Development and preliminary testing of a practical tool for visual assessment of seated posture

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Declaration

Name of candidate: Georgina Kydd

This thesis entitled “Development and preliminary testing of a practical tool for visual assessment of seated posture” is submitted in partial fulfilment for the requirements for the Unitec degree of Master of Osteopathy

CANDIDATE’S DECLARATION

I confirm that:

• This thesis represents my own work;
• 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: 2016-1008

Candidate Signature: ………………………………………………..Date: …………………

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List of Abbreviations

SPRT  Sitting Posture Rating Tool
FHP   Forward head posture
LBP   Low back pain
MSK   Musculoskeletal
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Introduction to thesis

Exposure to sitting during work and leisure is common in today’s society and has been linked to metabolic diseases such as type 2 diabetes, cardiovascular disease and premature mortality (Allman-Farinelli, Chey, Merom, & Bauman, 2010; Dunstan, Howard, Healy, & Owen, 2012; Gilson, Burton, Uffelen, & Brown, 2011; Pronk, Katz, Lowry, & Payfer, 2012). In addition to metabolic issues, there are musculoskeletal (MSK) consequences resulting from poor posture. This includes discomfort, commonly discussed as affecting the neck, shoulders and low back (Hartvigsen, Leboeuf-Yde, Lings, & Corder, 2000; Page, 2005; Szeto, Straker, & Raine, 2002). As exposure to sitting is increasing, more so than to standing, it is becoming more relevant to assess for manual therapists (Gilson et al., 2011; Hakala, Rimpelä, Saarni, & Salminen, 2006). Physical examination is used by manual therapists to assess requirements for intervention as well as to assess the result or effectiveness of intervention (Lederman, 2011). Currently within the literature there are studies investigating aspects of sitting posture, however, none use both a field-setting and field-based methods such as those used in clinical scenarios to find a rating tool with high ecological validity. Ecological validity is the part of external validity of which the experimental study investigates the postural assessment tool in conditions similar or of exact likeness to a similar setting which the sitting posture assessment tool will be used (Schmuckler, 2001). This implies that the studied tool uses the same type of equipment and the same setting as it would be used outside of the study. The results yielded should then be as close as to what they would be outside of the study. This type of validity is important to explore with clinical tools, to investigate how well the tool will work in the setting it will ultimately be used in. Due to the absence of investigations for sitting posture using field-expedient methods, this study aims to complete the development of a Sitting Posture Rating Tool (SPRT) and to do preliminary testing of the reliability of scores using the SPRT by raters.

This thesis is arranged into three sections. Section 1 is a literature review discussing sitting posture, the relevance in society and its relation to MSK discomfort. It also investigates other studies that have investigated sitting posture using both laboratory-type methods and field-based methods. These two methods are differentiated by either using specialised equipment or not using specialised equipment, respectively. This review will identify some components of posture that are commonly assessed in sitting posture and it will investigate the applicability of these postures in the development of the SPRT. Section 2 consists of a manuscript, styled according to the guidelines for Musculoskeletal Science and Practice: an
international journal of musculoskeletal physiotherapy [Appendix A]. The Manuscript reports a study of the SPRT outlining the process and results of the preliminary reliability testing of raters using the SPRT on subjects’ video. See Appendix D for the development of the SPRT. Section 3 comprises the appendices which contain materials supplementary to the thesis, including ethics documentation.
SECTION 1: Literature Review
1.1 Introduction

Exposure to sitting is increasing in today’s society particularly in countries with developed economies (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). This increase is noted particularly in office workers, schoolchildren, and adolescents and has been associated with the increase of personal computing (Kang et al., 2012; Mörl & Bradl, 2013). Sitting time is also increasing during leisure time and is linked to negative health outcomes including diabetes, poor cardiovascular health and MSK issues (Dunstan et al., 2012; Hakala et al., 2006; Hamilton et al., 2008; Patel et al., 2010). Poor sitting posture is also an aggravator of already present MSK pain (Ariëns et al., 2001; Vergara & Page, 2002). “Posture is a term that indicates the relative position of the body segments during rest or activity” (Twomey & Taylor, 1987). Poor posture, on the other hand, represents posture out of the neutral zone involving slouching or twisting such as slumped sitting or forward head posture (FHP), (Lis, Black, Korn, & Nordin, 2007; Yip, Chiu, & Poon, 2008).

The topic of time spent sitting and sitting posture is of interest because of the association between sitting and MSK conditions (Ciccarelli, Portsmouth, Harris, & Jacobs, 2012). This is represented through emerging studies investigating the benefits of standing desks and breaking up sitting time to have positive influences on upper back discomfort and fatigue levels (O’Sullivan, O’Sullivan, O’Sullivan, & Dankaerts, 2012; Straker, O’Sullivan, Smith, & Perry, 2009; Thorp, Kingwell, Owen, & Dunstan, 2014). Sitting has been linked to back and neck pain as well as shoulder issues through research investigating sitting, sitting time and self-rated pain questionnaires (Harris & Straker, 2000; Richards, Beales, Smith, O’Sullivan, & Straker, 2016). By using the observational methods of assessing sitting posture and comparing self-rated pain questionnaires, it has been distinguished that sitting for prolonged periods of time can result in MSK discomfort, particularly neck and back pain as well as sitting in awkward postures (Søndergaard, Olesen, Søndergaard, de Zee, & Madeleine, 2010).

Studies investigating the reliability of sitting posture assessment have mostly been performed in biomechanics laboratories with specialised equipment that would not be present in typical clinical settings. These studies also do not represent a time-frame suitable for clinical use as the setup of equipment using multiple cameras, computer software and analysis of the found data without intervention would take time, longer than a typical MSK therapists’ appointment (McEvoy & Grimmer, 2005; Straker et al., 2009; Straker & Mekhora, 2000; van Niekerk, Louw, Vaughan, Grimmer-Somers, & Schreve, 2008). Research performed in biomechanics
laboratories have high internal validity, however, it is unclear how much generalisability there is to clinical practice. This means if a rating tool is used in a laboratory, the results will reflect how that tool works in that laboratory, not how it will then work in clinical practice under less controlled conditions. The lack of research investigating a SPRT using non-specialised equipment suggests that there is no evidence proving that these laboratory-based studies translate into the clinical scenario in which these tools are ultimately designed to be used for. This literature review will investigate the link between sitting, sitting posture and MSK pain. It aims to explore current and previous research on sitting posture, and the tools currently used to assess posture. The review will also investigate which measures are useful in the assessment of posture by identifying which are used multiple times through different studies to assess different postural angles.

1.12 Epidemiology of time spent sitting

Exposure to time spent sitting is increasing during work and leisure time, particularly in Western and well-developed countries (Mörl & Bradl, 2013). The time spent sitting at work is not only increasing, but the postures that are adopted tend to be poor (Fenety & Walker, 2002; Hartvigsen et al., 2000). Studies by Kozev-Keadle, Libertine, Lyden, Staudenmayer and Freedson (2011), and Ryde, Brown, Peeters, Gilson and Brown (2013), particularly focus on the office-based setting and have resulted in reliable and valid methods of establishing the quantity of time spent sitting. These methods include using either camera set-ups monitoring office workers and their sitting habits, or using the sitting pad (Ryde et al., 2013), and wearable monitors called activPAL and ACTi Graph (Kozev-Keadle et al., 2011). Ryde et al. (2013) found that those who spent more time sitting were 9.0 times more likely to have a high BMI (95% CI; 1.9 to 41.9) and 2.8 times more likely to have a larger waist circumference (CI; 95%; 1.5 to 6.3). Obesity itself is not suggestive of poor sitting postures however, Gillear and Smith (2006) found significant reduced range of motion through the thoracic and thoracolumbar junction associated with more obese individuals. As a result of somatic dysfunction MSK discomfort can manifest (Gillear & Smith, 2007).

Mork and Westgaard (2009) also investigated the association between time spent sitting at work and LBP intensity in female computer workers and they were found to be positively linked. Sitting posture and time spent sitting, therefore, have potential implications for health, MSK pain, and pathology (Ariëns et al., 2001). As previously highlighted, there are a number of studies discussing the relationship with time exposure to sitting and the relationship to dysfunction, however, this review investigates the literature of sitting posture
at a workstation, posture and its relation to MSK pain, epidemiology of sitting and MSK pain, and current approaches to assessing sitting posture. In 2007, more than 75% of employees in industrial countries had jobs that required working in a sitting position (Lis et al., 2007). Sitting time is often related to the time spent computing either at a desktop or laptop (Shan et al., 2013). Discussed in the literature is the fact that posture and workstation design are risk factors in developing MSK disorders associated with computer use (Epstein, Colford, Epstein, Loye, & Walsh, 2012). Time spent at a work station with a desktop or laptop is not restricted to the adult population but also children and adolescents at school (Harris & Straker, 2000; Mörl & Bradl, 2013). Sitting in poor posture can be regarded as a causative and aggravating factor of MSK pain and therefore of interest to manual therapists (Zemp, Taylor, & Lorenzetti, 2013). MSK discomfort and pain resulting from these prolonged sitting postures are causing burden to individuals and ultimately businesses. Therefore, interventions targeting sitting posture to correct more provocative postures and reduce the likelihood of developing MSK pain are needed (Shan et al., 2013). To determine the correct interventions, further investigations of sitting assessments are first required for manual therapists (Deyo et al., 1992; May, Littlewood, & Bishop, 2006).

1.2 Sitting and musculoskeletal pain
Prolonged sitting can lead to increased biomechanical strain due to the static muscular contraction which leads to hypertonic musculature and muscle fatigue (Ariëns et al., 2001; Villanueva, Sotoyama, Jonai, Takeuchi, & Saito, 1996). Sitting also causes increases in mechanical loading through the intervertebral discs in some postures such as slumped sitting which can then result in perceived discomfort (Juul-Kristensen & Jensen, 2005; Kayis & Hoang, 1999). The non-contractile tissues also can be injured via sustained compression and consequently permanent stretch in the tissues especially with a flexed lumbar spine posture while seated (Evcik & Yücel, 2003; Szeto et al., 2002). Sitting also changes motor control eventuating in muscular weakness, in turn this can lead to non-specific low back pain (LBP) and other MSK discomfort (Dankaerts, O’Sullivan, Burnett, & Straker, 2006).

Musculoskeletal pain is one of the most widespread chronic impairments in developed countries and the second most common cause of disability (Storheim & Zwart, 2014). In 2001, MSK pain also resulted in the most expense of chronic impairments through healthcare and time off work in the United States (Woolf & Åkesson, 2001). The aetiology of MSK
pain is a complicated topic as it is multi-causal in nature. Two key factors involved in the aetiology of MSK pain include the duration of sitting as well as the type of posture (Ariëns et al., 2001). It is methodologically difficult to provide evidence and distinguish cause and effect of pain and posture (Lis et al., 2007; Szeto et al., 2002). However, there is common agreement regarding the association between sitting, sitting posture and previous complaints of MSK pain as a causative factor and also an aggravating factor to pre-existing pain (Brink et al., 2013; Corlett, 2006; Makhsous et al., 2009; May, Nanche, & Pingle, 2011; Peeters, Burton, & Brown, 2013; Ryde et al., 2013).

The increase in LBP and neck pain among adults, adolescents and children, associated with sitting and sitting posture incurs a large burden on the individual and society due to the physical, emotional, and financial impact (Ariëns et al., 2001; Epstein et al., 2012; Lis et al., 2007; Makhsous et al., 2009; Shan et al., 2013). Low back pain is a common MSK disorder, which alone is a very costly and complicated issue (Khaltaev et al., 2003; Manchikanti, Singh, Datta, Cohen, & Hirsch, 2009).

1.21 Sitting and neck pain

Forward head posture has been reported to be observed amongst office workers. This is a common poor posture which combines lower cervical flexion and upper cervical extension. FHP is established to be associated with MSK problems such as neck pain (Nejati, Lotfian, Moezy, & Nejati, 2015), protracted and elevated scapulae grouped to be labelled ‘upper crossed’ syndrome (Muscolino, 2015), temporomandibular dysfunction (Lee, Okeson, & Lindroth, 1995; Solow & Sandham, 2002), and headaches (Fernández-de-las-Peñas, Cuadrado, & Pareja, 2007). FHP is thought to be a potential risk factor in work-related neck and upper-limb disorders (Szeto et al., 2002). Assessment is performed clinically by combining the measure of craniovertebral angle and the gaze angle (Youssef, 2016). Postural attributions such as overly lordosed or overly kyphotic spinal curves, FHP and forward or rounded shoulder posture, are linked to decreased subacromial space which can lead to subacromial impingement and work-related shoulder and neck pain (Hakala et al., 2006; Hibberd et al., 2016; Lis et al., 2007; Mork & Westgaard, 2009; Page, 2005; Szeto et al., 2002).

There are several angles to address when looking at neck posture while sitting. The neck on body angle is defined as the angle formed between a line projected from the greater trochanter to the C7 spinous process and a line between C7 spinous process and the tragus of
the ear (Brink et al., 2013). The gaze angle is the angle formed between lines from the
canthus of the eye to the tragus of the ear to a horizontal line through the tragus of the ear
(Bonney & Corlett, 2002; McEvoy & Grimmer, 2005; Straker et al., 2009; Straker &
Mekhora, 2000; Szeto et al., 2002). Neck posture at a workstation has been positively linked
to neck pain in workers who sat for 70-95% of their work day (Ariëns et al., 2001). The
authors in this study collected data via a survey where participants were requested to
document the occurrence of their pain at three different time points across the month. This
data was then compared to their individual craniovertebral angles while sitting. An
association of pain was found with a smaller craniovertebral angle (Ariëns et al., 2001).
Assessment of the craniovertebral angle has more recently been investigated by Yip, Chiu
and Poon (2008) whereby they found that participants who reported neck pain and disability
had a five-degree smaller craniovertebral angle (a more severe FHP) than participants who
did not self-report any disability or neck pain.

In a study by Szeto, Straker and Raine (2002), an association was found between MSK pain
and posture by observation of office workers who were symptomatic in the neck or who were
experiencing headaches. These participants were found to habitually sit with a FHP by
observation through camera and two-dimensional computer analysis, while sitting at a
workstation (Szeto et al., 2002). A study by Kang, Park, Lee, Kim, Yoon, Jung et al. (2012)
separated a group of participants into two groups - one group who spent over 6 hours at a
computer workstation and another group who sat at a computer for less than an hour each day
and had been doing so for the last ten years. A key finding was the increase of FHP in the
first group compared to the second (Kang et al., 2012). Other findings from Kang et al.
(2012) included decreased mobility and postural control when compared to participants who
only used a computer one hour or less per day consistently over the period of 10 years (Kang
et al., 2012). This shows the negative impact that sitting at a workstation for prolonged hours
can have and could potentially link to the development of MSK pain. These results were
determined using observational methods to determine the neck angles of both sets of
participants and compared centre of gravity of each subject using the SMART Balance
Master® system. This set-up used a computer, screen and platforms finding the force applied
between the participants’ feet to determine balance. Despite the supposed benefits of using
laboratory-based equipment, unfortunately, Kang et al. (2012) fails to acknowledge who was
determining the angles and how controlled rating was within this study. For this reason, it is
difficult to determine who in practice is able to assess postural angles and whether rigorous training is required.

1.22 Sitting and low back pain

Low back pain has been established to be one of the highest costing issues amongst the working population in developed countries (Lis et al., 2007; Manchikanti et al., 2009) and amongst the most common reasons to seek consultation with general practitioners (Hakala et al., 2010; Ritzwoller et al., 2006). It is difficult to determine how much exactly it financially burdens society as the direct and indirect costs are not always recorded, however it was estimated to be well above $12.2 billion in the United States from 1997 till 2007 (Dagenais, Caro, & Haldeman, 2008). Low back pain is also the largest cause of non-pathological disability in over 50-year-olds (Makhsous et al., 2009). Furthermore, a history of LBP is a strong predictor of LBP reoccurring (Murphy, Buckle, & Stubbs, 2004). Sitting alone is not a significant risk factor in developing LBP, however, the combination of poor sitting posture and time spent sitting become significant risk factors in the development of MSK pain (Ariëns et al., 2001; Lis et al., 2007; O’Sullivan et al., 2010). It has been suggested that LBP, as a MSK issue, is linked to being a work-related disorder (Hartvigsen et al., 2000; Gupta, Christiansen, Hallman, Korshøj, Carneiro, & Holtermann., 2015). Interestingly, LBP is found in both manual workers and sedentary workers suggesting that sitting alone is not the only determinant of LBP in the workplace (Smith-Young, Solberg, & Gaudine, 2014). It could be assumed that LBP is therefore both caused and aggravated by repetitive issues, whether they are standing or sitting, static or under heavy loads. For this reason, it would be reasonable to assume that sitting related LBP issues are less understood by current authors than is realised. Due to the findings of LBP affecting sedentary workers, this may potentially relate to the workstation design, as a large risk factor in developing MSK disorders associated with computer use (Epstein et al., 2012). Neck and LBP are some of the most discussed issues regarding the link between MSK pain and sitting posture. Discussions are not only concerning adults either, sitting postures of children, and adolescents are also of growing concern (Hakala et al., 2010; O’Sullivan et al., 2012; Shan et al., 2013).

1.23 Sitting posture at a work station

It is likely that the lack of attention to the ergonomics of, and education around, optimal posture while at a computer workstation could result in large financial burden on individuals and businesses through the loss of production as well as cost of treatment for those affected by MSK pain and discomfort (Stewart, Ricci, Chee, Morganstein, & Lipton, 2003). While
both office workers and manual labourers can be affected, it appears to be those who sit at a
desk for long periods of time who have a higher prevalence of LBP compared to those who
are regularly on the move and performing medium to heavy lifting (Mörl & Bradl, 2013). A
positive correlation has been established by Mork and Westgaard, (2009) and Straker et al.
(2009), in that time spent sitting at work is related to LBP and neck and shoulder pain. Office
workers are found to sit on average 6 to 8 hours per working day (Neuhaus, Healy, Dunstan,
Owen, & Eakin, 2014). As this is mostly unavoidable, it is important to, at least, enable
workers to use the correct seated posture as to minimise the development of MSK pain
(Neuhaus et al., 2014). Mork and Westgaard (2009), investigated female computer workers’
back posture and found that the most common sitting posture of this group was a slight
posterior pelvic rotation and slight flexed lumbar spine. This posture was associated with an
exacerbation of LBP throughout the day with an immediate decrease in pain after the first
hour away from work (Mork & Westgaard, 2009). This helps to represent the link between
sitting at work and the development of MSK pain.

As previously mentioned, MSK issues relating to computer use are not limited to adults but
are also prevalent in adolescents and children (Harris & Straker, 2000; Murphy et al., 2004;
Sellschop, 2010). Children’s sitting posture is of particular interest, as there has been a rise
in MSK pain in young people that correlates with increasing time sitting spent by children not
just in leisure time but also at school at workstations (Hakala et al., 2010; Paraizo & De
investigated schoolchildren’s workstations and found that most dimensions of school
furniture did not accurately match the children’s body size. The chair depth matched none of
the children, and 95% of chairs were too high. Only 11.7% of children were suited to the new
tables in comparison to the 3.3% of the older tables at the school. These findings indicate
that equipment designed for children’s use is not necessarily well-suited to children’s
anthropometry. This would make it difficult for most children using these workstations to
assume a healthy habitual posture (Panagiotopoulou et al., 2004). Without proper assessment
of these conditions it is difficult to determine how to correct the postural issues to prevent
development of MSK pain in this age group.

In a study by Epstein et al. (2012), they observed whether feedback (singular or continuous)
influenced correct sitting posture in two separate groups. The first group consisted of school-
aged children between 10 and 15 years of age and the second group consisted of adult
employees at a telecommunications company. Specific verbal instructions were given to all
subjects on correct sitting posture at the beginning of the intervention. After 16 minutes it was found that almost 80% of the employees were sitting with poor posture despite having received initial education and intervention. However, when given continuous feedback i.e. verbal cues and prompting, posture improved. After education and verbal cueing on sitting posture in the school-aged group, the students improved their posture as well, however, this was also only on average, for 16 minutes before their posture returned to similar of that observed before cueing and intervention. Based on the results of this study, it may be appropriate to provide continuous feedback in order to ensure correct posture is maintained for longer than 16 minutes in both school-aged children and adults. Sitting for extended periods of time at school and in some careers’, may be largely unavoidable, therefore interventions aimed at workplace ergonomics and influencing the quality of sitting posture are potential areas for therapeutic targets for MSK therapists. However, as found by Epstein et al. (2012), before habits are formed, persistent prompting will be required for any intervention to have effect. Unfortunately, longitudinal studies observing sitting posture do not yet exist, therefore it is not yet known how long prompts would be required in the workplace in order for a healthy habitual sitting posture to be maintained, let alone how long before the prompts would be ignored. Research suggests that it takes approximately three months of regularly practising a habit before it becomes an engrained behaviour (Lally, Chipperfield, & Wardle, 2008) however future research would need to investigate this and how it relates to sitting posture in the workplace.

1.24 Sitting and musculoskeletal pain in young adults and children

Sedentary living is increasing, as is several associated health concerns, such as MSK pain. This is not only amongst adults but is also a growing concern among adolescents and children (Owen, Healy, Matthews, & Dunstan, 2010; Shan et al., 2013; Straker et al., 2009). Musculoskeletal pain applies to all age groups. As previously described, children are also being exposed to poorly-fitting workstations from a young age thereby potentially making them more susceptible to developing MSK pain in later life (Epstein et al., 2012; Panagiotopoulou et al., 2004). Neck pain and LBP have been rising in prevalence among adolescents since the 1990’s (Szeto et al., 2002). A national health survey in Australia found the prevalence of LBP in 15 to 24-year-olds to be 16% in 2001. Having MSK pain before adolescence is also a predisposing factor for developing chronic pain later in adult life (Manek & Macgregor, 2005). The exact reasons are unknown however it is possible that the pain experienced as a child may trigger physiological, psychological or behavioural responses
making them more sensitive to recurrent bouts later in life (Hall et al., 2011). A large amount of time, especially leisure time, is now being spent on personal computing by children (O’Sullivan, Smith, Beales, & Straker, 2011; Straker, Maslen, Burgess-Limerick, & Pollock, 2009). This age group and younger are choosing laptops over desktop computers which are associated with more neck and shoulder discomfort compared to desktop computer use (Harris & Straker, 2000; Shan et al., 2013). Computer and personal device use is increasing among all age groups, particularly younger age groups, for example in 2012 it was observed that 92% of Australian children between 5 and 14 years old used a computer. This data was obtained through standardised surveys in 14 schools (Ciccarelli et al., 2012). Of these children using computers, 40% stated they had discomfort specifically related to their computer use and reported finding it difficult to assume, what they considered, a safe posture while at a workstation (Tran & Ciccarelli, 2012). According to Harris and Straker (2000), children and adolescents are more frequently presenting to manual therapists with MSK pain, requiring treatment.

Straker, O’Sullivan, Smith, and Perry (2009), and Pronk et al. (2012), identified sitting with an increased lumbar lordosis is linked to neck and shoulder pain. Murphy, Buckle and Stubbs (2004) investigated MSK pain associated with the amount of time spent sitting and the type of posture assumed whilst sitting in children aged 11 to 14. They found that students sitting with 20 degrees of increased lordosis in the lumbar or cervical spine also reported higher pain levels on self-reported pain questionnaires compared to students sitting with a less extreme lordosis (Murphy et al., 2004). An increase in sedentary lifestyles among adolescents raise many health concerns around obesity. Obesity has been linked to increased flexion of the lumbar spine when compared to an individual with a normal BMI, as well as being a causative factor for neck and shoulder pain (Hakala et al., 2006; Marshall, Gorely, & Biddle, 2006; Shan et al., 2013; Straker, O’Sullivan, Smith, Perry, & Coleman, 2008). Adolescence is an important age group to address the factors associated with MSK pain as there is potentially a window of time to influence sitting posture (Kamper et al., 2016). Given chronic pain often comes along with negative associations such as psychological distress and mismanaged illness beliefs, which are known to affect improvement towards becoming pain free, intervention at this age also allows the opportunity to address MSK pain before it develops into a chronic issue affecting the individual’s future health. This is also a time in life when people are developing and being guided towards healthy habits so it
provides a time when sitting posture at a workstation can also be affected while in the classroom (Kamper et al., 2016).

1.3 Physical examination of sitting posture
Based on the evidence previously identified, it would appear that the assessment of posture is important and common for any clinicians addressing patients with MSK issues (Salahzadeh et al., 2014; Strender, Sjöblom, Sundell, Ludwig, & Taube, 1997; Zhang & Chawla, 2012). During a consultation with a manual therapist, treatment and examination need to be well structured and time efficient due to the limited duration of consultation time and to best meet the needs of a patient’s wellbeing. Manual therapists’ examination usually includes observation and assessment of standing, seated and other postures relevant to the case (Strender et al., 1997). It would be advisable for the patient and practitioner to use a time-efficient examination tool to predict the risk of injury or impairment as well as to guide treatment and intervention plans. Using a reliable rating tool can be used as a more objective measure of the patients’ progress with treatment interventions (Bushman, Canham-Chervak, Anderson, North, & Jones, 2016; Håland Haldorsen et al., 2002). Increased sitting time during work and during leisure time suggests that manual therapists may gain useful information from observation and evaluation of sitting posture to form a treatment plan that will have the most impact on the individuals presenting complaint. There is also discussion among literature regarding which sitting postures are less provocative and potentially cause less MSK pain (O’Sullivan et al., 2012). Studies such as those by O’Sullivan et al. (2012) indicate the benefit of being able to assess the quality of postures of the person presenting with MSK pain. It is also important to view how the person is sitting at a workstation and determine the value of changing their posture and whether this will in fact change their perceived pain or discomfort. The link between MSK pain and posture in adolescents indicates that influencing the sitting posture in this age group is a potential area for a preventative strategy to reduce MSK pain and future implications on the individuals MSK health.

1.4 Recommended sitting posture
The link between sitting posture and MSK pain is difficult to identify, as the development of MSK pain is complex and often manifests as a result of more than one issue (Punnett &
Similarly, although sitting predominates modern day living and the workplace, the literature does not define one optimal sitting posture. There is, however, a suggestion towards maintaining a neutral posture (meaning no joint resting at its end of range) with some engagement of musculature in the lumbar spine to maintain a more flattened curvature of the spine (Juul-Kristensen & Jensen, 2005). Straker, O'Sullivan, Smith and Perry (2009), suggest that slumped sitting is not an ideal posture, they found that maintaining a deep lumbar lordosis whilst sitting had a link to the presence of neck and shoulder pain. It is difficult to determine which sitting posture is best to reduce MSK pain however there are general acknowledgments from authors that there is limited understanding of optimal posture and that perfect sitting posture may not exist (Korakakis et al., 2016; Pownall, Moran, & Stewart, 2008). Posture and sitting posture is continuously shifting and changing and ideally the body is not positioned statically for long periods of time as static positioning affects structures in the body such as lumbar intervertebral discs (Cranz, 2000; Gerke, Brisme, Sizer, Dedrick, & James, 2011). Authors such as Pronk et al. (2012) have observed that during prolonged sitting there is an increase in the frequency of ‘in chair movements’ (Pronk et al., 2012). In chair movements are small movements that occur while maintaining the same posture but with slight changes around that postural equilibrium to relieve tension and discomfort through the body. These movements achieve dynamic sitting posture and are probably a result of discomfort but is also helpful in preventing discomfort by breaking up long periods of static sitting (Anne Fenety, Putnam, & Walker, 2000; Cascioli, Liu, Heusch, & McCarthy, 2016).

There is discussion within the literature on poor posture and how that appears. There are also some vague descriptions of what is considered neutral or close to optimal which are in the approximate mid-range of posture reducing strain in passive structures such as ligaments (Juul-Kristensen & Jensen, 2005; Keyserling, Brouwer, & Silverstein, 1992). Recently, several authors have discussed characteristics of posture that may reduce ligament strain and discomfort (Andersson, 1987; Castanharo, Duarte, & McGill, 2014; Claus, Hides, Moseley, & Hodges, 2009; Korakakis et al., 2016; Mork & Westgaard, 2009; O’Sullivan et al., 2010; Pope, Goh, & Magnusson, 2002; Williams, Hawley, McKenzie, & van Wijmen, 1991). These postures may appear as a slight thoracic kyphosis, lumbar lordosis and relative head retraction as discussed by authors such as Korakis et al. (2014) and O'Sullivan, et al. (2010). Preservation of the angle in the lumbar spine should remain similar to that when standing to reduce loads on the spine (Andersson, 1987; Castanharo et al., 2014; A. Claus et al., 2009;
Mork & Westgaard, 2009; Pope et al., 2002; Pynt, Higgs, & Mackey, 2001; Williams et al., 1991). Maintaining some lumbar lordosis muscle tone also minimises creep in passive structures such as discs and ligaments when the lumbar spine is in end of range of movement for prolonged periods (Pynt et al., 2001). A spine with flattened spinal curvatures is desirable as it ensures only a small amount of lumbar spine muscle activation (Mork & Westgaard, 2009; Pronk et al., 2012). It is also strongly recommended that a person adjusts their sitting posture periodically to maintain pelvic and lumbar flexibility (Tanoue et al., 2016) and to decrease any discomfort experienced (Fenety & Walker, 2002).

Straker et al. (2009) suggested that when considering the whole body, a slightly reduced curvature in the spine, whilst sitting, may be less provocative in causing pain than maintaining a deep lordosis whilst sitting. This view is supported by Caneiro, O'Sullivan, Burnett, Barach, O'Neil, Tveit and Olafsdottir (2010) as the flattened/ slight natural curves of the spine also result in the most efficient head posture. For the head, this would mean the line of gravity passes through the external auditory meatus, posterior to the coronal suture, and through the odontoid process (Brink et al., 2013). This posture is the most efficient as there is the least amount of energy required to counterbalance gravity (Grimmer, 1996; Kendall & Boynton, 1952). Neck posture is also influenced by the lower body while sitting. ‘Lumbopelvic sitting’ is described as an anterior rotation of the pelvis in order to achieve a neutral lordosis of the lumbar spine and results in the least activation of the neck and thoracic muscles and the most efficient head posture (Caneiro et al., 2010). The apparent link between the lower body and upper body in posture while sitting means that the whole body needs to be considered when identifying sitting postural problems.

1.5 Approaches in observational assessment of sitting posture measures
The current investigation into sitting posture assessment can be separated into two categories: (1) field-based measures and methods and (2) laboratory-based measures and methods. These can also be thought of as studies conducted with high internal validity (laboratory-based) and studies conducted with high external validity (field-based) (Godwin et al., 2003). There are several different methods and measures used throughout the literature to assess sitting posture including motion analysis, photographic analysis, radiographic (e.g. LODOX), electromyography (EMG), and observation without computer software analysis. Many studies consist of mixed field and laboratory methods depending on the aim of the study. The mixing can make it difficult to distinguish which methods were used in the study as there can
be a laboratory setting mimicking a field or a normal day-to-day setting and vice versa. Although laboratory methods generally attempt to mirror a field-based setting it remains that they are set in a laboratory with vast amounts of equipment and technology surrounding the participants. Manual therapists need a rating tool for sitting posture that is able to be performed within a one-hour appointment time-frame, that also allows them the time for patient history discussion and a treatment intervention to be put in place (Korthals-de Bos et al., 2003). Currently, there appear to be no studies purely investigating field-based measures. There also appears to be no established sitting posture tool for a person at a workstation.

1.51 Internal validity and external validity
It is important for MSK therapists to have highly reliable and valid sitting posture assessment tools so that they can be used in the clinical setting and be repeatable to obtain objective outcome measures for patients’ progress. Having both highly controlled laboratory testing and field-based testing is important in developing a sitting posture tool because with each type of study there is an external and internal validity trade-off (Godwin et al., 2003). For example, a study controlling for any external influence and which finds high reliability when conducted under ideal laboratory conditions, cannot then be taken from this artificial scenario and implemented in a real-world environment as the external influences will have a significant impact on the outcome. Therefore testing reliability in this artificial scenario means it is still not yet understood how much reliability there will be outside of this setting (Roe & Just, 2009). It is therefore not accurate to say that an assessment tool which has only been tested in a highly controlled setting can be reliably used in practice, as the validity of the tool under normal clinical conditions has not been established. To be deemed clinically applicable, assessment tools, ideally, should to be timely (able to be performed in a few minutes), inexpensive, and without the use of specialised equipment. An example from both van Niekerk et al. (2008) and Yip et al. (2008) use study designs with high internal validity which assess the reliability of sitting posture angles in a situation that is not translatable to examples outside of their study. For example, van Niekerk et al. (2008) used the gold standard LODOX method - a low dose radiograph, to compare sitting posture against the Photographic Posture Analysis Method (PPAM). While both the LODOX and the PPAM showed good reliability, neither methods are likely to be reproducible for manual therapists as many manual therapists do not have LODOX or a multiple camera set-on-hand in clinic. While these authors find high reliability within their studies there is no understanding as to how they would apply to MSK therapists as the studies have little external validity.
An investigation of sitting posture needs to be performed using similar conditions and equipment used routinely by MSK therapists. The lack of research using low tech equipment in a field-based setting to assess sitting posture leaves a gap in literature and a gap in knowledge for clinical practice. While studies using laboratory methods to investigate sitting posture are important in order to establish a rating tool without bias, it is also necessary for these assessment tools to be applicable in a clinical setting for MSK therapists to use. This means using field methods and conditions while investigating an assessment tool are important to determine how much external validity there will be.

1.52 Laboratory methods

Laboratory-based measures are usually in environments different from what the participant would normally find themselves in their daily lives. In these types of studies, participants are placed in laboratories with multiple cameras whereby anatomical markers and specialised computer software are used for motion analysis to determine postural angles during sitting. Using these highly technical methods is useful as they help to provide precise biomechanical measures and can indicate the internal validity of tools such as the sitting posture tool however, they are let down by their lack of practicality and poor accessibility.

There are several examples in the literature using laboratory-type methods to assess sitting posture including the study by Niekerk et al. (2008) who investigated the reliability and validity of using Photographic Posture Analysis Method (PPAM) against LODOX. PPAM is a method using photographs taken of a subject with reflective markers on relevant anatomical points of the body and analysed using computer software to calculate sitting posture angles. Niekerk et al. (2008) compared PPAM results against the reference standard of low dose radiographs. It was found that PPAM was as reliable and valid as radiographs, but was more clinically accessible. For this reason, it was suggested to be a valid and practical tool to use when in a field-setting for radiographers. Unfortunately, there was no mention of suitability of use for manual therapists. It is not feasible that manual therapists will have time in every appointment to take multiple photographs and upload to a new computer programme to compare postures, particularly without a simple and standardised rating tool to understand what changes are occurring throughout the course of intervention.

Similar methods were used by Brink et al. (2013) in a study to find the validity of a Three-dimensional Posture Analysis Tool (3D-PAT). Although the study differed in that it was completed in a laboratory using comparable workstations to the participants’ normal
schooling workstations. Six cameras were used to surround the sitting subject with computer software that can take information from the cameras to provide a three-dimensional picture of the sitting subject. The authors found high validity to determine head angles within this study however it remains unclear how this applies clinically. In normal clinical practice having six cameras and computers available to all manual therapists’ is unlikely and the expense of the software for the 3D-PAT means that it is unlikely that practitioners in a normal setting would also be able to determine head angles in this way to get the same reliability as using the 3D-PAT in a laboratory. Another study also using laboratory-type methods was carried out by Pownall, Moran and Stewart, (2008). Pownall et al. (2008) aimed to find the intra-rater and inter-rater reliability in consistency of standing and sitting posture in males over a one-week interval. Subjects had adhesive reflective markers on significant anatomical landmarks related to poor sitting posture. A video camera, tripods, and two cameras were used to take footage of subjects in sitting and standing positions. Raters were highly reliable in finding different head angles and finding the angle between the fibular head to femur, in lateral views of sitting posture. Studies such as these are important in the development of tools to find validity underlying measurements and protocols. However, given the time commitment and equipment that is required, it could be said that these methods are only useful in laboratory-type settings and are difficult to replicate in a clinical scenario. These studies used laboratory-based methods and not all manual therapists will treat only patients with sitting posture related MSK pain. They are therefore unlikely to have appropriate equipment set up for assessment in sitting posture. An assessment tool that could be used in the field such as an ergonomic workplace assessment would need methods that require little set up and to be quick to fit in around a work day, without disruption. The studies using methods which require a laboratory and elaborate equipment would not yield the same results in that the equipment could not be easily transported and set-up on the spot. Furthermore, if the assessment itself took a significant amount of time it is also not an efficient use of time. It is important to MSK therapists clinically to be able to track progression in patients and their sitting posture. In an everyday MSK practitioners’ consultation, it is not economical or timely to set-up anatomical reflective markers, take photographs, analyse the data and then continue with treatment or intervention within a half hour or hour-long appointment. Therefore, characteristics of a clinically applicable tool might include equipment readily available in most clinical practices, a quick assessment and rating measures that will inform therapeutic intervention for manual therapists.
1.53 Field-based measures

A pragmatic approach to determining the reliability of a sitting posture tool would require investigation of the procedures and methods that would be used by practitioners in the clinical setting. Using these methods would then express the ecological validity of the sitting posture assessment. Testing of field-expedient methods is necessary to determine the clinical relevance and generalisability as well as reliability of the sitting posture assessment tool. Field-based measures are measures that are practical and simulate a day-to-day scenario or a clinical setting, completed in a time suitable for clinical use and do not require expensive and specialised equipment. There are a limited number of studies investigating whole body sitting posture rating tools that are strictly field-based as they tend to mix field and laboratory type methods and measures. However, these studies to be discussed deemed as ‘field-expedient’ differ from the laboratory-type methods as they are more clinically applicable than the studies discussed previously.

Forward head posture is considered a commonly assumed posture by individuals sitting for extended periods of time. A landmark study by Yip, Chiu, and Poon, (2008), although not specifically assessing sitting posture, they investigated FHP with a Head Posture Spinal Curvature Instrument. This study showed that this tool was reliable in finding inappropriate forward head posture in a field-setting. However, the equipment used means it is not as applicable in clinical practice, unless this practice has a Head Posture Spinal Curvature Instrument. An earlier study by Straker, Jones, and Miller (1997), investigated the differences in sitting posture when using either a laptop or a desktop through observation of posture and the subjects completing a self-reported pain scale. The authors found that while subjects were using laptop computers they displayed increased FHP compared to the same subjects’ posture at a desktop computer. More discomfort with the laptop use was also reported. This study reflects field-work based measures very well as the study was conducted in the subjects’ work place with furniture they would normally use. The participants however were still required to have anatomical markers set up which devalues its reproducibility in a clinical setting. Furthermore, given the tool they used was new and unestablished, reliability and validity evaluations had yet to be performed and it was not clear whether the raters in this study were reliably matched.

Other studies, including those of Brink et al. (2014) and Szeto et al. (2002), investigated neck posture in office workers and postures of children in school. These studies were conducted in a field-setting as they were completed at the participant’s workplace and the children’s
school, respectively. However, the specialised equipment such as the use of 3D postural
analysis limits the external validity as the use of five cameras and altered clothing will begin
to affect the subjects comfort levels and therefore decrease the “real-life” perspective (Brink
et al., 2013).

The aforementioned studies which were either performed in a laboratory type setting or
attempt to use field-based measures provide sitting posture assessment tools with high
internal validity but less ecological validity. These tools, once applied in a daily clinical
setting without the anatomical markers, and without the use of computer software to calculate
the angles, may have considerably less reliability than one that was investigated under
clinically similar conditions. The studies as a strength have high internal validity but
consequently, there is less external validity as a trade-off indicating the lack of investigations
into sitting posture assessment using non-specialised equipment. A standardised sitting
posture tool needs to be tested using non-specialised equipment to provide a sitting posture
rating tool with high generalisability and usefulness in a clinical setting. To add to this, there
are no landmark studies investigating a full-body sitting posture assessment tool. However,
among the studies which have investigated posture and postural dysfunction there are a
number of postural angles addressed in more than one study indicating relevance and
usefulness of these aspects (McEvoy & Grimmer, 2005). Some of these angles such as those
in FHP and upper-back/shoulder posture should then be considered in the development of
new tools. These postural angles were taken into consideration, and were used in the tool
being proposed, in the preliminary development stage by Moran, Silvester, and Henwood
(2014).

1.54 Studies investigating reliability of sitting posture assessment using observational
methods

Posture is commonly assessed through observation by manual therapists (Sahrmann, 1988).
Physical assessment of static posture can be a reliable and objective measurement to assess
the posture of a person’s body. If a person is spending long amounts of time in one posture
and pain is then persisting, then an intervention to this posture may assist in reducing the
MSK discomfort. Five studies were found for this review which investigated the reliability
of sitting posture assessment using observational methods (Brink et al., 2013; Korakakis et
al., 2016; McEvoy & Grimmer, 2005; Straker et al., 2009; van Niekerk et al., 2008)
(Appendix C). The studies found were conducted in a laboratory-type setting with
laboratory-type methods. The studies used some or all of ultrasound adhesive marker
placement, multiple cameras, radiographs and computer software to calculate the angles (Brink et al., 2013; Korakakis, Sideris, & Giakas, 2014; Pownall et al., 2008; Straker et al., 2009; van Niekerk et al., 2008). Korakakis et al., (2014) investigated the reliability of placing subjects into a predetermined sitting position. The authors were accurately able to reproduce sitting posture, this means in a manual therapy setting practitioners are likely to have good reliability with therapeutic intervention of their patients sitting posture, when in a similar setting to this study (Korakakis et al., 2014). Brink et al, (2013) investigated the reliability of a three-dimensional (3D), portable, non-invasive posture analysis tool called the 3D-PAT. The 3D-PAT was found to be a reliable way to measure upper-quadrant postural angles but once again, it is difficult to determine the relevance of these findings for manual therapists’ due to the expense and time involved to set up the equipment required, decreasing the applicability in clinical scenarios. A study by Straker et al. (2009) investigated whether neck/shoulder pain in adolescents was related to their habitual sitting posture. Straker et al. (2009), similar to previous authors, performed research in a laboratory and used motion analysis software which is more specialised than most manual therapists would use in practice. It has also been discussed by van Niekerk et al. (2008) that when compared to low dose radiographs, the reliability of determining sitting posture angles with the use of photographs, acceptable agreement can be found. van Niekerk et al. (2008) used photographs which are considered as a valid method to rate sitting posture only in a laboratory type setting due to the low ecological validity.

1.55 Common themes in field and laboratory tested posture rating tools
Throughout the studies using either laboratory or field-based methods, there are common postural angles investigated. Although these angles can have different names in different studies, they are commonly investigating the same measure. Examples of the angle investigated names include the terms: head flexion, craniocervical and craniovertebral angle, neck angle, gaze angle, cervico-thoracic angle, scapula displacement, arm angle, trunk angle and pelvic tilt (Brink et al., 2013; Korakakis et al., 2016; Pownall et al., 2008; Straker, O’Sullivan, Smith, Perry, & Coleman, 2008; van Niekerk et al., 2008). None of these studies were tested using purely field-based settings and field-based methods. Gaze angle and head on neck angle together determine the angle of flexion or extension of the neck (Nejati et al., 2015; Salahzadeh et al., 2014; Youssef, 2016). When the combination of flexion of the lower neck and extension in the upper section of the neck this becomes the previously discussed FHP. Forward head posture has been discussed as being linked to head, neck and shoulder
pain or dysfunction hence the relevance of assessing the severity of this angle (Cheung Lau, Wing Chiu, & Lam, 2009; Corlett, 2006; Hickey, Rondeau, Corrente, Abysalh, & Seymour, 2000; Muscolino, 2015). Measuring the magnitude of FHP is clinically useful as an outcome measure to determine the effectiveness of interventions intended to influence posture. Cheung Lau et al. (2009) maintain that FHP has a correlation to postural related pain and disorders such as neck and shoulder pain and headaches (Cheung Lau et al., 2009). This study also points out that participants who were asymptomatic had larger cervicocranial angles or less severity of expressed FHP than those participants affected by neck, shoulder and head discomfort and pain (Cheung Lau et al., 2009). Due to the influence of neck posture on MSK disorders it is important to investigate the angles associated with FHP.

1.6 Research Purpose

1.61 A Sitting Posture Rating Tool
The limitations found in this literature review were largely related to external validity, that is, the findings of these studies may not translate well to clinical fieldwork. To assess the generalizability of a sitting posture tool or assessment of sitting postural angles there needs to be a rationale for each postural angle to ensure they are objective measures, accessible to all manual therapists, and are clinically relevant. There also needs to be further research assessing inter-rater and intra-rater reliability of all the assessed postural angles using field-expedient methods. A field expedient sitting posture tool assessing angles of the whole body whilst sitting would be clinically relevant for manual therapists to use with people living a modern sedentary lifestyle. Manual therapists often make attempts to observe and make comment on patient posture at the beginning of appointments, but without the use of specialised equipment (Albertson, 2011). Therefore, to be deemed clinically applicable a sitting posture rating tool needs to be timely (able to be performed in a few minutes), inexpensive, and without the use of specialised instruments.

Previous studies evaluating sitting posture found that under highly controlled conditions in field and laboratory type settings, sitting posture could reliably be assessed (Brink et al., 2013; Korakakis et al., 2016; Pownall et al., 2008; Straker et al., 2008). The next section of this thesis discusses a sitting posture rating tool which is being designed to be used clinically. To achieve this, it will be without the aid of any instrumentation such as EMG, ultrasound, anatomical markers, video camera or other devices. The tool that is being developed is a
A collection of 6 components of sitting posture, drawn from the literature, which appear to be appropriate for clinical assessment use. This tool enables the manual therapists to objectively assess patients sitting posture, whether they are in a normal range or where they are not achieving normal sitting. This tool also aims to provide a semi-objective indication of progress following clinical intervention.

1.62 A proposed Sitting Posture Rating Tool
A sitting posture rating tool was proposed by Moran, Silvester and Henwood in the year of 2014. This tool comprised of 6 subtests with a three-point rating scale (Moran, Silvester & Henwood, 2014). The chosen elements were decided upon from professional opinion and clinical experience in the rating of sitting posture. Further from this, the sub-tests were researched to find their relevance compared to other studies findings of clinically relevant angles to monitor during sitting posture. These have been summarised into a table found in Appendix C. This tool was then used in this study and further developed. Appendix D shows the process of developing the tool and Appendix E displays the final SPRT tool that was used in this study. Once this tool was developed, initial reliability testing was performed, aiming to complete the study with high external validity to determine its potential relevance in the clinical field for manual therapists to assess sitting posture.

1.63 Three-point scale
The proposed SPRT employed a three-point ordinal scale for five of the sub-tests and a two-point scale for one sub-test. In the recent literature, visual measuring protocols with four-point scales have often been used for assessment of static standing posture and movement assessment such as the Functional Movement Screen and Selective Functional Movement Assessment, (Cook, Burton, Hoogenboom, & Voight, 2014; Teyhen et al., 2012). A four-point scale has higher reliability than a six-point scale, according to Watson and Mac Donncha. (2000) “the use of any more categories made a distinction between categories difficult and reduced the reliability of the procedure”. This study will employ a three-point scale to aim for higher inter-rater and intra-rater reliability and divide rated subjects into groups to distinguish between the levels of the outcome measure. It differs from the studies mentioned in that subject’s do not need the category “with pain” or “unable to perform movement” as this is not discussed with the subject. A three-point scale balances the compromise between appropriate validity, practical use, and adequate reliability. A three-point scale therefore allows for group distinction and practicality for therapists to improve test re-test outcomes for an objective scale of rating.
1.7 Summary

MSK pain and discomfort is a disorder that burdens individuals, businesses, governments, and healthcare providers. This burden is emotional, physical and financial. It is a problem affecting many people and developed countries. This pain and discomfort has been discussed as being linked to sitting posture, as well as time spent sitting. People who experience pain associated with sitting are likely to seek healthcare from manual therapy practitioners. With the increase in time spent sitting in leisure, work, and school it is important that there is a readily available assessment to guide interventions in the sitting environment. There has been little research investigating sitting posture and MSK discomfort of which use settings and methods to reflect ‘real-world’ conditions. Most of these studies fail to investigate posture using methods that are applicable to clinic use. A tool assessing sitting posture which is clinically relevant and ready to use in the field such as at a workplace or within a typical clinical consultation is therefore required. In summary, this review has presented an argument that a clinically applicable SPRT without the use of specialised equipment or taking long amounts of time, would be useful and relevant for manual therapists. The next section of this thesis is a manuscript that reports the findings of an investigation of rater reliability of scores derived from using the SPRT.
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SECTION 2: Manuscript

Note to the reader: This manuscript has been prepared according to the guidelines for the journal of *Musculoskeletal Science and Practice: an international journal of musculoskeletal physiotherapy* available here: https://www.elsevier.com/journals/musculoskeletal-science-and-practice/2468-7812/guide-for-authors
Development and preliminary testing of a practical tool for visual assessment of seated posture

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ABSTRACT

Background The assessment of sitting posture is most commonly carried out in laboratory-type settings using methods that have limited applicability to typical clinical practice. It is important that field-based methods are employed to assess sitting posture so that once the assessment tool is applied in a clinical setting the results are still reliable. This study investigated a Sitting Posture Rating Tool (SPRT) that employed a simple 3-point ordinal rating scale to assess video clips of sitting posture recorded using a smartphone digital camera.

Design This study took a partially formed SPRT and investigated the reasoning for the tool through a literature review. From this, a discussion with an expert advisory group was undertaken to find agreement on which aspects of posture were important to include. A repeated measures design was used to test inter-rater and intra-rater reliability of the SPRT using ratings from pre-recorded videos of sitting subjects.

Aims To develop and establish a SPRT as well as do some preliminary testing on the inter-rater and intra-rater reliability of the SPRT using field-expedient methods.

Method Novice raters (n=14) were trained to use the developed SPRT to rate 20 videos of subjects’ (n=12 females; n=8 males) sitting posture. Inter-rater and intra-rater reliability was determined using repeat testing.

Results Inter-rater agreement of the six separate sub-tests demonstrated ‘moderate’ (AC2 = 0.41-0.60) to ‘good’ agreement (AC2 = 0.61-0.80). However, the ICC value for SPRT composite scores (sum of scores from each independent sub-test) did not reach the acceptable level in order to be considered satisfactorily reliable (ICC2,1 = 0.44, 95% CI 0.29 to 0.64). Intra-rater agreement values for the six subtests had varying results on their first day of rating however 75% of raters could achieve above ‘moderate’ reliability (AC1>0.40).

Conclusion Intra-rater results were more reliable than the inter-rater agreement outcomes so individual manual therapists could effectively use the SPRT to monitor treatment outcomes within their practice however how results are used between therapists needs more consideration. This study found that the SPRT is a time efficient field-based tool in the assessment of sitting posture but will need further investigation before it is considered a robust tool that can be confidently used in practice.

Keywords: Reliability, Sitting, Posture, Screening, Sitting Posture Rating Tool.
INTRODUCTION

Given the prevalence of sitting in modern society (Allman-Farinelli et al., 2010; Chau, van der Ploeg, Merom, Chey, & Bauman, 2012), consideration of sitting posture is of clinical interest to manual therapists involved in the management of musculoskeletal (MSK) disorders. Poor head posture, specifically Forward Head Posture (FHP), is a common posture found in people who sit often and it is associated with neck pain (Hibberd et al., 2016; Yip, Chiu, & Poon, 2008). Neck pain, along with other MSK discomfort, consequently results in more healthcare seeking behaviour including manual therapy treatment (Ariëns et al., 2001; Dankaerts et al., 2006; Stewart et al., 2003). Manual therapists use physical examination to inform diagnostic and therapeutic reasoning (Deyo et al., 1992). Present studies in the literature regarding sitting posture assessment are performed using specialised equipment and the results do not then translate into the clinical field because of the low ecological validity. Previous studies such as by O’Sullivan et al. (2010) and van Niekerk, Louw, Vaughan, Grimmer-Somers, and Schreve (2008), find acceptable levels of reliability with high internal validity for assessment of sitting posture using laboratory type methods and settings. From studies, such as these two, it is difficult to determine the ecological validity and therefore it is not useful outside of a laboratory. Some studies including those by authors Szeto, Straker and Raine (2002) and Mörl and Bradl (2013) conduct their studies in a field-type setting however the sitting posture assessment is implemented with expensive equipment and takes a lot of time to complete. As a result, these assessments do not generalise well to clinical scenarios. Manual therapists require a sitting posture physical examination tool to address sitting posture in practice. There is currently no tool to assess sitting posture that is quick, inexpensive, simple and not using specialised equipment. Studies to explore sitting posture tools under field conditions are lacking. More of these studies are required to provide a simple sitting posture rating tool that has acceptable ecological validity for manual therapists in a clinical scenario.

The methods in this study were chosen to further investigate the Sitting Posture Rating Tool (SPRT) in a field setting using field-expedient measures, unlike other studies on sitting posture to date. The aims of this study were to 1) Complete development of a SPRT and 2) Determine the inter-rater and intra-rater reliability of the SPRT.
METHODS

Design and Ethics
A repeated measures, test re-test reliability design was used to investigate the inter-rater and intra-rater reliability of the SPRT. This was applied to video clips recorded using a digital camera on a smartphone to represent the type of equipment available to manual therapists in clinical settings. Raters attended two sessions. During these sessions they applied the SPRT to video clips of each subjects’ sitting posture. The same subjects’ videos were used for each session however in differing orders. The two rating sessions were spaced seven days apart to reduce recall bias (Hargovan, 2010). The study design and reporting was informed by the Quality Appraisal for Reliability Studies (QAREL) checklist (Appendix B), (Lucas, Macaskill, Irwig, & Bogduk, 2010). The study was approved by the Unitec Research Ethics Committee, and all participants gave their written informed consent prior to participation (UREC Approval No: 2016-1008).

Participants and Procedures

Participant Recruitment:
Two types of participants were recruited. ‘Subjects’ were recruited as the participants who sat at a workstation to have their posture video recorded. ‘Raters’ were recruited to apply the SPRT to video recordings of the subjects.

Subjects

Subject Selection:
The eligibility criteria for subject recruitment was designed to recruit a sample that would be representative of young adults who were tertiary students. Convenience sampling using posters and word-of-mouth was used to recruit subjects. Inclusion criteria were: males and female tertiary students between the ages of 18 and 25 years. Exclusion criteria were any participants whose footage made them recognisable such as bright clothing or other distinctive features, for example, wearing a sling, or taping (Lucas et al., 2010; Lucas et al., 2013).

Procedures for Subjects:
Recordings of subjects took place in a computer laboratory, with a standard adjustable office chair and a desktop computer workstation with keyboard, monitor on top of the system unit, and mouse (see Supplementary Video S1 for example of footage, before Appendices). The
researcher used a hand-held smartphone with a 13 mega-pixel digital camera (Sony Xperia, Sony Corp., Japan) to record ~20s video clips of the subjects’ sitting posture.

Each subject was asked to sit using the chair provided at the workstation. Subjects were invited to adjust the chair height and position for their own comfort. The subject was asked to complete a generic online quiz to encourage mouse use for the duration of the recording. While the resulting seated posture of any given subject was not a concern of the study, five minutes were allowed for the subject to get comfortable and become settled into a habitual posture before video recording commenced (Claus, Hides, Moseley, and Hodges, 2016 and Murphy et al., 2004). A video recording was taken, beginning from the subjects’ right-hand side, panning to the posterior aspect, then around to the left-hand side, further around to anterior view then over the top of the desktop and subject to see the full superior view of the subject (see Supplementary Video S1 above Appendices).

**Video Procedures:**
Prior to the main experiment, video clips were independently rated by the researcher and a co-investigator and the findings compared. Differences in ratings were resolved by discussion and reference to the rating criteria. This was to check for the prevalence of scores among the sub-tests to ensure there was a spectrum of ratings across the range available within the rating tool. This was to help determine whether more extremes of posture could be picked-up by the tool or whether all results would be inappropriately lumped into one rating. Video footage of 20 subject videos were placed in separate files and saved in randomised orders for presentation to raters. Randomisation was performed using http://www.random.org.

**Raters**

**Rater Selection:**
A convenience sample of postgraduate osteopathy students was recruited using word of mouth and poster advertising. To be eligible raters needed to be currently undertaking clinical training and be enrolled in the Unitec, Master of Osteopathy programme.

**Procedures for Raters:**
Each rater was presented with the video clips on a desktop computer. Each rater then inspected each clip and recorded ratings directly using a spreadsheet template.
**Sitting Posture Rating Tool Protocol:**
The SPRT consists of six sub-tests, with each sub-test rated using a three-point ordinal scale (Appendix D and E). The SPRT information sheets were used for training of raters prior to data collection. Printed copies of these sheets were given to the raters and could be used as a reference during the rating of the videos.

**Rater Training:**
Raters attended two teaching sessions (total time = 2 hours) prior to data collection. The first teaching session was attended by all raters and was conducted in a classroom style. During the teaching session, raters were introduced to the tool and examples were provided before the group undertook practice rating examples using videos of subject footage that were not included in the main study. A verbal self-efficacy scale ranging from 0 to 100 was presented to the raters following this first teaching session to identify how confident they were to apply the tool in the study to videos of subject participants. The answers were all in the range from 80-90. Following this session, a second teaching session was conducted one-on-one for each individual rater. This session was focused on clarifying between more difficult examples of ratings for neck on body, gaze angle and thoracic kyphosis as these were the sub-tests that had the lower level of agreement during consensus ratings. The rater then guided the learning through question and answer interactive learning with the researcher. The duration of this session varied between 30 and 60 minutes, however, did not end until the rater achieved 100% on the self-efficacy verbal scale which is the reason for the varying length of this session between raters.

**Data Collection Procedure:**
In accordance with the QAREL criteria (Lucas et al., 2010), raters were blinded to each other’s ratings and scored all videos on an individual basis. Data collection was supervised by the researcher. Raters were requested to check the last three digits of the ID number of the labelled rating rubric and then match it with the ID of the video, to avoid errors in the recording of scores. Each of the video clips were rated by all of the raters on two separate occasions spaced seven days apart. This time-frame was chosen as it closely represents the time which usually separates appointments with manual therapists (Hargovan, 2010). The raters had no restrictive instructions on how to rate the videos i.e. they could replay and pause each video clip as needed. They were however instructed to follow the rating criteria and use the card even if they did not think it was necessary.
**Data Analysis**

Raw data were extracted from excel spreadsheets, checked and tabulated into AgreeStat (2015.5, Advanced Analytics, Gaithersburg, MD, USA). Gwet’s first (AC1) and second (AC2) order coefficients were used to determine the agreement coefficients within and between raters (Wongpakaran, Wongpakaran, Wedding, & Gwet, 2013). The reliability of composite scores (sum of scores for six sub-tests) were calculated using intraclass correlation coefficients (model ICC2,1). The AC2 value was calculated using quadratic weightings (Gwet, 2008, 2010). This was to increase penalties for larger differences in scores and less for closer scorings so that the numeric value more closely reflected the ratings produced by the raters (Fleiss, 1971). This type of weighting ensures that the further the rater is from the correct rating, the lower their score will be and vice versa. A confidence interval of 95% was set for all reliability calculations. Descriptors to interpret reliability coefficients were taken from Landis and Koch (1977) described as: 0.01-0.20 = slight; 0.21-0.40 = fair; 0.41-0.60 = moderate; 0.61-0.80 = good; 0.81-1.0 = almost perfect. To consider an agreement coefficient to have satisfactory reliability, the AC1 or AC2 value needed to be ≥ 0.4 (Gwet, 2008, 2010), and ICC ≥ 0.6 (Chinn, 1991) respectively.

**RESULTS**

Figure 1 illustrates the process of recruitment, video recording, training and rating tasks to completion. In total, 20 subjects’ (11 females, 9 males) sitting posture videos were used for rating in this study. The mean ± SD subject age was 22.5 ± 1.8 years and average BMI was 24.4 kg.m⁻². In total, there were 14 raters (9 females, 5 males) attending all sessions, all raters were senior osteopathy students currently enrolled in a postgraduate pre-registration degree.
Methodology Diagram

Phase 1: Subject recruitment and video footage collection

Figure 1: Diagram of recruitment to data collection process

Phase 2: Rating procedure using the sitting posture rating tool

Figure 1: Diagram of recruitment to data collection process
Intra-Rater Reliability
Intra-rater reliability was calculated for each of the 14 raters. Figure 2 illustrates the results of the intra-rater reliability for each of the raters n=14. Panels A to F (Figure 2) show the intra-rater coefficients for each of the sub-tests.
Figure 2: Graph of intra-rater reliability for each of the raters n=14 for each sub-test. The shaded area represents all results that reached above the 0.4 threshold thereby achieving a ‘moderate’ and satisfactory level of agreement.
For neck on body angle (Panel A) 10 of 14 raters demonstrated at least ‘moderate’ (AC1 > 0.41) agreement. Gaze angle (Panel B) had a lot more variance between raters’ results whereby nine raters achieved at least ‘moderate’ agreement (AC1 0.41-0.60), four of those which were in the ‘good’ range of reliability (0.61-0.80). The other five of the raters however only came to ‘slight’ (AC1= 0.01-0.20) agreement in this sub-test. In the rating of thoracic kyphosis (Panel C), eight raters reached ‘good’ agreement (AC1 > 0.61-0.80) and three were within the ‘moderate’ range (AC1 = 0.41- 0.60). For coronal symmetry (Panel D), seven raters achieved at least ‘moderate’ (AC1 = 0.41- 0.60) agreement and four reached ‘good’ (AC1 = 0.61- 0.80) agreement. For glenohumeral internal rotation (Panel E) six raters achieved ‘almost perfect’ (AC1 = 0.81- 1.0) agreement and four raters achieved ‘good’ agreement (AC1 = 0.61 -0.80). For the body to monitor sub-test (Panel F), six raters achieved ‘moderate’ (AC1 = 0.41- 0.60) and five reached ‘good’ (AC1 = 0.61- 0.80) agreement.

**Inter-Rater Reliability**

Inter-rater reliability was calculated using the ratings made from the first session for each sub-test (Figure 3). Overall, the weighted inter-rater agreement, in the sample of 14 raters, exceeded the minimum threshold for acceptable reliability (AC2 ≥ 0.4). However, the lower confidence limit for 4 sub-tests (gaze angle, neck on body angle, glenohumeral internal rotation and body to monitor angle) was less than the 0.4 threshold. The coronal symmetry sub-test reached into ‘almost perfect’ agreement and thoracic kyphosis ranged within the ‘good’ range. (Figure 3).
**Reliability of Composite Scores**

Reliability of the overall inter-rater composite scores was below the satisfactory limit of 0.6 (ICC = 0.44, 95% CI 0.29 to 0.64).

**DISCUSSION**

**Overview**

The main aim of this study was to investigate the reliability of the SPRT using a smartphone i.e. a field-expedient method which is low cost, accessible, practical and therefore able to be applied clinically by manual therapists. This study found the developed SPRT had an overall above ‘moderate’ result for the level of intra-rater reliability agreement levels. The combined results for the six sub-tests did not reach acceptable inter-rater reliability agreement levels however the individual AC2 values did reach above the 0.4 threshold. This implies there is potential for the SPRT to be used clinically as none of the results showed no agreement however, investigation towards improving the inter-rater reliability is required in order to become a more successful rating tool. To date, studies investigating sitting posture, place emphasis on using a laboratory-based setting, producing studies with high internal validity.
Although high internal validity has been found in these studies, the trade-off is limited external validity which means it is not translated well into the clinical field for manual therapists (Brink, Louw, Grimmer, Schreve, van der Westhuizen, & Jordaan, 2013., Korakakis, Sideris, & Giakas, 2014., Niekerk, Louw, Vaughan, Grimmer-Somers, & Schreve, 2008., Pownall, Moran, & Stewart, 2008., Straker, O'Sullivan, Smith, Perry, & Coleman, 2008). As well as issues with practical application, time restraints are also a significant concern for many manual therapists (Jensen, Shepard, & Hack, 1990) and it is uncommon in normal practice to have access to specialised video analysis equipment. An additional finding of this study is that using a smartphone for recording is easily accessible and completion of the SPRT on a patient takes, on average, under two minutes to complete. Together, these findings make the SPRT are very attractive tool to use in the assessment of sitting posture in a clinical setting.

**Wider Literature**

There appear to be few studies that have used a field-expedient battery of tests intended for practical application in clinic using non-specialised equipment. However, previous studies have investigated aspects included in the SPRT. Yip et al. (2008) found above acceptable reliability of a tool used to find the craniovertebral angle which determines the severity of FHP. Although the reliability was high and performed in a field setting it used equipment not available to all therapists. Unlike this study it only investigates one aspect of sitting posture. A study by Fedorak, Ashworth, Marshall, and Paull, (2003) found similar results investigating reliability in how accurately physical therapists could rate lumbar and cervical lordosis. This study also was performed in field-expedient conditions however investigated standing posture. Similar to the present study, intra-rater had acceptable results and inter-rater reliability had acceptable AC2 value results, however, the results from these authors were more consistent (Fedorak et al., 2003).

Due to the widespread availability of smartphones, the present study chose to use a single camera on one of these devices. Smartphones are increasingly being used in health and medical practice for a range of applications including Healthcare Applications (Apps) for smartphones (Mosa et al., 2012), patient access to their own healthcare information (Boulos et al., 2011) and tracking duration and type of physical activity (del Rosario, Redmond, & Lovell, 2015).
A smartphone is easily accessible to most therapists today compared with video set-up such as the PPAM used by van Niekerk, Louw, Vaughan, Grimmer-Somers, and Schreve, (2008). The methods used by these authors resulted in high internal validity of the study however little external validity compared to the present study. Inter-rater reliability results in this study did not have as higher agreement results as the authors using more laboratory-type settings and methods. This is potentially due to the more field-type setting allowing more external influence to affect results as would in normal practice.

Contrasting to other studies in the literature to date, the findings from this study found some acceptable reliability results with high ecological validity due to the design and aim to produce a tool that is field-expedient.

**Internal Validity**
Guidelines such as the QAREL criteria (Lucas, Macaskill, Irwig, Moran, & Bogduk, 2009; Lucas et al., 2010) are useful to follow when conducting reliability studies to improve validity. In this study, QAREL criteria were addressed to varying degrees. Possible sources of bias within this study were recall bias, controlling of blinding, and additional cues (Lucas et al., 2010). To reduce recall bias in the intra-rater reliability the two rating sessions were spaced 7 days apart, this interval is sufficient to reduce the likelihood of a rater recalling an individual rating (Hargovan, 2010) and is also representative of the interval between clinical consultations by MSK therapists (Houvenagel, 2012). Raters attended rating sessions alone with the researcher and were unable to re-access their previous ratings, thus maintaining blinding to their previous results and those of other raters. The sub-tests, neck on body, gaze angle, thoracic kyphosis and coronal symmetry were sub-tests agreed upon by the researcher and co-investigator when determining consensus ratings of the sub-tests. More extensive educational material was provided for the sub-tests neck on body, gaze angle, thoracic kyphosis and coronal symmetry during the second training of the raters. In this study, particular attention was afforded to rater training and additional cues affecting rater bias whilst rating. Training of the 14 raters was specific, using teaching material for both a static image and actual video footage of subjects. These recordings were not included in the main study. The similar footage presented was to ensure the training matched how the material would be presented in the actual rating sessions. Using self-efficacy as the determinant of learning is a more effective assessment and allows for longer learning times for each individual rather than allocating a set time-frame (Axboe et al., 2016). Usefulness of self-
efficacy rating scales are discussed in the literature as being more than just a passive self-judgment but a useful predictor of self-expected performance (Ammentorp et al., 2013; Axboe et al., 2016). In this study, using a self-efficacy outcome measure as opposed to a set time allowed for raters with lower attentiveness, or those taking more time, to learn how to use the tool before being allowed to begin rating, therefore, increasing the precision of ratings. Compared with studies such as those by Brink et al., (2013) and Szeto et al., (2002) the different methods produced somewhat similar results, although as expected, reliability was not as accurate as results in studies using strict laboratory-type methods. This could be due to this being preliminary testing or due to the nature of less perfect testing conditions such as not using anatomical markers or having an artificial workstation that is much easier for raters to observe.

**External Validity**
This study was conducted using real-life methods defined in this study as a real-world setting using no high-tech equipment or computer analysis software, in an attempt to produce a field expedient tool. Although not formally measured, it was observed that time taken for raters to rate each subject was approximately 1.5 to 2 minutes per subject. There are time constraints in appointments with most MSK therapists, therefore, this tool aimed to be timely and achieved this. The SPRT was tested under field conditions in a field-type setting to investigate whether it was reliable for MSK therapists to use in practice. The subjects and raters were chosen to represent the populations the tool would be used by and used on.

The tool was aimed to be for manual therapists and therefore the raters used were novice manual therapists in training. While the raters in this sample were novice raters with less than three years’ clinical experience some may argue that raters with more clinical experience may have been better suited for the study. However, studies investigating the role of clinical experience and its impact on rater-reliability in the role of posture, indicate that clinical experience is not related to superior reliability (Aitken, 2009; Moran & Ljubotenski, 2006). Due to the field-expedient methodology, the reliability findings are more generalizable beyond the participants used in this study than found in other studies to date.
Implications for Future Research
There are three main lines of enquiry for future research. Firstly, further investigation into the factor structure and other psychometric properties of the SPRT including internal consistency, the role of rater training and applicability to standing desk posture is required (Mokkink et al., 2010). There are currently six sub-tests however it is not yet known whether all six sub-tests are necessary for an upper-body sitting assessment or whether this number could be reduced. In this study, all totals were added together however it is unclear whether the factor structure supports this. Future studies may elucidate whether it is valid to sum these sub-tests totals or whether they do not correlate sub-test to sub-test.

Secondly, further investigation is required in the role of rater training and experience in the use of the SPRT and how this may affect the rater reliability. Some of the sub-tests had lower reliability coefficients (neck on body, gaze angle and body to monitor), and the rating criteria should be subject to further development. The inconsistency of the AC2 values could be due to multiple reasons including complacency of use of the business cards to assess straight lines. It could also be that assessing body to monitor was too complicated by having to check four lines to assess the posture. A different approach could be to increase the number of teaching sessions as the amount of ‘rules’ may be too overwhelming for novices in the SPRT procedures. More sessions using the tool may reflect results of much higher reliability agreement.

Thirdly, as a new avenue of research, further investigation could be done into whether modification or adaption of the tool could then be applied to standing posture whilst at a standing desk workstation. Increasing interest has been shown in the use of standing desks with positive associations being found. Recent studies such as from Buckley, Mellor, Morris and Joseph, (2014) and Patston, Henry, McEwen, Mannion and Ewens-Volynkina, (2017) have investigated the influence of standing desks on metabolic health, MSK discomfort and the effect on cognitive function. These studies have found positive trends towards productivity and metabolic health encouraging the importance of using standing desks in the workplace. As the bank of research into standing desks is rapidly developing and their popularity of use in the workplace is growing, it will important to have a tool to assess posture in this body position. It could then be advantageous to further develop the SPRT tool so that it could be adapted to postures assumed whilst using a standing desk. This will mean
we have a better understanding of static postures and their associated treatment should MSK pain and poor posture become an issue with these new workstations.

**CONCLUSION**

The aim of this study was to develop a SPRT and test the intra-rater and inter-rater reliability of the tool. This study found acceptable levels of agreement in the intra-rater agreement and below acceptable levels of agreement for the combined inter-rater reliability for the six sub-tests overall. The results show that when different raters use the SPRT to assess sitting posture in the same participants they will yield comparable results when the sub-tests are performed independently, only. This would be useful in a clinical setting if a patient was unable to meet with their usual MSK therapist for a progress check-up on a given seated body posture. However, when the SPRT was broken down into its individual sub-tests, there were also varying degrees of the level of reliability agreements. The sub-test, body to monitor had the least inter-rater agreement meaning that of the sub-tests, raters agreed on the grade for this posture the least. Gaze angle also had five raters not reach 0.40 threshold meaning that the raters assessing the same person more than once were unable to agree on what rating to give the sitting participant. This means in clinical practice that the same manual therapist using the SPRT may be unable to precisely determine change in this particular sub-test during sitting posture and whether any recorded change is due to an intervention or whether their rating is changing and the patients sitting posture has not changed. While these findings indicate that further development and investigation is required into at least three of the sub-tests, it does not take away from this study’s finding that the SPRT has found overall acceptable levels of intra-rater reliability, supporting its preliminary use in clinical practice. In order for this tool to become more robust and more widely used, future research is suggested to investigate the clinical relevance and accuracy of the independent sub-tests. The clarification of the guidelines of the sub-tests, as well as a focus on the training of raters will also be important to ensure increased confidence in the use of the SPRT in clinical practice.
Conflict of interest

None declared.

Ethical approval

Ethical approval for the study was approved by the Unitec Research Ethics Committee (UREC Approval No.: 2016-1008).

Funding

None declared.

Conflicts of Interest

None declared.
REFERENCES


Albertson, P. (2011). *What are the factors that guide an osteopath during the process of technique choice?* Unitec Institute of Technology.


Supplementary Material Video S1

https://www.dropbox.com/s/oosfxkgs0caiv4l/video-1471380027.mp4?dl=0
SECTION 3: Appendices
Appendix A: Author information Musculoskeletal Science and Practice: An International Journal of Musculoskeletal Physiotherapy
A link to the instructions for authors in submitting a paper to the Musculoskeletal Science and Practice journal, formerly known as the Manual Therapy Journal, can be found here:

https://www.elsevier.com/journals/musculoskeletal-science-and-practice/2468-7812/guide-for-authors
Appendix B: Quality Appraisal of Diagnostic Reliability (QAREL) Checklist
<table>
<thead>
<tr>
<th>Item</th>
</tr>
</thead>
</table>
| 1. Was the test evaluated in a sample of subjects who were representative of those to whom the authors intended the results to be applied?  
  (DEF: 3, 4, 5, 7, 8, 9) |
| 2. Was the test performed by raters who were representative of those to whom the authors intended the results to be applied?  
  (DEF 3, 4, 6, 7, 8, 9) |
| 3. Were raters blinded to the findings of other raters during the study?  
  (DEF 10) |
| 4. Were raters blinded to their own prior findings of the test under evaluation?  
  (DEF 11) |
| 5. Were raters blinded to the results of the reference standard for the target disorder (or variable) being evaluated?  
  (DEF 12) |
| 6. Were raters blinded to clinical information that was not intended to be provided as part of the testing procedure or study design?  
  (DEF 13) |
| 7. Were raters blinded to additional cues that were not part of the test?  
  (DEF 14) |
| 8. Was the order of examination varied?  
  (DEF 15, 16) |
| 9. Was the time interval between repeated measurements compatible with the stability (or theoretical stability) of the variable being measured?  
  (DEF 17) |
| 10. Was the test applied correctly and interpreted appropriately?  
  (DEF 18) |
| 11. Were appropriate statistical measures of agreement used?  
  (DEF 19, 20, 21) |

Appendix C: Table of reliability in studies using observational methods of sitting posture
Sitting Posture Reliability Table

The following table summarises the studies found investigating reliability using observational methods to assess sitting posture. Literature was reviewed through the online Unitec Library search including the databases Scopus (Elsevier), Directory of Open Access Journals (DOAJ), MEDLINE/PubMed (NLM) and OneFile (GALE). Images following the table are from the authors to show the angles discussed in diagrammatic form.

Keywords included combinations of the following: sitting, posture, examination, assessment, observation, work station, ergonomics, reliability and analysis. Papers were included from the date of inception of the database till December 2016. Papers were excluded if they did not meet the inclusion criteria by, using an intervention, using participants with physical disabilities or investigating sitting posture with intentions other than finding the reliability.

Studies were included in the table if they directly investigated reliability of assessing angles in sitting posture and from English-language journals. Papers were included if they assessed both sitting and standing posture however only the data from the sitting aspect was included in this table.
<table>
<thead>
<tr>
<th>Author &amp; Date</th>
<th>Design</th>
<th>Participants (n)</th>
<th>Study’s used name of Angle</th>
<th>Reliability of Angle</th>
<th>Result</th>
<th>Setting &amp; equipment used</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Niekerk, 2008</td>
<td>RMOS P R</td>
<td>17 15-yo (7M, 10F), 22 16yo (12M 10F)</td>
<td>Sagittal head Angle</td>
<td>“Moderate to good reliability”</td>
<td>ICC=0.98</td>
<td>L</td>
<td>P R</td>
</tr>
<tr>
<td>Perry, 2008</td>
<td>CSS O</td>
<td>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</td>
<td>Head flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brink, 2013</td>
<td>RMOS</td>
<td>10M and 14F, HSS 15 to 18yo</td>
<td>Head flexion</td>
<td>“almost perfect reproducibility”</td>
<td>ICC=0.86</td>
<td>L</td>
<td>3D-PAT VMAS</td>
</tr>
<tr>
<td>Koraklis, 2014</td>
<td>SST-R</td>
<td>25 healthy US - 13M MA 24.5, 12F MA 23.3</td>
<td>Head Angle</td>
<td>ICC=0.96</td>
<td>L</td>
<td>P U VB</td>
<td></td>
</tr>
<tr>
<td>Pownall, 2008</td>
<td>RMOS</td>
<td>11M, MA 29.6</td>
<td>Head Angle</td>
<td>“Nearly perfectly reproducible. Reliable”</td>
<td>ICC=0.92</td>
<td>L</td>
<td>P DV</td>
</tr>
</tbody>
</table>

**Head Neck** – Angle between the line of tragus of ear and canthus intersecting with the HL

**Head Angle** – The euler angle between the segments of the head and thorax regarding the VA in their embedded three-axis co-ordinate system

**Head Angle** – HL through C7 forms an angle with line through C7 to tragus
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Study Details</th>
<th>Measure</th>
<th>Reproducibility</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Displacement</td>
<td>Horizontal distance between markers at C7 and tragus</td>
<td>Perry, 2008 CSS O, 765M, 715F, mean; age=14.1, H=1.64 m, weight=57.7 kg</td>
<td>Head displacement</td>
<td>IaR – “Excellent” InR - “fair to good”</td>
<td>IaR ICC= 0.972, InR ICC=0.618</td>
</tr>
<tr>
<td>Head tilt angle of head lateral bending</td>
<td>The lateral angle between line drawn from OCI to the tragus with the vertical line through OCI</td>
<td>Korakis, 2014 SST-R, 25 healthy US, 13M MA 24.5, 12F MA 23.3</td>
<td>Head tilt Angle</td>
<td>ICC=0.96</td>
<td>L P U VB</td>
</tr>
<tr>
<td>Head rotation</td>
<td>The angle formed from a line drawn from the tragus MP to the canthus with the ant axis in the transverse plane</td>
<td>Brink, 2013 RMOS, 10M and 14F, HSS 15 to 18yo</td>
<td>Head rotation</td>
<td>“poor reproducibility”</td>
<td>ICC=0.29</td>
</tr>
<tr>
<td>Head Angle</td>
<td>HL through C7 forms an angle with line through C7 to tragus</td>
<td>Pownall, 2008 RMOS, 11 M MA 29.6</td>
<td>Head Angle</td>
<td>“Nearly perfectly reproducible. Reliable”</td>
<td>ICC=0.92</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Participants</td>
<td>Measurement</td>
<td>ICC</td>
<td>Reliability</td>
</tr>
<tr>
<td>-------</td>
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<td>-----</td>
<td>--------------</td>
</tr>
<tr>
<td>Perry, 2008</td>
<td>CSS O</td>
<td>765M, 715F, MA of 14.1y, H=1.64 m and weight=57.7 kg</td>
<td><strong>Craniocervical Angle</strong></td>
<td>IaR ICC=0.849, InR ICC=0.396</td>
<td>L</td>
</tr>
<tr>
<td>Brink, 2013</td>
<td>RMOS</td>
<td>10M and 14F, HSS 15 to 18yo</td>
<td><strong>Cranio-cervical A</strong></td>
<td>“substantial reproducibility” ICC=0.64</td>
<td>L</td>
</tr>
<tr>
<td>van Niekerk, 2008</td>
<td>RMOS P R</td>
<td>17 15-yo (7M, 10F), 22 16yo (12M 10F)</td>
<td><strong>Cervical A</strong></td>
<td>“Moderate to good reliability” ICC=0.98</td>
<td>L</td>
</tr>
<tr>
<td>Brink, 2013</td>
<td>RMOS</td>
<td>10M and 14F, HSS 15 to 18yo</td>
<td><strong>Neck flexion (NF)</strong></td>
<td>“substantial reproducibility” ICC=0.69</td>
<td>L</td>
</tr>
<tr>
<td>Perry, 2008</td>
<td>CSS O</td>
<td>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</td>
<td><strong>Neck flexion</strong></td>
<td>IaR – “Excellent” InR - “fair to good” IaR ICC=0.968, InR ICC=0.</td>
<td>L</td>
</tr>
<tr>
<td>Korakis, 2014</td>
<td>SST-R</td>
<td>25 healthy US - 13M MA 24.5, 12F MA 23.3</td>
<td><strong>Neck Angle</strong></td>
<td>ICC=0.85</td>
<td>L</td>
</tr>
</tbody>
</table>

**Craniocervical Angle** – Angle between line of canthus to tragus and HL of tragus to C7 (measured ant)

**Neck Flexion** – The angle formed by the line of the tragus to C7 intersecting with a vertical line from the tragus

**Neck Flexion or Neck Angle** – The angle between a line drawn from the OCI to the C7 SP and the vertical axis
<table>
<thead>
<tr>
<th><strong>Head Protraction Angle</strong> – Aggregation of HT and NE angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korakis, 2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Neck lateral bending</strong> – Angle between a line drawn from the OCI to the C7 SP, with the VA going through the C7 in the frontal plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brink, 2013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Cervico-thoracic Angle</strong> – Line between the ORBVM and C7 SP marker intersecting the line between the C7-T5 SP markers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korakis, 2014</td>
</tr>
<tr>
<td>Perry, 2008</td>
</tr>
<tr>
<td>Brink, 2013</td>
</tr>
</tbody>
</table>
**Protraction/retraction Angle** – MP of the humerus to C7 SP and the angle HL MP of the humerus

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Participants</th>
<th>Protraction/retraction Angle</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perry</td>
<td>2008</td>
<td>17 15-yo (7M, 10F), 22 16-yo (12M, 10F)</td>
<td>“Moderate to good reliability.”</td>
<td>ICC=0.94 L P R</td>
</tr>
</tbody>
</table>

**Scapula displacement** – Horizontal distance between markers at C7 and the anterior border of the acromion

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Participants</th>
<th>Scapula displacement</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perry</td>
<td>2008</td>
<td>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</td>
<td>IaR – “Excellent” InR – “fair to good”</td>
<td>IaR ICC=0.990 InR ICC=0.617 L MAPM</td>
</tr>
</tbody>
</table>

**Scapula elevation** – Vertical distance between markers at C7 and the anterior border of the acromion

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Participants</th>
<th>Scapula elevation</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perry</td>
<td>2008</td>
<td>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</td>
<td>IaR – “Excellent” InR – “fair to good”</td>
<td>IaR ICC=0.997 InR ICC=0.699 L MAPM</td>
</tr>
</tbody>
</table>

**Arm Angle** – Line between the MP of the humerus and the lateral epicondyle of the elbow and the angle to the vertical line through the MP of the humerus

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Participants</th>
<th>Arm Angle</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>van Niekerk</td>
<td>2008</td>
<td>17 15-yo (7M, 10F), 22 16-yo (12M, 10F)</td>
<td>“Moderate to good reliability”</td>
<td>ICC=0.99 L P R</td>
</tr>
<tr>
<td>Measurement</td>
<td>Description</td>
<td>Participants</td>
<td>Reliability Measure</td>
<td>Reproducibility</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Thoracic Angle</strong></td>
<td>Obtained from the 7-T5 SP marker segment and the T5-T10 SP marker segment</td>
<td>Korakis, 2014: 25 healthy US 13M MA 24.5, 12F MA 23.3</td>
<td>ICC=0.98</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SST-R</td>
<td>P</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Thoracic Angle</strong></td>
<td></td>
<td>VB</td>
</tr>
<tr>
<td><strong>Thoracic Angle</strong></td>
<td>The line between the SP C7 and the manubrium and the angle to the line through SP of T8 and the manubrium</td>
<td>van Niekerk, 2008: 17 15-yo (7M, 10F), 22 16yo (12M 10F)</td>
<td>“Moderate to good reliability”</td>
<td>ICC=0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMOS P R</td>
<td>P</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Thoracic Angle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trunk flexion</strong></td>
<td>Angle formed from a line drawn from the C7 SP to the MP of the GT and the VA</td>
<td>Brink, 2013: 10M and 14F. HSS 15 to 18yo</td>
<td>“almost perfect reproducibility”</td>
<td>ICC=0.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMOS</td>
<td>3D-PAT</td>
<td>VMAS</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Trunk flexion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thoracic trunk rotation</strong></td>
<td>The angle between a line from the sternum to the T5 SP, with the ant axis in the transverse plane (negative to the left)</td>
<td>Brink, 2013: 10M and 14F. HSS 15 to 18yo</td>
<td>“poor reproducibility”</td>
<td>ICC=0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RMOS</td>
<td>3D-PAT</td>
<td>VMAS</td>
</tr>
<tr>
<td><strong>Trunk Angle</strong> – Angle between line of C7 to T12 and line of 12 to GT (measure post to intersect)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----</td>
<td>----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perry, 2008</td>
<td>CSS O</td>
<td>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trunk Angle</strong></td>
<td>IaR ICC=0.998</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>InR ICC=0.806</td>
<td>MAPM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Segment Thoraco-lumbar Angle** – Obtained from the T5-T10 SP markers segment and the T10-L3 SP marker segment |
|----|----|----|
| **Thoraco-lumbar Angle** | ICC=0.94 | L |
| U |
| VB |

| **Lumbar Angle** – T10-L3 SP marker and the L3-S2 SP marker |
|----|----|----|
| **Lumbar Angle** | ICC=0.96 | L |
| P | U | VB |

| **Pelvic Tilt** – Line of GT to ASIS with respect to HL |
|----|----|----|
| Perry, 2008 | CSS O | 765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg |
| **Pelvic tilt** | IaR – “Excellent” InR - “fair to good” |
| IaR ICC=1 | InR ICC= 0.489 |
| L | P MAPM |

<p>| <strong>Hip-trunk Angle</strong> – Line from C7 marker through GT intersected by line through GT and FH |
|----|----|----|
| Pownall, 2008 | RMOS | 11 M MA 29.6 |
| <strong>Hip-trunk Angle</strong> | ICC=0.55 | L |
| P DV |</p>
<table>
<thead>
<tr>
<th>Lumbar Angle</th>
<th>T12 to ASIS intersected with line of ASIS to GT (posterior angle)</th>
<th>Perry, 2008</th>
<th>CSS</th>
<th>765M, 715F, mean; age=14.1 H=1.64 m weight=57.7 kg</th>
<th>Lumbar Angle</th>
<th>IaR – “Excellent” InR - “fair to good”</th>
<th>IaR ICC=1 InR ICC= 0.491</th>
<th>L</th>
<th>P MAPM</th>
</tr>
</thead>
</table>

| Greater trochanter Angle | Angle formed between a HL through the GT and a line formed between the GT and FH | Pownall, 2008 | RMOS | 11 M MA 29.6 | Greater trochanter Angle | “reliable” ICC=0.93 | L | P DV |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pownall, 2008 | RMOS | 11 M MA 29.6 | C7-T4 | ICC=0.93 | L | P DV |
| Pownall, 2008 | RMOS | 11 M MA 29.6 | T4-T8 | ICC=0.57 | L | P DV |
| Pownall, 2008 | RMOS | 11 M MA 29.6 | T8-T12 | ICC=0.70 | L | P DV |
| Pownall, 2008 | RMOS | 11 M MA 29.6 | T12-L5 | ICC=0.66 | L. |
**Pelvic Angle** – obtained from the global ant-post axis and the line connecting two virtual markers representing the MP of the two ASIS and the two PSIS. This angle represented the sagittal pelvic tilt and angular values greater than 180 degrees were obtained for ant pelvic tilt beyond the ant-post axis.

KSG2014 SST-R 13M MA 24.5, 12F MA 23.3 **Pelvic Angle** ICC=0.94 L P U VB

**Key:**
- M=Male
- F=Female
- L=Lab Setting
- F=Field Type Setting
- P=Photographic
- R=radiograph
- DV=Digital Video
- U=Ultrasound
- MA=Motion Analysis
- VMAS=Vicon motion analysis System
- VB=Vicon Bodybuilder
- 3D-PAT=Three-dimensional portable, non-invasive posture analysis tool
- RMOS=Repeated Measures Observational Study
- O=Observation
- CSS=cross sectional survey
- SST-R=Single Session test-retest
- GT=Greater Trochanters
- VA=VA
- SP=spinous proves
- A=angle
- OCI=MP between the left and right tragus
- FH=Fibular Head
- US=University Students
- VA=VA
- HSS=Highschool students
- MA=Mean age
- H=Height
- Ant=Anterior
- Post=posterior
- Horizontal Line=HL
- PSIS=posterior superior iliac spines
- ASIS=anterior superior iliac spines
- MP=midpoint
- IaR=Intra rater
- InR=Inter rater
Diagrammatic representation to clarify the angles discussed in the previous table:

<table>
<thead>
<tr>
<th>Angle</th>
<th>Description</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal head angle</td>
<td>The line between the lateral canthus of the eye and midpoint of the tragus and the angle of the horizontal line through the middle of the tragus. ( \tan ) ( \theta ) ( \frac{T_{1}-C_{3}}{T_{3}-C_{3}} ) ( \text{(Appendix 1)} )</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Cervical angle</td>
<td>The line between the midpoint of the tragus and spinous process of C7 and the angle to the horizontal line through the spinous process of C7. ( \tan ) ( \theta ) ( \frac{T_{1}-C_{7}}{T_{3}-C_{7}} ) ( \text{(Appendix 1)} )</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Protraction/retraction angle</td>
<td>The line between the midpoint of the humerus and spinous process of C7 and the angle to the horizontal line through the midpoint of the humerus. ( \tan ) ( \theta ) ( \frac{C_{7}-H_{2}}{C_{7}-H_{2}} ) ( \text{(Appendix 1)} )</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Arm angle</td>
<td>The line between the midpoint of the humerus and the lateral epicondyle of the elbow and the angle to the vertical line through the midpoint of the humerus. ( \tan ) ( \theta ) ( \frac{E_{2}-H_{2}}{E_{2}-H_{2}} ) ( \text{(Appendix 1)} )</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Thoracic angle</td>
<td>The line between the spinous process C7 and the manubrium and the angle to the line through spinous process of T8 and the manubrium. ( \cos ) ( \theta ) ( \frac{T_{1}T_{3}}{T_{1}T_{3}} ) ( \text{(Appendix 1)} )</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Diagrammatic representation to clarify the angles discussed in the previous table:

Diagrammatic representation to clarify the angles discussed in the previous table:

Diagrammatic representation to clarify the angles discussed in the previous table:

Appendix D: Description of the steps of development for the Sitting Posture Rating Tool (SPRT)
Development of the SPRT

The idea for the tool was drafted by Moran, Henwood, and Silvester chosen due to the group's experience in physical assessment of sitting posture and knowledge on the literature available identifying a need for an objective rating tool that was practical for manual therapists. The six sub-tests chosen for the tool were: Neck on Body Angle, Gaze Angle, Arm Angle, Thoracic Kyphosis, Body to Monitor and Coronal Symmetry. A three-point scale was used with the terms, poor, fair and good to distinguish the sub-tests. Some description of what these six sub-tests were included and a marking sheet, however, the sitting assessment tool remained untitled. No further development or investigation was undertaken by these authors.

A literature review was then undertaken for this thesis by the researcher GK. The only sub-test that changed was the the Arm Angle. Instead of focusing on elbow flare, became Glenohumeral Internal Rotation which became more inclusive of assessment of the upper limb as it allowed the inclusion for the elbow flare aspect in the description.

Following the literature review investigating other angles of sitting posture assessed by other authors, an advisory group meeting was held with Robert Moran, GK, and Mark Silvester to discuss whether there was adequate evidence for each of the sub-test to be included and whether a three-point scale was necessary. The resultant sub-tests were Neck on Body Angle, Gaze Angle, Glenohumeral Internal Rotation, Thoracic Kyphosis, Body to Monitor and Coronal Symmetry with further instructions on the criteria to grade each of the sub-tests.

Lateral photographs were taken to continue finding an operational definition for the three categories of Thoracic Kyphosis and Gaze Angle. This aided in distinguishing between the three categories for each of the sub-test. Subjects were then recruited for the sitting posture video recordings of which the decided camera angles are shown in the Supplementary video 1. GK and the principal supervisor RM used the sitting posture rating tool now named SPRT to rate each of the subjects. From here more of the operational definitions for raters were determined by finding sub-tests that were commonly rated differently by GK and RM. These sub-tests with lower reliability then underwent “tightening up” of criteria. This was done through discussion and rating the subjects again as well as on new subjects’ footage till better reliability was found between GK and RM. Through this process, it was decided for Internal Glenohumeral Rotation that a 2-point scale would suffice due to the complication of distinguishing it between three categories.

All subject’s footage that was taken was then rated to gain consensus ratings between RM and GK. This was done through separate ratings then comparing and discussing any sub-tests not agreed upon till a consensus rating was gained.

The resultant tool from this process is shown in Appendix E below.
Appendix E: Sitting Posture Rating Tool
Sitting Posture Rating Tool

<table>
<thead>
<tr>
<th></th>
<th>1. Satisfactory</th>
<th>2. Fair</th>
<th>3. Poor</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck on body angle</td>
<td>Over/post to clavicle</td>
<td>Line falls over body however anterior to clavicle</td>
<td>Anterior of the clavicle and base of the neck</td>
<td></td>
</tr>
<tr>
<td>Gaze angle</td>
<td>Horizontal line or so close that a slight wobble from the tragus of the card touches on the canthus</td>
<td>Not horizontal – if you are looking multiple times to see if poor then probably fair</td>
<td>Obvious line not horizontal</td>
<td></td>
</tr>
<tr>
<td>Thoracic kyphosis</td>
<td>Minimal curve protruding from behind the business card</td>
<td>Some curve protruding from behind the business card</td>
<td>Large amount of curve protruding from behind business card. If a very leaned back posture or large slump, automatically poor</td>
<td></td>
</tr>
<tr>
<td>Glenohumeral rotation</td>
<td>No internal rotation at GH – not at all a point worth intervening for if thinking about correcting posture</td>
<td>X</td>
<td>Internal rotation, marked elbow flare a point at all where it would be worth correcting for the person sitting</td>
<td></td>
</tr>
<tr>
<td>Coronal symmetry</td>
<td>Cervical spine(Csp) aligns with Thoracic spine (Tsp)/Lumbar spine (Lsp) and shoulders are level</td>
<td>One of these aspects is wrong – un-level shoulders or head leaning to a side</td>
<td>All three do not line up/not level shoulders. Or one markedly unaligned aspect.</td>
<td></td>
</tr>
<tr>
<td>Body to monitor</td>
<td>Line of the bottom of the monitor is parallel to the line of the hips, parallel to the line of the shoulders</td>
<td>One tilt of the business card is required</td>
<td>Two tilts measuring these lines is required when lining up the business card</td>
<td></td>
</tr>
</tbody>
</table>

If very doubtful mark more harshly

Operational Definitions for Raters:

1. **Neck on body angle** The angle formed between a line projected from the greater trochanter to the C7 spinous process and a line between C7 spinous process and the tragus of the ear. The more acute this angle then the greater the head is projected forward of the body. This angle is part of the measure for a common clinical finding “forward head posture”

   **How to rate this item:** Use a straight edged piece of paper or business card to drop a line from the tragus of ear, this line should be parallel to the line of the subject’s body. If this falls over the midpoint of the clavicle or slightly behind this is considered to be ‘satisfactory’. If it drops anterior to the clavicle however still over the body it is ‘fair’. Once this line drops forward of the body then this postural characteristic is poor. If the line drawn is questionable and difficult to distinguish between poor and fair it can be helpful to look at the whole neck and head and get the idea of whether it is actually quite poor or could be worse (fair).

2. **Gaze Angle (head on neck angle).**
   The angle formed between lines from the canthus of the eye to the tragus of the ear to a horizontal line through the tragus of the ear. This line represents the degree to which the upper and mid cervical spine is postured in extension. The closer this angle is to zero the less extension is present. **How to rate this item:** When assessing this a useful question is; “could this be better?” i.e. more flexed or could it be worse i.e. more extended. For satisfactory this line needs to be horizontal or within a wobble of the card that the canthus is touched by the edge
of paper. For fair, this line must be not horizontal and just out of reach when a slight wobble is done with the card. Poor is a significantly raised or lowered line from the horizontal line.

3. Thoracic kyphosis
The degree of thoracic kyphosis affects head and neck position. This can be quite obvious however try to separate each of the postural aspects to achieve finding the source of the issue in the persons sitting posture. The kyphotic curve is estimated to be satisfactory if there is minimal curve and poor if there is significant curve and slouching forwards fair would be a curve that could be better but could also be worse. How to rate this item: Cover the body from C7 – T10/12 straight edged paper or business card to expose just the thoracic kyphosis. Look particularly at the zone T6 -T 10 this is most commonly where there is increased curve. Again a useful question to ask is “could this be better, could this be worse”. If the subject is leaning far back in the chair or extremely slumped, then the grade for this is automatically poor.

4. Glenohumeral rotation
The amount of internal rotation or positioning of the glenohumeral joint that may be compromising the shoulder girdle position and or sub acromial space. The more internal rotation there is at the glenohumeral joint the greater the angle between the forearm and the upper arm in the sagittal plane indicating looking at the elbow position can help with assessing the GH orientation. How to rate this item: This has only two grading choices either a satisfactory or poor grade. If there is any internal rotation or elbow flaring this grade will be poor. If the hand is outside the line of the elbow or inline, then this is satisfactory.

5. Coronal/Axial asymmetry
The deviation from the midline of the head, to either side, in the coronal plane only side bending can be noted (not rotation) as this is done from the posterior view. There are three things to look for in this aspect. Neck/head line, thoracic/ lumbar line and the orientation of the AC joint to AC joint line. How to rate this item: For a satisfactory grade both the line of the Tsp and the line of the Csp need to match, the shoulders also need to be level. Fair may be that the Csp and Tsp may be aligned however the shoulders are asymmetrical. A poor grade would include asymmetry of the shoulders and also misalignment of the Csp and Tsp. A poor grade would also be chosen if there was one marked curve in the coronal plane i.e. an obvious lean to one side.

More of an ergonomic design assessment than purely posture, depends on their adjustment of the seat and workstation as well as their resultant posture. This characteristic is assessed from an above view. Look to find line of the AC joints/eyes, hips if able to view and the line of the monitor run parallel to each other. How to rate this item: Using a business card line up from the monitor, line of hips and line of AC joint and the eyes. To achieve satisfactory grade all of these three lines need to be parallel with each other and to the monitor. For a fair grade only one change the angle of the business card at the hips AC line or eyes. Two and three changes to the orientation of the business card would indicate a poor grade.

Additional notes
Asymmetry If someone is sitting off centre when looking from the front often one shoulder will be lower and or the head not central. Usually they will be sitting with more weight on one buttock, this may be obvious when looking at them. Habits which encourage this are leg crossing or sitting on one foot.
Sitting posture Observation of the thoracic kyphosis and lumbar lordosis. Ideally when one is sitting there should be a shallow lumbar lordosis and no significant exaggeration of the kyphosis. Poor sitting posture often leads to forward head position
Arm position When using the hands for example on the mouse ideally the palm should be facing down and the wrist in pronation. If this is the case the elbow (olecranon) will be pointing down not out to the side (fish fins). If the student is using internal rotation to get the palm down the olecranon will point predominantly laterally out to the side. This can cause neck tension and shoulder problems.
Head position Head position is key to having a comfortable upper quadrant. The head can be regarded as forward if a vertical line dropped from the ear lobe drops on or forward of the clavicle. This tends to occur if the thoracic spine or CT junction is habitually flexed. If the mid cervical or upper cervical spine is simultaneously extended in order to look forward this is can cause problems. Another issue to look out for is cradling the head in the hand or hands especially if the support is along the jaw, this position causes stress on the upper cervical spine and the TMJ.
**General** When looking at each of the criteria do not let other characteristics alter your grading for that one aspect. However also do not become so minimalistic that you forget to look at the whole aspect, this is particularly true for Neck on body angle.

**Process**

Raters were provided with this outline along with a straight edged piece of paper to investigate the video clips and determine the rating outcomes for each of the sub-tests.

Ratings were then entered into the rating grid represented by an x, on an excel spreadsheet which for the reliability study was a simplified version as shown here:

<table>
<thead>
<tr>
<th></th>
<th>Satisfactory</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck on body angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaze angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic kyphosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glenohumeral rotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal symmetry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body to monitor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Participant Information sheet
Participant Information Sheet

Research Project Title: Development and preliminary testing of a practical tool for visual assessment of seated posture

Outline of the project

My name is Georgina Kydd. I am currently enrolled in the Masters of Osteopathy degree at Unitec Institute of Technology, New Zealand. As part of my Osteopathy degree, I am required to complete a research project and thesis whereby I will need to recruit a selection of participants who give their consent to partake in my study. The aim of my study is to develop a sitting posture assessment tool and use it to assess participants’ postures and ultimately determine whether it is a reliable tool for use in a clinical setting.

What we are doing

I will be developing criteria to rate sitting posture, and then taking digital images (photographs and short video clips) of participants in a seated position at a desk. Once images of all participants are taken they will then be shown to raters who are familiar with physical examination. These raters will be asked to review the posture seen on the photographs using the criteria from the tool we have designed. The information gained from this research will inform whether this tool is reliable to use in practice by manual therapists.

What it will mean for you

If you were to consent to being involved in this research study, you would simply be required to sit at a set-up work station, this will be located Clinic 41, Mount Albert Campus of Unitec Institute of Technology. It will be necessary for the purpose of the study that you wear fitting clothing (not loose or baggy clothing). You may undertake computer based tasks of your own choosing so that we can gain images. A computer and work-bench would be provided for you to work on.

The images taken of your posture will then be used for the rest of this study to use a posture rating tool assessing your posture.
If accepted into the study you will be asked to sign a consent form saying that you agree to the requirements of the study. You still may decide not to participate after this. If you change your mind and wish to withdraw your and moving forward with the rest of the study you may withdraw (including your photographs) up to 2 working days after your photograph has been taken.

It is possible that a rater viewing your image may know you or identify you because of a relationship outside of this project however your name and any sensitive information will not be shared with any other participants. All the information involved with this study which may include details of your participation will be stored securely on a computer at Unitec for a period of 5 years. Hard copy information will be kept in a locked filing cabinet at Unitec, only the researcher and supervisors will have access to this information.

Please contact the researcher Georgie Kydd or primary supervisor, Robert Moran should you have any concerns or would like more information about the project.

Georgie Kydd

Phone: 0277239161

Email: KYDDG02@wairaka.com

Robert Moran:

Phone: (09) 815-4321 ext. 8197 or

Email: rmoran@unitec.ac.nz

UREC REGISTRATION NUMBER: 2016-1008

This study has been approved by the UNITEC Research Ethics Committee from 17 March 2016 to 17 March 2017. 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 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix G: Information for Raters
Information for Raters

Research Project Title Development and preliminary testing of a practical tool for visual assessment of seated posture

Outline of the project

My name is Georgina Kydd. I am currently enrolled in the Masters of Osteopathy degree at Unitec New Zealand and seek your help in meeting the requirements of research for a Thesis course which forms a substantial part of this degree. We will be making a postural assessment tool and a group of recruited raters (you) will use this tool to assess participants’ posture.

What we are doing

I will be forming criteria to produce a tool which rates sitting posture. Taking video footage of recruited subjects and then using raters (you) who are familiar with physical examination to rate the posture seen in the video footage. The information gained from this research will inform whether this tool is reliable to use in practice by manual therapists.

What it will mean for you

You will need to be a student enrolled in the Masters of Osteopathy programme at Unitec Institute of Technology or a Master of Osteopathy Students, or qualified musculoskeletal therapists (ie physiotherapy, chiropractic) with formal training and practical experience in postural examination.

You will be asked to attend 3 sessions all of these sessions together will not exceed 5 hours in total. These will be in allocated times with other recruited raters within 2 weeks from beginning to finish. The first session will teach you how to use the rating tool which may take up to 2 hours. The following two sessions will be spaced one week apart and take up to 1.5 hours per session. In these two sessions you will be using the recorded footage of recruited subjects to use the tool and rate them. What you fill out will be used by the researcher to assess the reliability of the tool that has been produced.
You will be in a room with other raters when learning how to use and when the actual data collection takes place. This means to these other raters your identity will not be confidential however your name and other sensitive information will not be used, shared or relevant to the study. If you agree to participate, you will be asked to sign a consent form. This does not stop you from changing your mind if you wish to withdraw from the project. However because of the research data analysis you can only withdraw your data until 2 working days after you have attended each data collection session.

Please contact the researcher Georgie Kydd or primary supervisor, Robert Moran should you have any concerns or would like more information about the project.

Georgie Kydd

Phone: 0277239161

Email: KYDDG02@wairaka.com

Robert Moran:

Phone: (09) 815-4321 ext. 8197 or

Email: robmoran@unitec.ac.nz

UREC REGISTRATION NUMBER: 2016-1008

This study has been approved by the UNITEC Research Ethics Committee from 17/03/2016 to 17/03/2017. 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 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Subject Consent Form

Research Project Title: Development and preliminary testing of a practical tool for visual assessment of seated posture

I have had the research project explained to me and I have read and I understand the information sheet that was given to me.

I understand that I do not have to be part of this research project should I choose not to participate and that I may withdraw myself and digital images of me from the study up to 2 working days after images have been taken.

I understand that my full image will be photographed and shown to other participants named ‘raters’ during this study for the use of the researcher.

I understand none of the information I give such as name and age will be made known to the other participants. I also understand that all the information that I give relevant to the study will be stored securely on a computer at Unitec for a period of 5 years.

I understand that I can see the finished research document if I request it.

I have checked this box to receive an email including a summarised rating of my sitting posture using this tool via my email address I provide below ☐

Email address:

I have had time to consider all that is involved and I give my consent to be video-recorded and to be part of this study.

Participant Name: …………………………………………………… Date: …………………………………

Participant Signature: …………………………………………… Email: ………………………………

Project Researcher: Georgina Kydd

UREC REGISTRATION NUMBER: 2016-1008

This study has been approved by the UNITEC Research Ethics Committee from 17 March 2016 to 17 March 2017. 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 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Raters’ Consent Form

Research Project Title: Development and preliminary testing of a practical tool for visual assessment of seated posture

I have had the research project explained to me and I have read and understand the information sheet given to me.

I understand that I don’t have to be part of this research project should I choose not to participate and may withdraw my participation up until 2 working days post each data collection session.

I understand that other raters, the researcher and supervisors may be able to identify me however none of my information such as name or age will be used, shared or relevant to this study. I also understand that all the information that I give will be stored securely on a computer at Unitec for a period of 10 years.

I understand that my data will be used to find the reliability of the tool used in this study.

I understand that I can see the finished research document if I request it.

By signing this document, I also agree to keep all other participants including subject’s identities confidential. I have had time to consider all that is involved and I give my consent to be a part of this study.

Participant Name: ………………………………………………..…                  Date: ……………………………

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

Project Researcher: Georgina Kydd

UREC REGISTRATION NUMBER: (2016-1008)

This study has been approved by the UNITEC Research Ethics Committee from 17/03/2016 to 17/03/2017. 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 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Georgina Kydd  
14 Frederick Street  
Blenheim  

18.5.16

Dear Georgina,

Your file number for this application: **2016-100 8**

Title: **Development and preliminary testing of a practical tool for visual assessment of seated posture.**

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

**Start date: 11.5.16**  
**Finish date: 17.3.17**

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,

Sara Donaghey  
Deputy Chair, UREC  

cc: Rob Moran  
Cynthia Almeida
17.3.16

Dear Georgina,

Your file number for this application: 2016-1008
Title: Development and preliminary testing of a practical tool for visual assessment of seated posture.

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: 17.3.16
Finish date: 17.3.17

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,

Sara Donaghey
Deputy Chair, UREC

cc: Rob Moran
Cynthia Almeida
Full name of author: Georjha Kydd

Full title of thesis/dissertation/research project ('the work'):
Development and preliminary testing of a sitting posture rating tool

Practice Pathway: Health and Community - Osteopathy
Degree: Master of Osteopathy
Year of presentation: 2016

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Signature of author: ____________________________
Date: 22/1/16