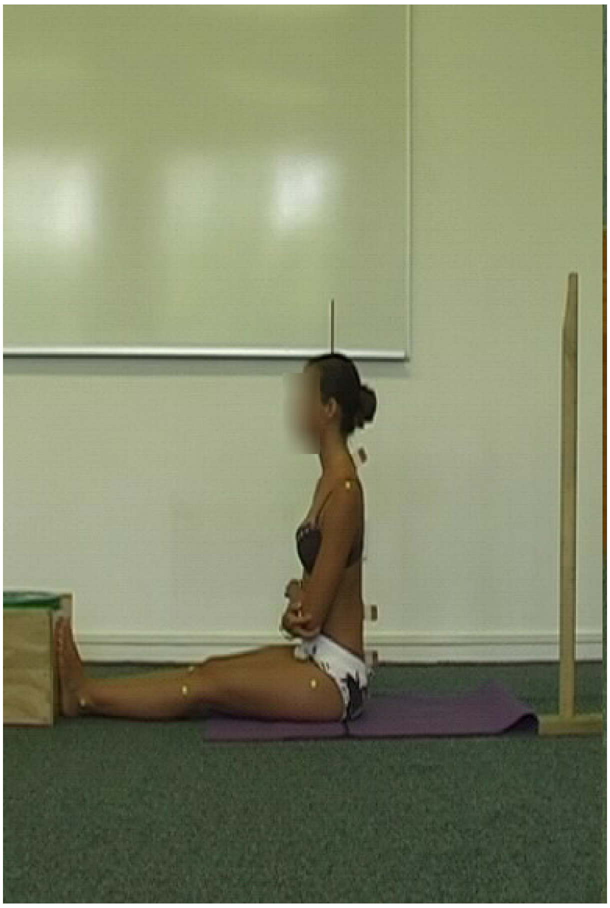
B) Anterior view of Normal squat

C) Lateral view of variant squat



D) Anterior view of variant squat

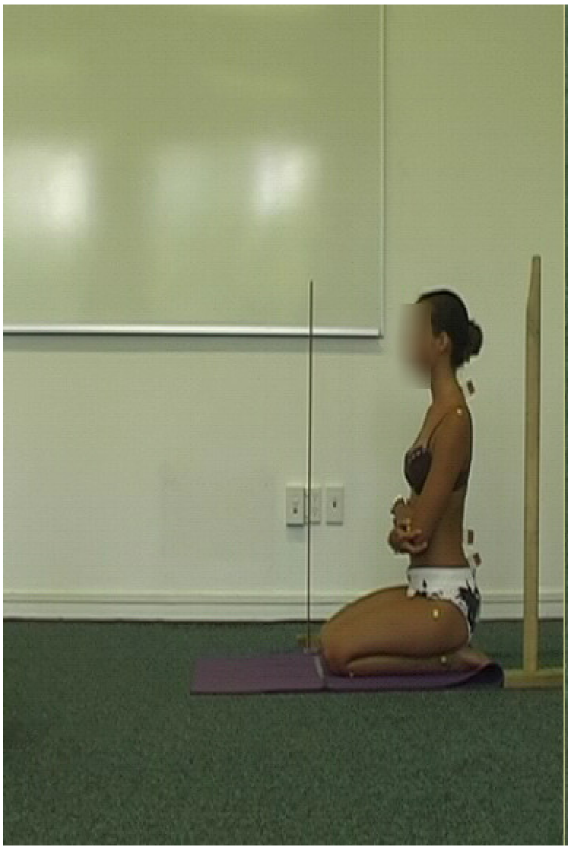
E) Lateral view straight leg sit



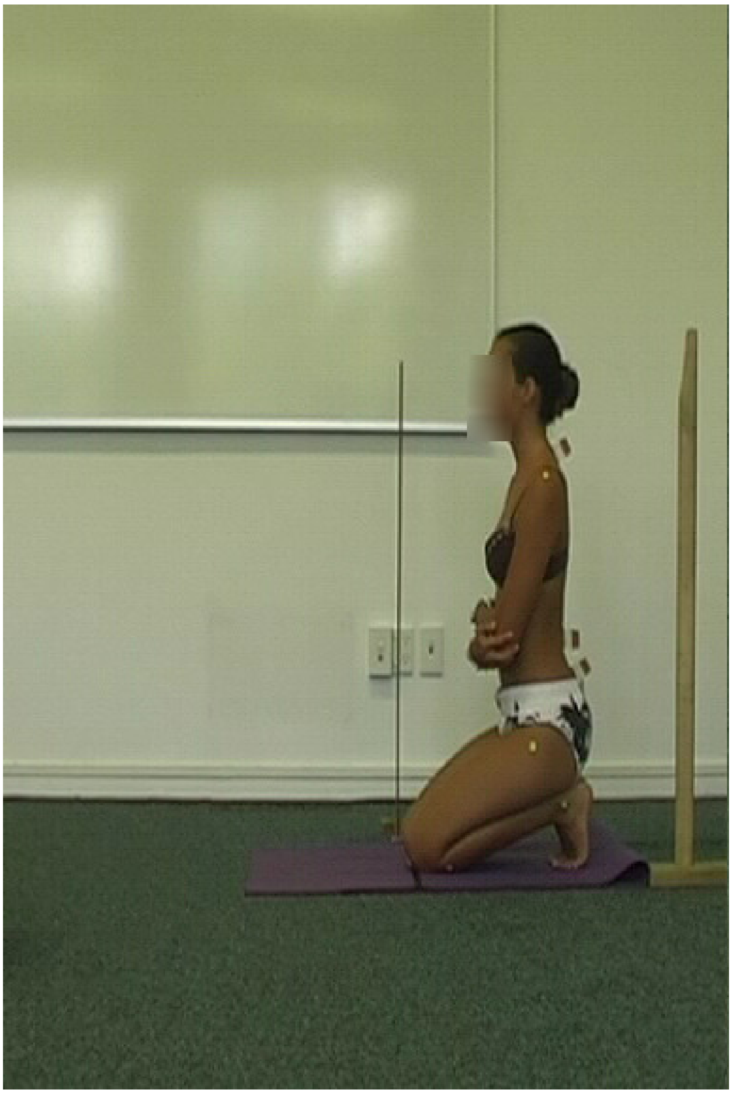
F) Anterior view right cross legged sit

G) Anterior view left cross legged sit

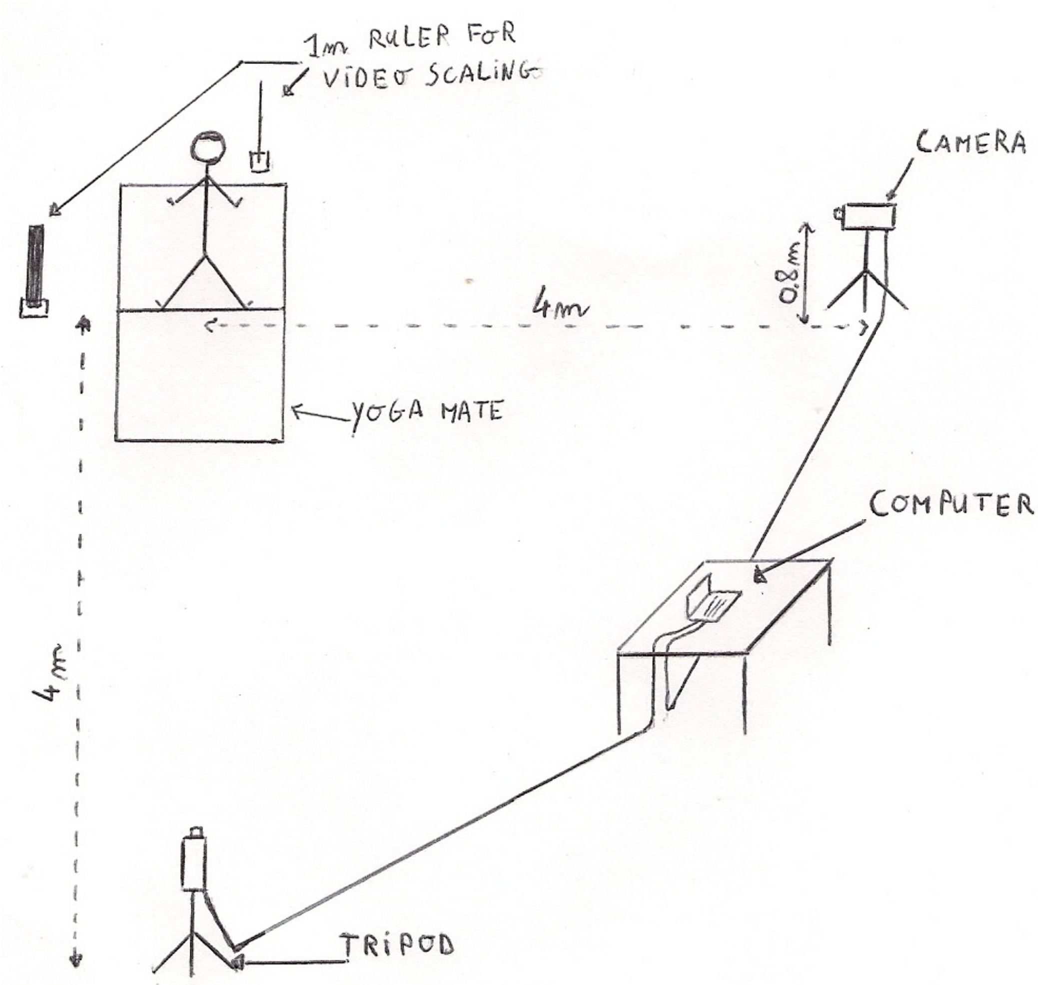
H) Lateral view low kneel



I) Lateral view high kneel



Appendix C: Diagram of the video recording setup



Appendix D: Recruitment Posters and Flyers

A) Poster

Can you sit on the floor?

No matter the answer to the above question, if you are above18 years of age you may be eligible to participate in this study

We are currently completing a Masters of Osteopathy degree at Unitec New Zealand, part of which involves a research project. The study will investigate the extent to which people are able to sit on the floor.
The aim is to develop a rating criteria and determine the use of floor sitting postures in a clinical setting.

If you are interested in participating please contact:

Bhakti Hargovan
Phone: 021 1730328

Matthias Houvenagel
Phone: 021 1578278

Unitec NEW ZEALAND Te Whare Wānanga o Wairaka

Can you help in this study?

Contact Bhakti on 0211730328
Email bhargovan@gmail.com

Contact Matthias 0211578278
Email matthiashou@yahoo.fr

Contact Bhakti on 0211730328
Email bhargovan@gmail.com

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Email matthiashou@yahoo.fr

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B) Flyers

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Email: bhargovan@gmail.com

Matthias Houvenagel
Phone: 021 1578278
Email: matthiashou@yahoo.fr

Unitec
NEW ZEALAND

Can you help in this study?

Appendix E: Ethics approval, Information sheet and Consent Form

A) Ethics approval

Unitec
NEW ZEALAND
Te Whare Wānanga o Wairaka

phone +64 9 849 4180 fax +64 9 815 2901 web www.unitec.ac.nz
address Private Bag 92025, Auckland Mail Centre, Auckland 1142, New Zealand
Mt Albert campus Carrington Rd, Mt Albert, Auckland, New Zealand
Waitakere campus Ratanui St, Henderson, Auckland, New Zealand

Bahakti Hargovan
90A Tiverton Road
New Windsor
Auckland 0600

1 March 2011

Dear Bahakti,

Your file number for this application: 2010-1136
Title: Project 1: The development of criterion for rating floor sitting postures and investigation of intra- and inter-session biological variability. Project 2: The intra- and inter-rated reliability of the developed criterion for the floor sitting postures.

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been **approved** for the following period:

Start date: 26 January 2011
Finish date: 25 January 2012

Please note that:
1. The above dates must be referred to on the information AND consent forms given to all participants
2. You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely

P.P. KJones.

Lyndon Walker
Deputy Chair, UREC

cc: Matthias Houvenagel, co-investigator
Rob Moran, Osteopathy
Cynthia Almeida

B) Subject information sheet

RESEARCH INFORMATION FOR PARTICIPANTS

Investigation of floor sitting postures by development and evaluation of clinical rating criterion

You are invited to participate in our research investigation. Please read carefully through this information sheet before you make a decision about volunteering.

Principal Researchers

Bhakti Hargovan and Matthias Houvenagel (4th year Osteopathy Students)
Bhakti and Matthias are studying for a Master of Osteopathy at Unitec New Zealand.

Our Purpose

The aim of this study is to develop and evaluate a tool that assesses people's ability to perform 5 floor sitting postures.

It has been suggested that inability or limited ability to perform these floor-sitting postures may be linked to musculoskeletal problems. Hence, this tool could provide a quick and simple diagnostic test of optimal musculoskeletal function.

Your voluntary participation

Your participation in this study is entirely voluntary and you may withdraw at any time during the study. Data collected from your involvement in the study may be withdrawn up until 1 week following your final assessment.

Who may participate?

To participate in this study you need to be 18 years of age or older. Participants may be included in the study if they lack physical recognisable characteristics (such as tattoos), and are mobile without any external help.

Unfortunately you will not be eligible to take part in the study if you:

- have intense pain performing any movement within the study protocol.
- are currently diagnosed with systemic, neurological or rheumatological diseases.
- are pregnant
- have persistent symptoms from previous history of trauma or surgery that could be aggravated while performing the study.

Please feel free to contact the principal researchers if you are unsure about your eligibility

What will happen in the study?

Should you agree to participate in the study, you will be required to attend 2 sessions.

The first session will take approximately 1 hour 30 minutes of your time. During this session you will be:

- measured for height and weight
- asked to fill questionnaires which are informative of your daily physical activity

- asked to undress into underclothing (briefs and bra) for the purpose of clear video recording while performing the 5 floor sitting postures
-

The second session will take approximately 1 hour or your time. During this session you will be:

- asked to re-perform the 5 floor sitting postures under the same conditions
- asked to perform 3additional flexibility tests measuring angles of range of movement

Video footage of you performing these floor sitting postures will undergo pixilation of participants identifying features (face, birth marks etc.) to maintain anonymity. Finally, the video will be graded according to participant ability to perform the posture by a sample of osteopath and physiotherapist practitioners.

What we do with the data and results, and how we protect your privacy.
Personal information is collected and stored under the guidelines provided by the Privacy Act 1993 and the Health Information Privacy Code 1994. In all instances of information collection your identity will remain anonymous and you will simply have an identification number. If the information you provide is reported or published, this will be done in a way that does not identify you. All the data recorded will be stored in a password-locked computer and archived in a locked file room in the Unitec Student Osteopathic Clinic and will be stored for a minimum of 5 years. Access to this data will be limited to the principal researchers (Bhakti Hargovan and Matthias Houvenagel), their research supervisors, and yourself.

Compensation may be available in the unlikely event of injury of negligence
Should you incur a physical injury as a result of your participation in this study, you may be covered by ACC under the Injury Prevention, Rehabilitation and Compensation Act 2002. You may or may not be entitled to ACC compensation, depending on several factors such as whether or not you are an earner. ACC will usually cover a proportion of income lost due to a physical injury, this does not cover mental injury unless as a direct result from a physical injury. ACC cover may affect your right to sue. Please contact your nearest ACC office for further information (0800 735 566) or visit their website: www.acc.co.nz

Please contact us if you need further information about the study.

Contact Details:

Bhakti Hargovan
Phone: 021 1730328
Email: bhargovan@gmail.com

Matthias Houvenagel
Phone: 021 1578278
Email: matthiashou@yahoo.fr

UREC REGISTRATION NUMBER: (insert number here)
This study has been approved by the UNITEC Research Ethics Committee from (date) to (date). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

C) Rater information sheet

Participant information sheet

RESEARCH INFORMATION FOR PARTICIPANTS

Investigation of the intra- and inter-rater reliability of the developed grading criteria for the floor sitting postures

You are invited to participate in our research investigation. Please read carefully through this information sheet before you make a decision about volunteering.

Principal Researchers

Bhakti Hargovan and Matthias Houvenagel (5th year osteopathy students) are studying for a Master of Osteopathy at Unitec New Zealand.

Our Purpose

The aim of this study is to develop and evaluate a rating criteria that assesses people's ability to perform 5 floor sitting postures, and determine the use of the floor sitting posture in a clinical setting.

It has been suggested that inability or limited ability to perform these floor-sitting postures may be linked to musculoskeletal problems. Hence, this tool could provide a quick and simple diagnostic test of optimal musculoskeletal function.

Your voluntary participation

Your participation in this study is entirely voluntary and you may withdraw within 1 week following involvement

Who may participate?

You are eligible to take part in the study if you are:

- 18 years of age or older
- An osteopath or physiotherapist currently enrolled in the Osteopathic Council of New Zealand (OCNZ) or Physiotherapy Board of New Zealand (PBNZ).

- An Osteopathic student enrolled in the master of osteopathy at UNITEC Auckland, New Zealand.

What will happen in the study?

Should you agree to participate in the study, you will be required to attend 2 sessions. The first session will take approximately 2 hours of your time. During this session:

- You will be asked to fill a short questionnaire which is informative of your osteopathic professional career.
- You will be taught to use the floor sitting posture rating criteria
- You will be Asked to rate a sample of pictures of participants performing the postures.

The second session will take approximately 1 hour of your time. During this session you will be:

- Asked to re-rate a sample of pictures of participants performing the postures

What we do with the data and results, and how we protect your privacy

Personal information is collected and stored under the guidelines provided by the Privacy Act 1993 and the Health Information Privacy Code 1994. In all instances of information collection your identity will remain anonymous and you will simply have an identification number. Information will only be used in the Masters of Osteopathy Thesis only. If the information you provide is reported or published, this will be done in a way that does not identify you. All the data recorded will be stored in a password-locked computer and archived in a locked file room in the Unitec Student Osteopathic Clinic and will be stored for a minimum of 5 years. Access to this data will be limited to the principal researchers (Bhakti Hargovan and Matthias Houvenagel), their research supervisors, and yourself.

Compensation may be available in the unlikely event of injury of negligence

Should you incur a physical injury as a result of your participation in this study, you may be covered by ACC under the Injury Prevention, Rehabilitation and Compensation Act 2002. You may or may not be entitled to ACC compensation, depending on several factors such as whether or not you are an earner. ACC will usually cover a proportion of income lost due to a physical injury, this does not cover mental injury unless as a direct result from a physical injury. ACC cover may affect your right to sue. Please contact your nearest ACC office for further information (0800 735 566) or visit their website: www.acc.co.nz

Please contact us if you need further information about the study.

Contact Details:

Bhakti Hargovan Matthias Houvenagel

Phone: 021 1730328 Phone: 021 1578278

Email: bhargovan@gmail.com Email: matthiashou@yahoo.fr

UREC REGISTRATION NUMBER: (2010-1136)

This study has been approved by the UNITEC Research Ethics Committee from (12/17/2010) to (12/17/2011). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the

UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

D) Participant Consent Form

Participant consent form

Investigation of floor sitting postures by development and evaluation of clinical rating criterion

This form is to ensure that you understand the requirements of your participation and that you aware of your rights. Please read carefully through the points below. If you are happy and agree with the points then please sign at the bottom of the page. If you have any questions at all please ask the researcher before signing this form.

- I have had the research project explained to me and I have read and understood the information sheet given to me.
- I understand that I don't have to be part of this if I don't want to and I may withdraw at any time up to 1 week following the end of my involvement.
- I understand that everything I say and the information I provide will be collected in accordance with the Health Information Privacy Code 1994 and kept confidential and in accordance with the Privacy Act 1993. I understand that the only persons who will have access to my information will be the researchers and their supervisors.
- I understand that all the information I give will be stored securely on a computer at Unitec for a minimum period of 5 years.
- I understand that I can see the finished research document.
- I have had time to consider the information provided, to ask questions, and to seek any guidance.
- I give my consent to be a part of this project

Participant Signature: ………………………….. Date: ……………………………

Principal Researcher: ………………………….. Date: ……………………………

UREC REGISTRATION NUMBER: (insert number here)
This study has been approved by the UNITEC Research Ethics Committee from (date) to (date). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Appendix F: Demographic questionnaire

Demographic questionnaire

Name: ____

Date of Birth: __/__/_____ Age: ____ Female ☐ Male ☐

Height (m):__________ Weight (kg):________ BMI: ______ (mass/ (height) ^{2})

Ethnicity:____

Occupation:____

Address:____

Ph: (H) _______________ (Mob) ___________________ (Email) ________________________________

Person to contact in case of accident:____

Ph: (H) _______________ (Mob) ___________________ (Email) ________________________________

Medical History Questions:	***YES***	***NO***
Do you have any rheumatologic condition?	☐	☐
Do you have any malignant conditions?	☐	☐
Are you pregnant?	☐	☐
Are you being treated by any manipulative or bodywork therapist?	☐	☐

Any pain or injuries to: *please tick which body part and add when the pain or injury started (eg. 6 months, 1year)*

Back: _________________________________ Neck: _____________________________

Knees: ________________________________ Ankle: _____________________________

Hips __________________________________ Shoulders: __________________________

How severe is your pain? Circle the number below that corresponds to your pain level.

Little to no pain **1 2 3 4 4 5 6 7 8 9 10** **Severe pain**

How many hours do you spend in a seated position during a typical working day?

At a desk or table…………………………….. hour(s)
In a vehicle (car, bus, plan, boat, others)…….. hour(s)
On a sofa, couch other……………………….. hour(s)

Total: hour(s)

Appendix G: Intra-rater reliability of criterion Cohen's Kappa analysis

Table 1

Normal femoral angle

Raters	Kappa	SE	Boundaries lower	Upper
1	0.8852	0.3025	0.2923	1.4782
2	0.8852	0.3025	0.2923	1.4782
3	0.8727	0.3299	0.2262	1.5193
4	1	0.3276	0.358	1.642
5	1	0.2875	0.4364	1.5636
6	0.8056	0.2902	0.2368	1.3743
7	1	0.3276	0.358	1.642
8	1	0.2875	0.4364	1.5636
9	0.8727	0.3299	0.3299	1.5193
10	0.7667	0.2917	0.195	1.3384
11	0.6316	0.3183	0.0077	1.2554
12	1	0.378	0.2592	1.7408

Graph 1

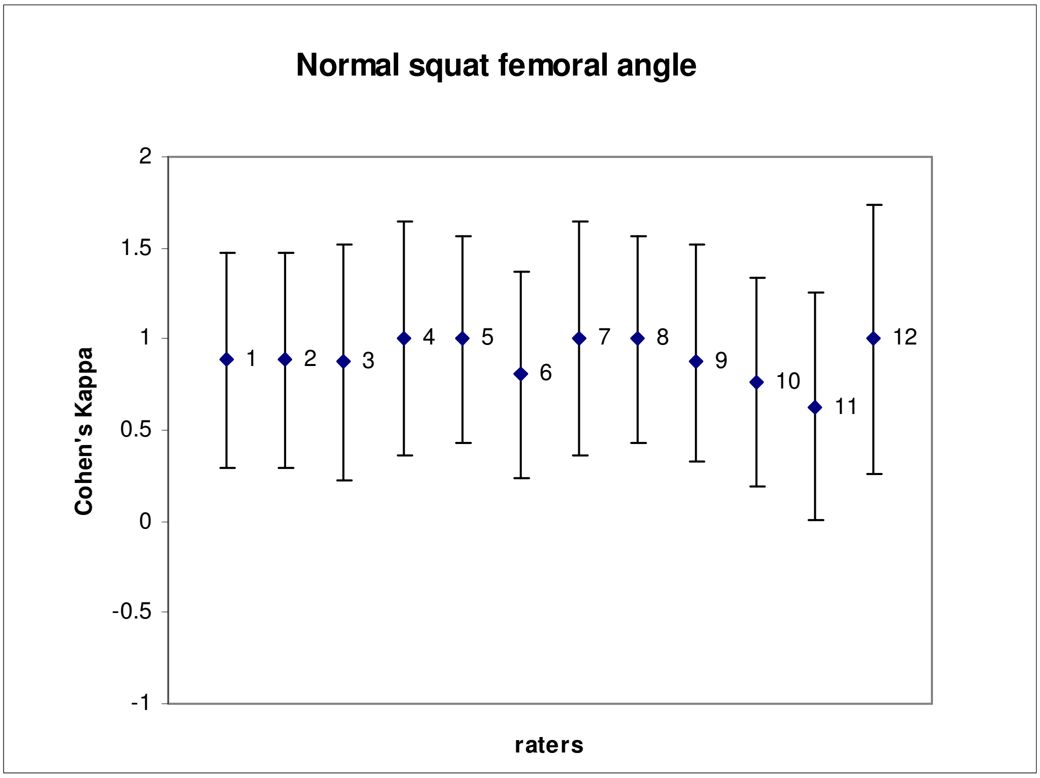


Table 2

Normal convergence

Raters	Kappa	SE	Boundaries lower	Upper
1	0.8372	0.2878	0.2731	1.4013
2	1	0.3054	0.4014	1.5986
3	0.5333	0.3097	-0.0738	1.1404
4	-0.129	0.1889	-0.4992	0.2412
5	1	0.378	0.2592	1.7408
6	0.4615	0.2326	0.0057	0.9174
7	0.5625	0.2835	0.0069	1.1181
8	0.3913	0.2903	-0.1776	0.9602
9	0.8372	0.2878	0.2731	1.4013
10	0	0.2857	-0.56	-0.56
11	0.6957	0.36	-0.01	1.4013
12	0.6957	0.36	-0.01	1.4013

Graph 2

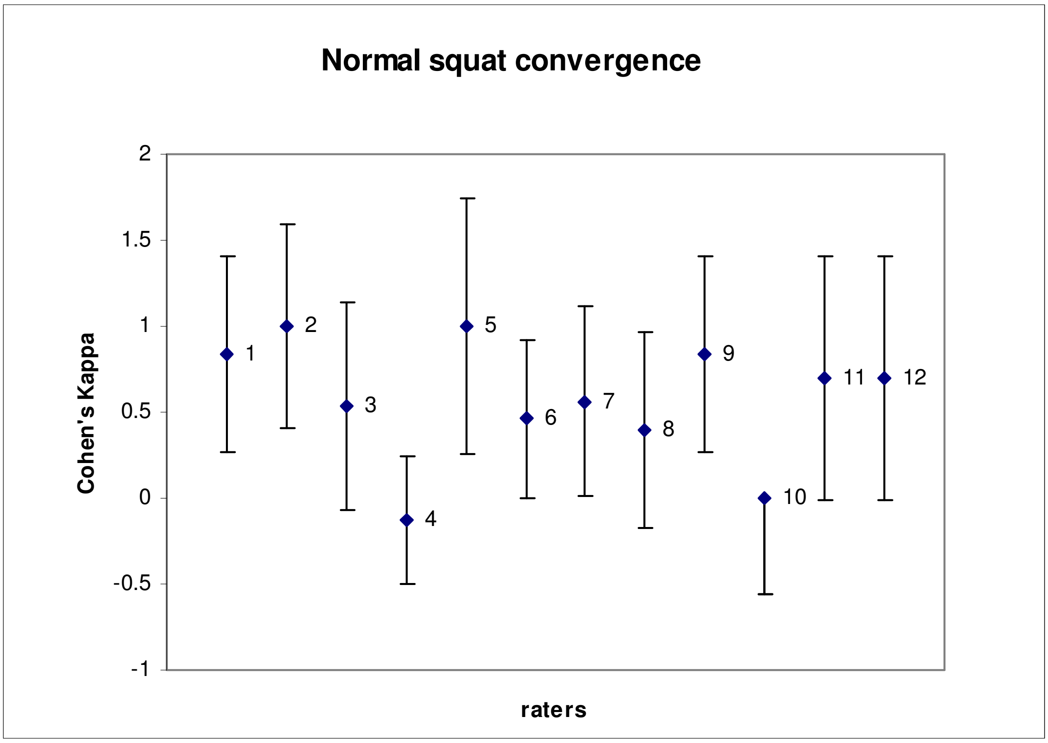


Table 3

Normal Right Tibial Alignment

Raters	**Kappa**	**SE**	**Boundaries lower**	**Upper**
1	0.8108	0.271	0.2796	1.3421
2	0.6111	0.3057	0.0119	1.2104
3	1	0.2955	0.4209	1.5791
4	0.8	0.2799	0.2513	1.3487
5	0.7586	0.2607	0.2477	1.2695
6	0.5116	0.2878	-0.0524	1.0757
7	0.6316	0.2609	0.1202	1.1429
8	0.4878	0.1844	0.1264	0.8492
9	0.6316	0.2713	0.0998	1.1633
10	0.8	0.3024	0.2074	1.3926
11	0.4878	0.2856	-0.072	1.0476
12	0.8108	0.2918	0.2389	1.3828

Graph 3

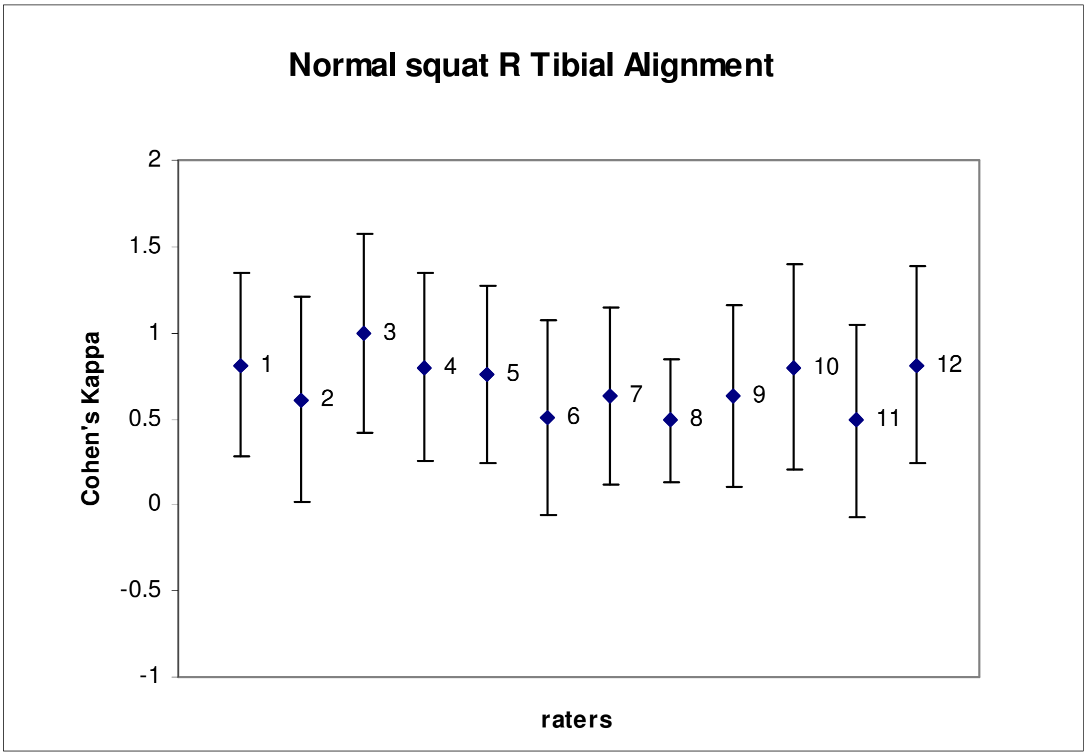


Table 4

Normal Left Tibial Alignment

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.2878	0.4358	1.5642
2	0.6111	0.2955	0.032	1.1902
3	1	0.2835	0.4444	1.5556
4	0.65	0.2699	0.121	1.179
5	0.6818	0.2617	0.1689	1.1947
6	0.6957	0.2903	0.1267	1.2646
7	0.65	0.2699	0.121	1.179
8	0.65	0.2699	0.121	1.179
9	0.5882	0.2374	0.123	1.0535
10	0.8108	0.2918	0.2389	1.3828
11	1	0.3091	0.3942	1.6058
12	0.8	0.2799	0.2513	1.3487

Graph 4

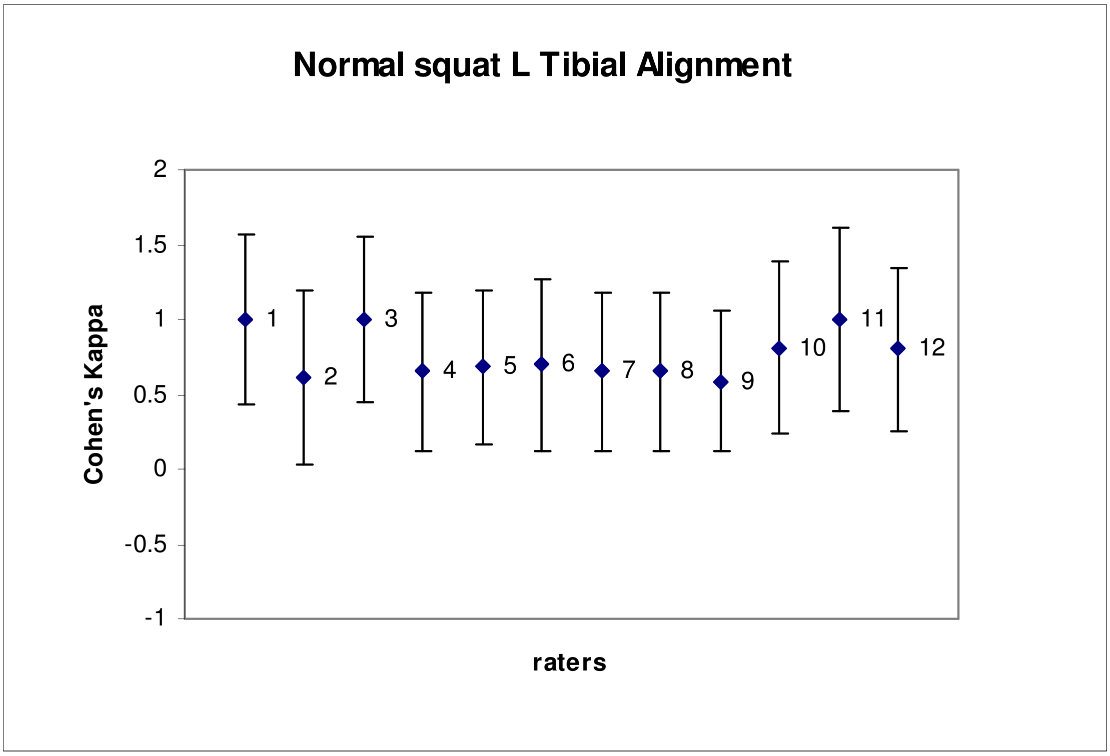


Table 5

Head position

Raters	Kappa	SE	Boundaries lower	Upper
1	0.3636	0.2916	0.2078	0.9351
2	0.6957	0.36	-0.01	1.4013
3	0.6957	0.36	-0.01	1.4013
4	0.6957	0.36	-0.01	1.4013
5	0.5882	0.3444	-0.0869	1.2633
6	1	0.378	0.2592	1.7408
7	0.6957	0.36	-0.01	1.4013
8	1	0.378	0.2592	1.7408
9	0.5882	0.3444	-0.0869	1.2633
10	0.5882	0.3444	-0.0869	1.2633
11	0.72	0.3628	0.0088	1.4312
12	0.6957	0.36	-0.01	1.4013

Graph 5

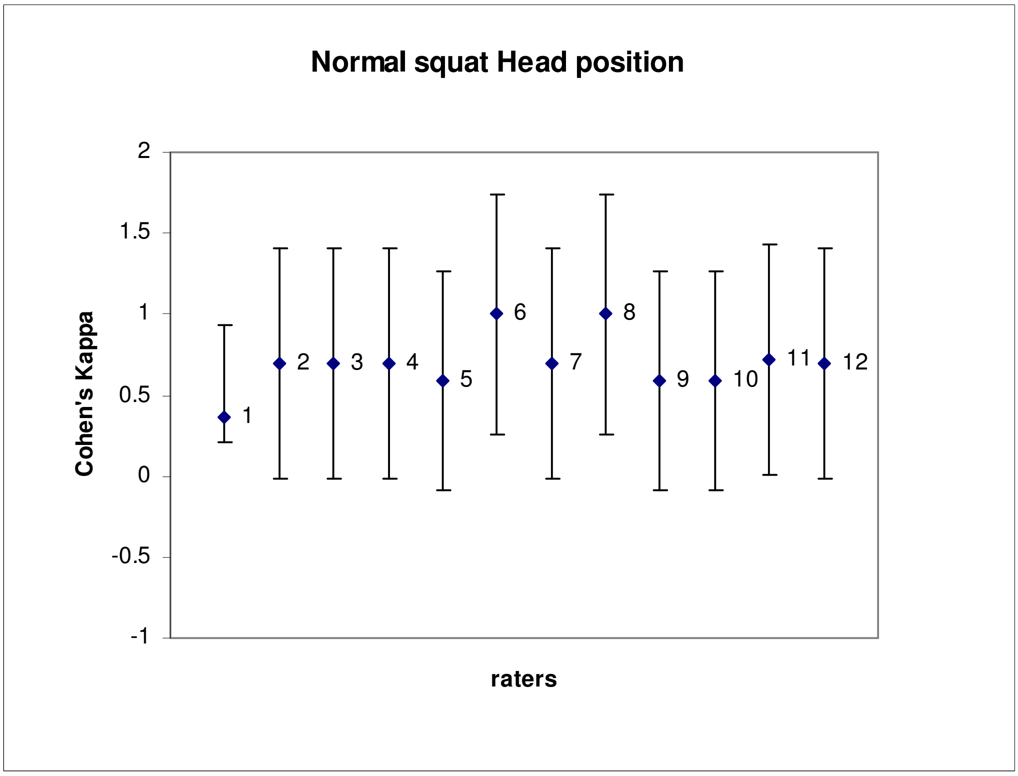


Table 6

Variant femoral angle

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.2625	0.4856	1.5144
2	1	0.2625	0.4856	1.5144
3	1	0.3091	0.3942	1.6058
4	1	0.3091	0.3942	1.6058
5	0.6818	0.2617	0.1689	1.1947
6	0.8955	0.2679	0.3704	1.4207
7	1	0.2812	0.4488	1.5512
8	0.7586	0.2607	0.2477	1.2695
9	1	0.3091	0.3942	1.6058
10	0.6316	0.2679	0.1065	1.1566
11	1.0000	0.3091	0.3942	1.6058
12	0.7586	0.2607	0.2477	1.2695

Graph 6

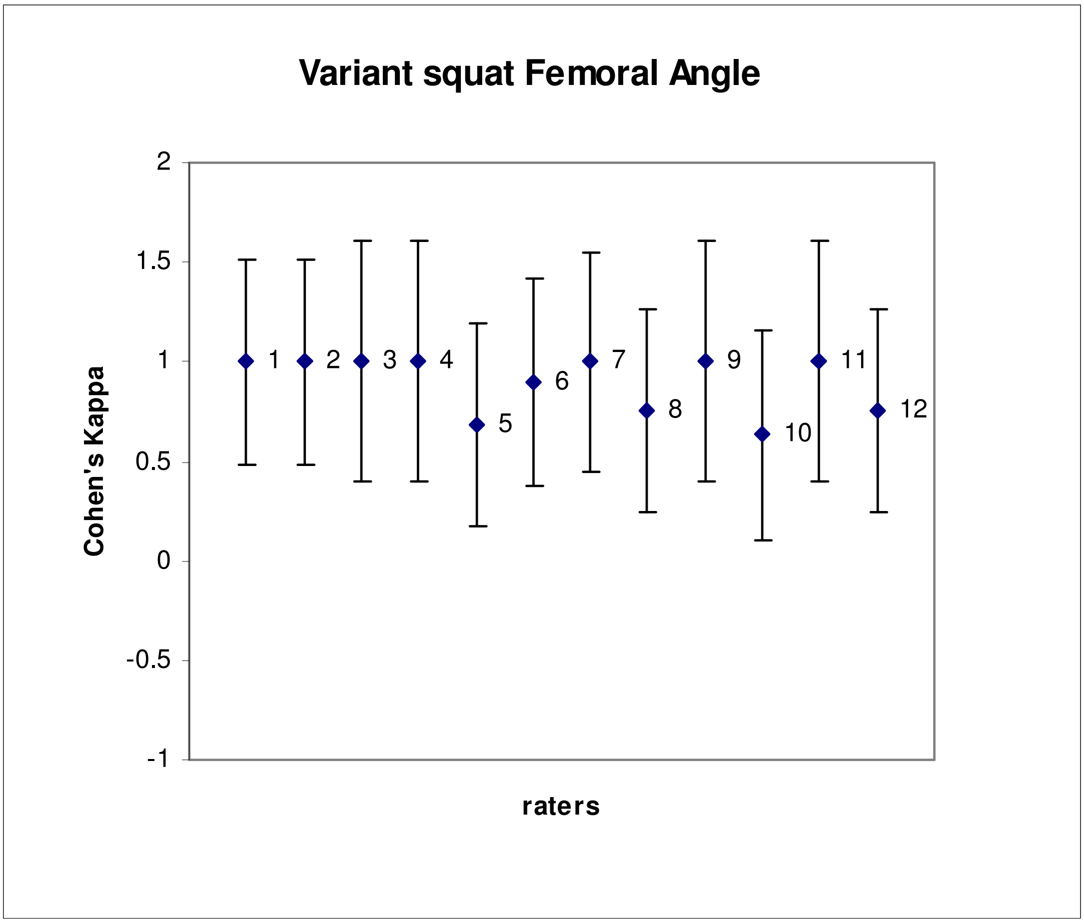


Table 7

Variant Convergence

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.378	0.2592	1.7408
2	1	0.378	0.2592	1.7408
3	1	0.3222	0.3685	1.6315
4	0.2759	0.2607	-0.235	0.7868
5	-0.1667	0.378	-0.9075	0.5741
6	0.65	0.3047	0.0527	1.2473
7	0.7407	0.28	0.192	1.2895
8	1	0.3222	0.3685	1.6315
9	0.4	0.3024	-0.1926	0.9926
10	0.5333	0.276	-0.0077	1.0743
11	1	0.378	0.2592	1.7408
12	0.4167	0.244	-0.0615	0.8949

Graph 7

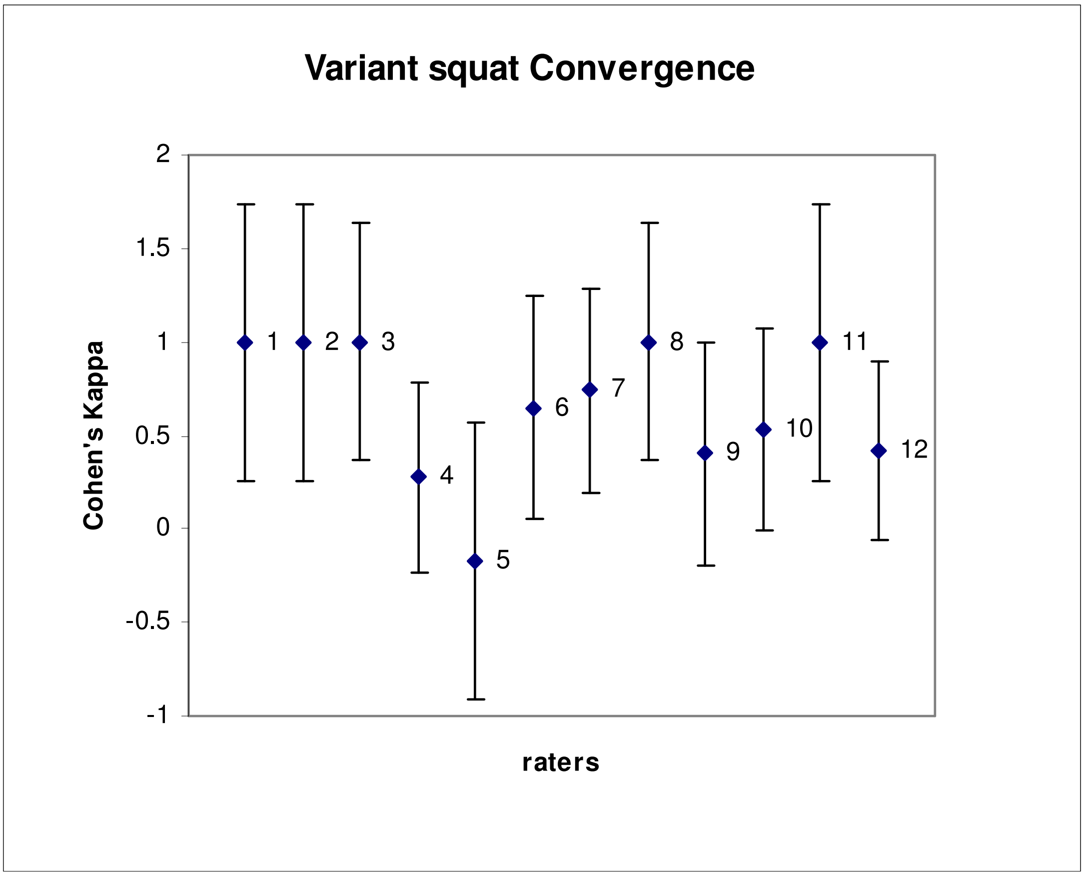


Table 8

Variant Right Tibial Alignment

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.2878	0.4358	1.5642
2	0.6111	0.2955	0.032	1.1902
3	1	0.2835	0.4444	1.5556
4	0.65	0.2699	0.121	1.179
5	0.6818	0.2617	0.1689	1.1947
6	0.6957	0.2903	0.1267	1.2646
7	0.65	0.2699	0.121	1.179
8	0.65	0.2699	0.121	1.179
9	0.5882	0.2374	0.123	1.0535
10	0.8108	0.2918	0.2389	1.3828
11	1	0.3091	0.3942	1.6058
12	0.8	0.2799	0.2513	1.3487

Graph 8

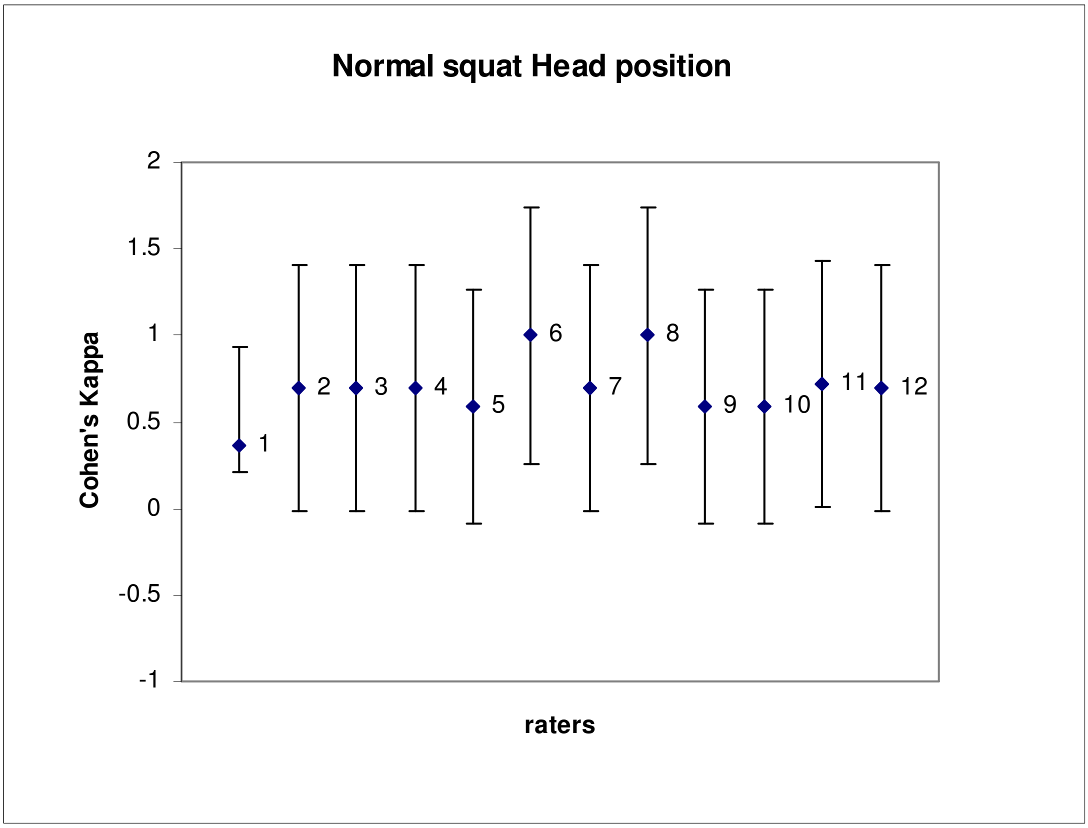


Table 9

Variant Left Tibial Alignment

Raters	Kappa	SE	Boundaries lower	Upper
1	0.5333	0.276	0.0077	1.0743
2	1	0.378	0.2592	1.7408
3	0.5333	0.276	-0.0077	1.0743
4	0.65	0.2699	0.121	1.179
5	0.2759	0.2212	-0.1577	0.7094
6	-0.2069	0.2212	-0.6404	0.2266
7	0.3	0.378	-0.4408	1.0408
8	0.5882	0.3444	-0.0869	1.2633
9	0.5882	0.2515	0.0952	1.0813
10	-0.129	0.2926	-0.7026	0.4445
11	0.5625	0.2835	0.0069	1.1181
12	0.8108	0.2918	0.2389	1.3828

Graph 9

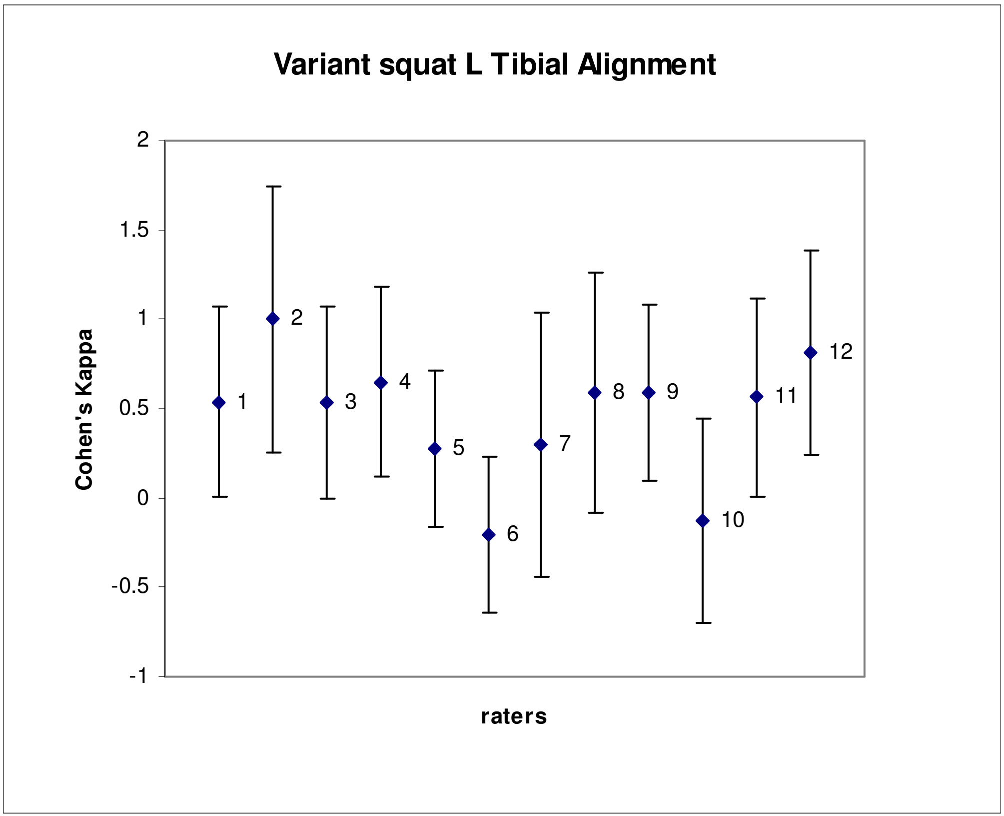


Table 10

Variant Head position

Raters	Kappa	SE	Boundaries lower	Upper
1	0	0	0	0
2	0.6957	0.36	-0.01	1.4013
3	0	0	0	0
4	1	0.378	0.2592	1.7408
5	0.6957	0.36	-0.01	1.4013
6	1	0.378	0.2592	1.7408
7	0	0	0	0
8	0.5882	0.3444	-0.0869	1.2633
9	1	0.378	0.2592	1.7408
10	1	0.378	0.2592	1.7408
11	1	0.378	0.2592	1.7408
12	1	0.378	0.2592	1.7408

Graph 10

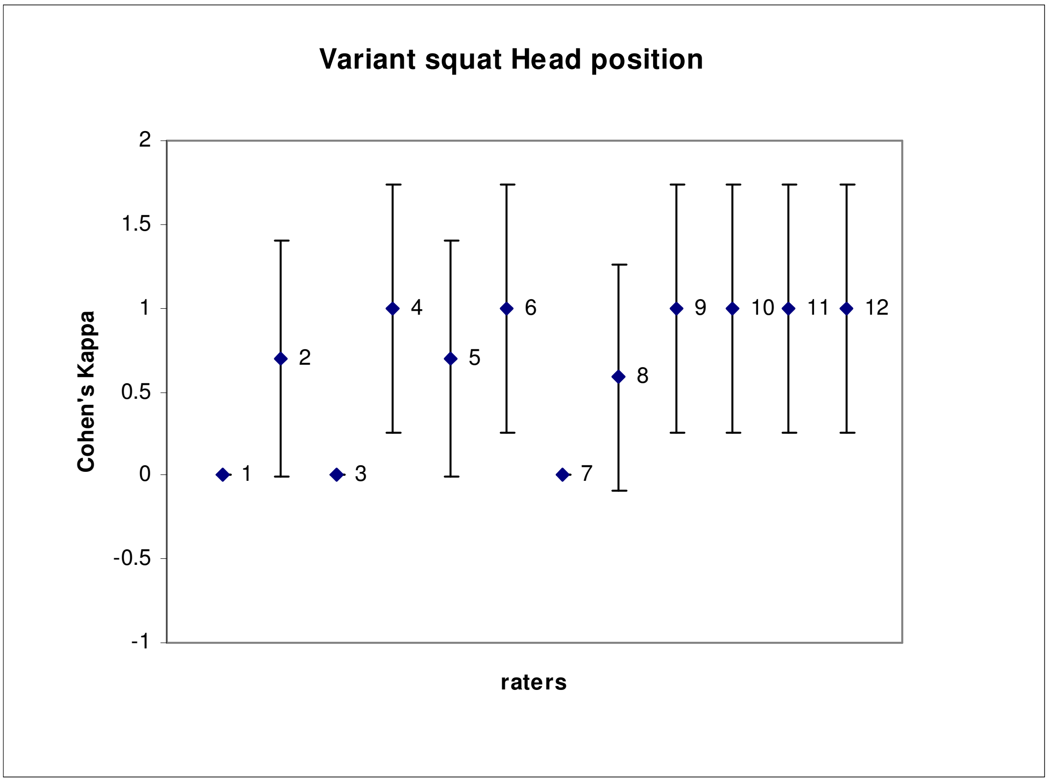


Table 11

Straight Leg Sit Raters	Kappa	SE	Boundaries lower	Upper
1	0.6957	0.36	0.01	1.4013
2	0.4615	0.2789	-0.085	1.0081
3	0.4324	0.2918	-0.1395	1.0044
4	0.3226	0.2926	-0.2509	0.8961
5	0.3636	0.2509	-0.1282	0.8555
6	1	0.3054	0.4014	1.5986
7	0.5882	0.3444	-0.0869	1.2633
8	0.6957	0.36	-0.01	1.4013
9	0.72	0.3628	0.0088	1.4312
10	0.4324	0.2238	-0.0062	0.8711
11	0.16	0.2342	-0.2991	0.6191
12	0.5532	0.2729	0.0182	1.0882

Graph 11

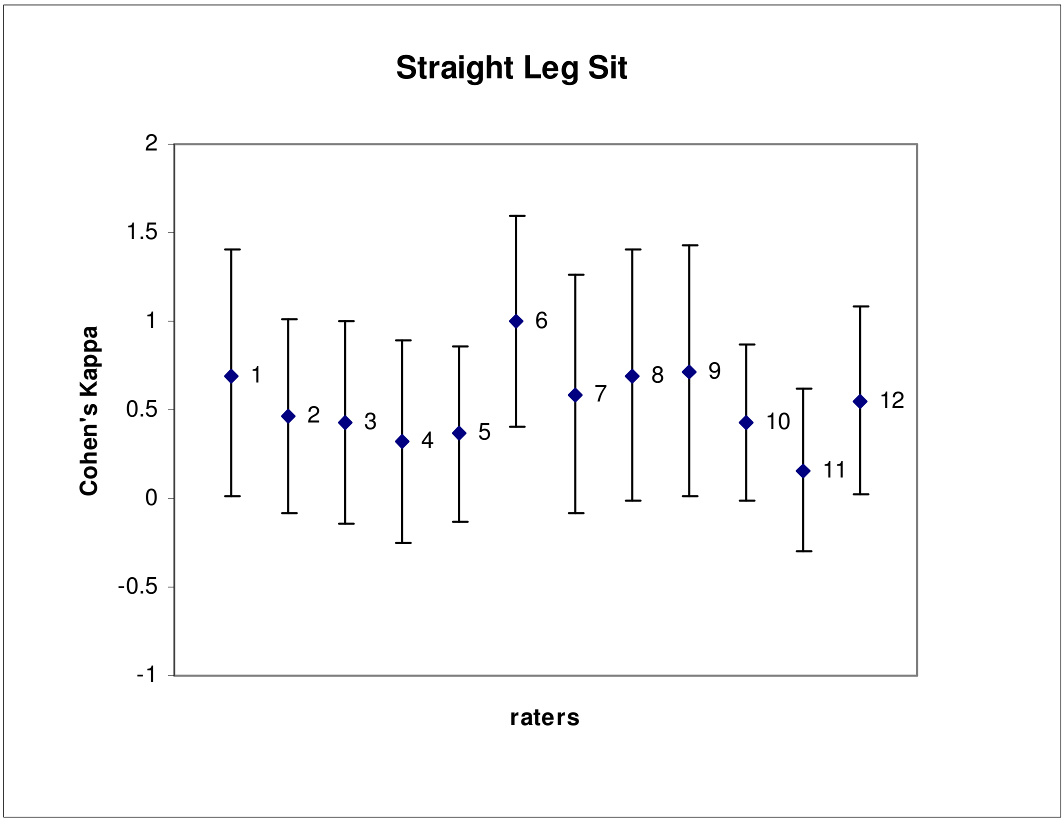


Table 12

Cross Leg Sit Right

Raters	Kappa	SE	Boundaries lower	Upper
1	-0.12	0.1512	-0.4163	0.1763
2	1	0.3054	0.4014	1.5986
3	1	0.2955	0.4209	1.5791
4	1	0.3341	0.3452	1.6548
5	1	0.2878	0.4358	1.5642
6	1	0.3054	0.4014	1.5986
7	0.8293	0.2856	0.2694	1.3891
8	0.8444	0.3097	0.2373	1.4515
9	0.8511	0.3102	0.2431	1.4591
10	0.8293	0.2856	0.2694	1.3891
11	0.6667	0.2857	0.1067	1.2267
12	0.6957	0.2903	0.1267	1.2646

Graph 12

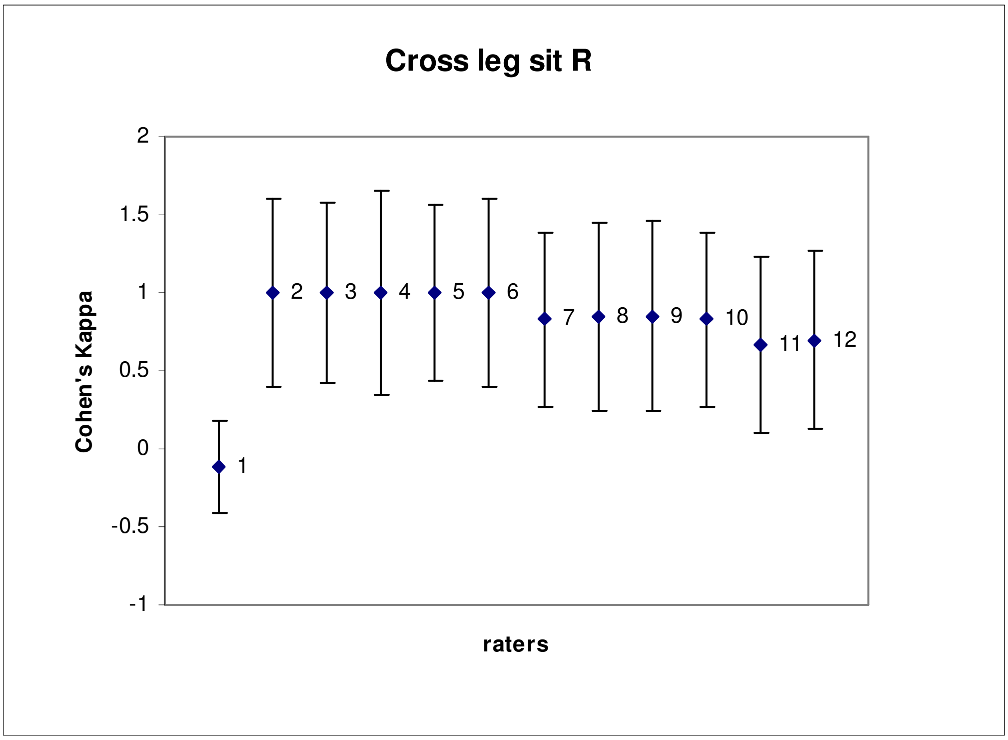


Table 13

Cross Leg Sit Left

Raters	Kappa	SE	Boundaries lower	Upper
1	-0.12	0.1512	-0.4163	0.1763
2	0.8511	0.3102	0.2431	1.4591
3	1	0.3054	0.4014	1.5986
4	0.8511	0.3102	0.2431	1.4591
5	0.6667	0.252	0.1728	1.1605
6	1	0.3054	0.4014	1.5986
7	0.6957	0.2903	0.1267	1.2646
8	0.8444	0.3097	0.2373	1.4515
9	0.8293	0.2856	0.2694	1.3891
10	1	0.2955	0.4209	1.5791
11	1	0.3054	0.4014	1.5986
12	0.8108	0.271	0.2796	1.3421

Graph 13

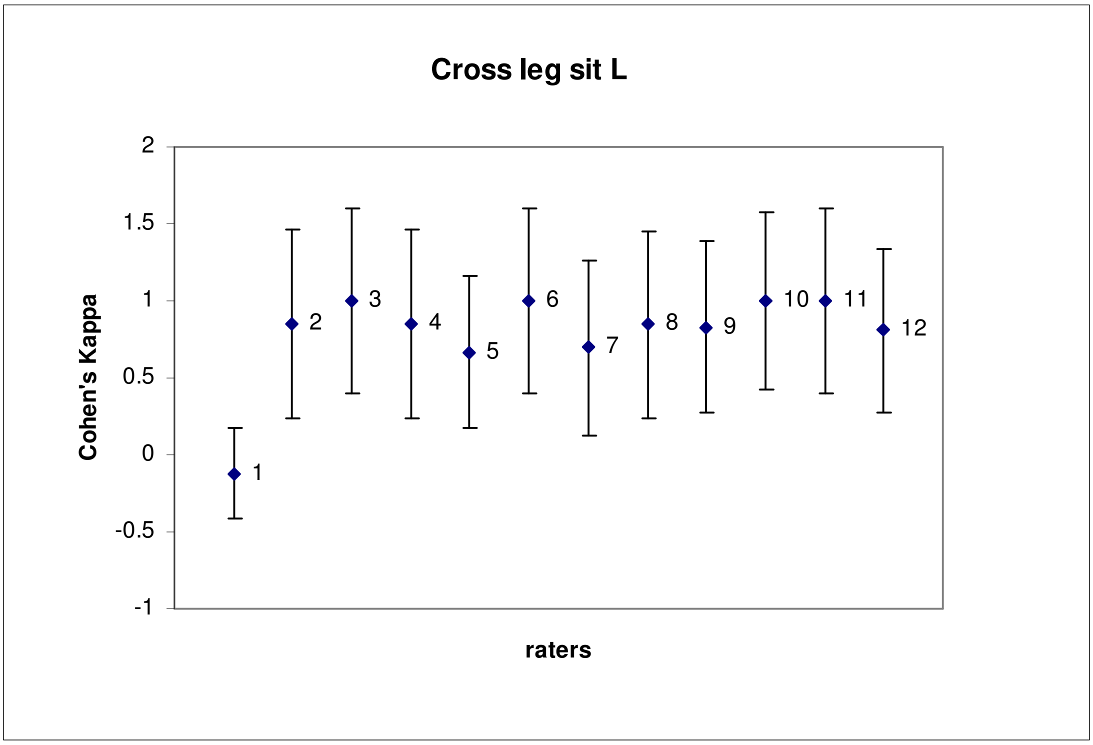


Table 14

Low Knee

Raters	Kappa	SE	Boundaries lower	Upper
1	0.4615	0.3185	-0.1627	1.0858
2	0	0	0	0
3	0.087	0.36	-0.6187	0.7926
4	1	0.378	0.2592	1.7408
5	0.3636	0.2916	-0.2078	0.9351
6	0.6316	0.2387	0.1637	1.0995
7	0	0	0	0
8	1	0.378	0.2592	1.7408
9	0.4167	0.244	-0.0615	0.8949
10	0.5882	0.3444	-0.0869	1.2633
11	0.4167	0.244	-0.0615	0.8949
12	1	0.378	0.2592	1.7408

Graph 14

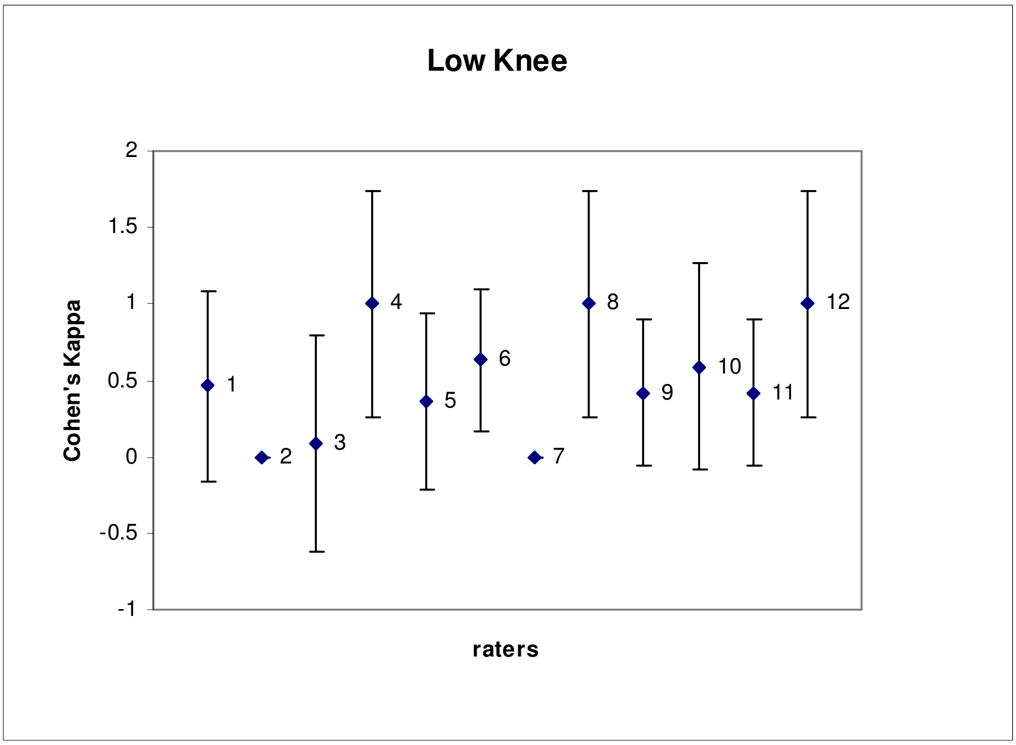


Table 15

Buttok Heel Contact

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.378	0.2592	1.7408
2	1	0.378	0.2592	1.7408
3	1	0.378	0.2592	1.7408
4	1	0.378	0.2592	1.7408
5	1	0.378	0.2592	1.7408
6	0.4167	0.244	-0.0615	0.8949
7	0	0	0	0
8	1	0.378	0.2592	1.7408
9	1	0.378	0.2592	1.7408
10	1	0.378	0.2592	1.7408
11	1	0.378	0.2592	1.7408
12	1	0.378	0.2592	1.7408

Graph 15

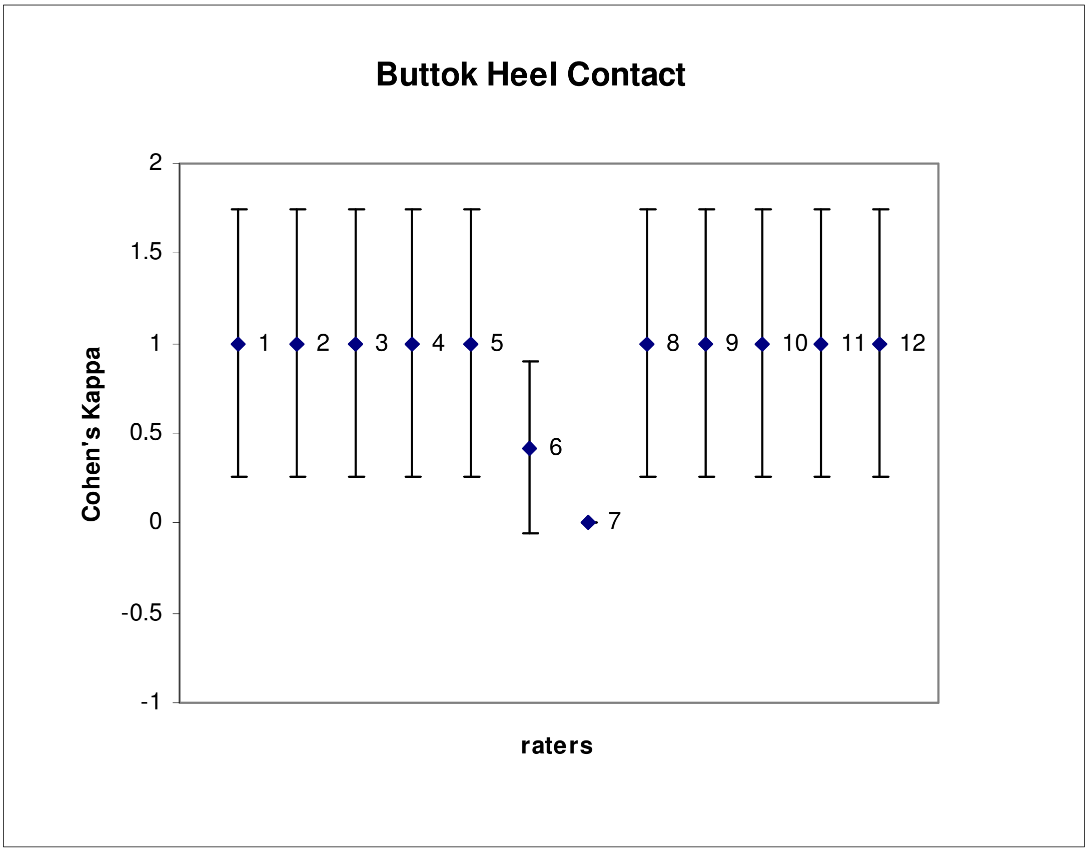


Table 16

Anckle Dorsiflexion

Raters	Kappa	SE	Boundaries lower	Upper
1	1	0.2955	0.4209	1.5791
2	0.6316	0.2713	0.0998	1.1633
3	0.8293	0.2856	0.2694	1.3891
4	0.6667	0.2857	0.1067	1.2267
5	0.8444	0.3097	0.2373	1.4515
6	0	0	0	0
7	0.1026	0.2326	-0.3533	0.5584
8	0.8293	0.2856	0.2694	1.3891
9	0.5333	0.276	-0.0077	1.0743
10	0.8372	0.2878	0.2731	1.4013
11	1	0.3054	0.4014	1.5986
12	0.5116	0.2723	-0.0222	1.0454

Graph 16

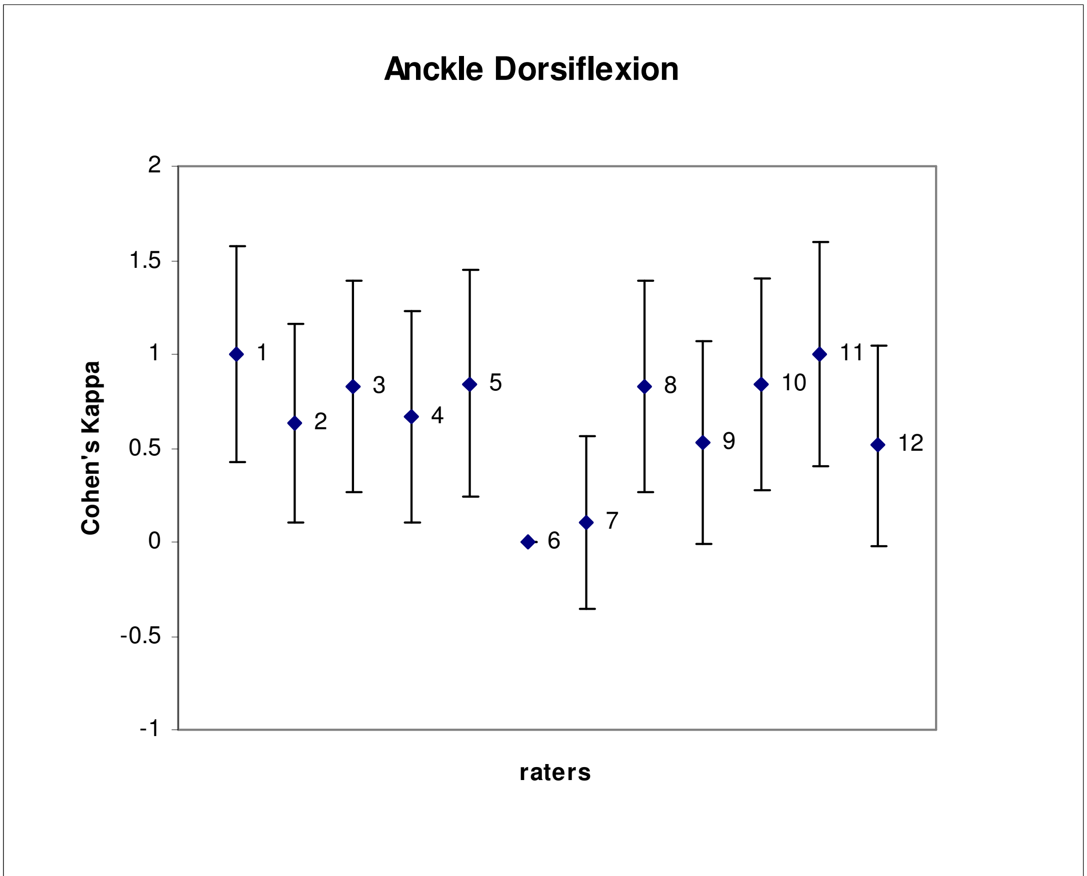
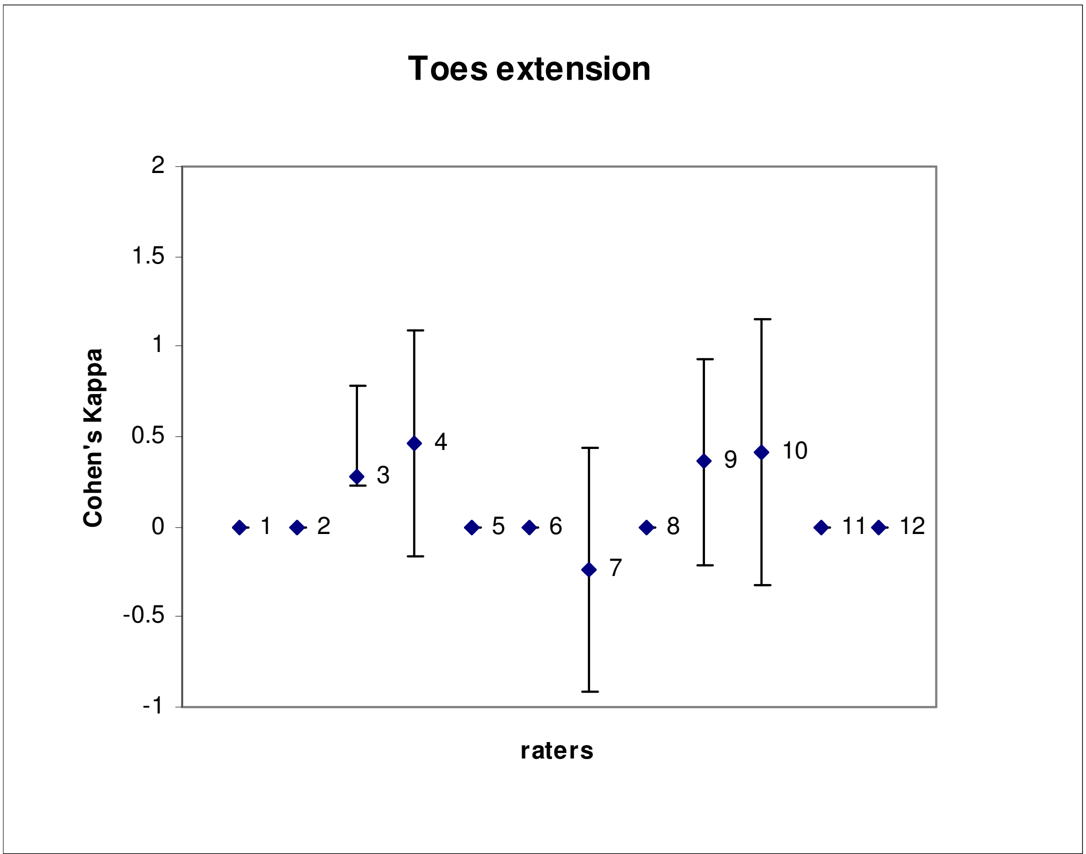


Table 17

Toes extension

Raters	Kappa	SE	Boundaries lower	Upper
1	0	0	0	0
2	0	0	0	0
3	0.2759	0.2607	0.235	0.7868
4	0.4615	0.3185	-0.1627	1.0858
5	0	0	0	0
6	0	0	0	0
7	-0.2353	0.3444	-0.9104	0.4398
8	0	0	0	0
9	0.3636	0.2916	-0.2078	0.9351
10	0.4167	0.378	-0.3241	1.1575
11	0	0	0	0
12	0	0	0	0

Graph 17



Appendix H: Manual Therapy guide for authors

Manual Therapy

Guide for Authors

http://www.elsevier.com/wps/find/journaldescription.cws_home/623058/authorinstructions

The journal editors, Ann Moore and Gwen Jull, welcome the submission of papers for publication.

Submission to this journal proceeds totally online at http://ees.elsevier.com/ymath. Use the following guidelines to prepare your article.
You will be guided stepwise through the creation and uploading of the various files. The system automatically converts source files to a single Adobe Acrobat PDF version of the article, which is used in the peer-review process. Please note that even though manuscript source files are converted to PDF at submission for the review process, these source files are needed for further processing after acceptance. All correspondence, including notification of the Editor's decision and requests for revision, takes place by e-mail and via the Author's homepage, removing the need for a hard-copy paper trail.

The above represents a very brief outline of this form of submission. It can be advantageous to print this "Guide for Authors" section from the site for reference in the subsequent stages of article preparation.

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere, that its publication is approved by all Authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, without the written consent of the Publisher. Reliability Studies will only be accepted if they are innovative and add to the current body of knowledge within manual therapy.

Word Count
Manuscripts should not exceed the following word counts:
Original Research Articles using quantitative data - 3500 words
Original Research Articles using qualitative data - 4000 words
Reviews - 3500 words, but Systematic Reviews may be longer, up to 4000 words
Technical and measurement notes - 2000 words
Case reports and professional issues - 2000 words
Masterclass - 3500 words
Letters to the Editors - 500 words

These word counts include Abstract, Keywords, Acknowledgements and the references contained within the article. The reference list at the end of the article, figures/tables, title and author information and Appendices are not included in the word count.

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