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Determining the reliability of a custom built seated stadiometry set-up for measuring spinal height in participants with chronic low back pain

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ABSTRACT

Indirect measurement of disc hydration can be obtained through measures of spinal height using stadiometry. However, specialised stadiometers for this are often custom-built and expensive. Generic wall-mounted stadiometers alternatively are common in clinics and laboratories. This study examined the reliability of a custom set-up utilising a wall-mounted stadiometer for measurement of spinal height using custom built wall mounted postural rods. Twelve participants with non-specific chronic low back pain (CLBP; females n = 5, males n = 7) underwent measurement of spinal height on three separate consecutive days at the same time of day where 10 measurements were taken at 20 s intervals. Comparisons were made using repeated measures analysis of variance for 'trial' and 'gender'. There were no significant effects by trial or interaction effects of trial x gender. Intra-individual absolute standard error of measurement (SEM) was calculated for spinal height using the first of the 10 measures, the average of 10 measures, the total shrinkage, and the rate of shrinkage across the 10 measures examined as the slope of the curve when a linear regression was fitted. SEMs were 3.1 mm, 2.8 mm, 2.6 mm and 0.212, respectively. Absence of significant differences between trials and the reported SEMs suggests this custom set-up for measuring spinal height changes is suitable use as an outcome measure in either research or clinical practice in participants with CLBP.

1. Introduction

Chronic low back pain (CLBP) is a highly prevalent condition (WHO, 1998; ONS, 2000; Waddell and Burton, 2000; Walker, 2000; NICE, 2009) representing an enormous economic cost worldwide (Van Tulder et al., 1995; Guo et al., 1999; Maniadakis and Gray, 2000; Ekman et al., 2005; Waddell et al., 2002; Stewart et al., 2003; Ricci et al., 2006; Katz, 2006; NICE, 2009; Freburger et al., 2009). CLBP is a multifactorial condition with a variety of associated symptoms (National Research Council, 1998; National Research Council & Institute of Medicine (2001)), abnormalities in the intervertebral discs being a common association, and also suspected as a potential source of pain in CLBP (Adams and Roughley, 2006; Adams et al., 2010). A frequent disc abnormality and one which is known to be potentially painful when associated with nerve root deformation/displacement is disc herniation (DeLeo and Winkelstein, 2002). Disc herniation is thought to typically occur in younger more hydrated discs (Adams and Muir, 1976; Adams and Hutton, 1985) whereas older degenerated discs are generally characterised by cracks (Goel et al., 1995). However, more recently researchers have shown that degenerated discs with lower osmotic pressures and decreased annular stresses are more likely to enhance the opening of cracks in the anullus and lead to herniation (Wognum et al., 2006). In fact Videmann et al. (1995) documented that vertebral body osteophytes are highly associated with end plate irregularity and disc bulging, yet osteophytes are generally accepted as secondary to disc and end plate trauma despite taking years to develop (McGill, 2007). Thus degenerative discs may be at greater risk of herniation.

Loss of disc hydration and disc height is commonly considered indicative of degenerative processes as opposed to being age

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related (Adams and Roughley, 2006; Griffith et al., 2007). Disc hydration is often measured via magnetic resonance imaging (MRI; Paajanen et al., 1994), but indirect measurement can be obtained through measures of spinal height using stadiometry (Kourtis et al., 2004). As such, for researchers wishing to examine the effects of potential interventions upon CLBP and associated symptoms such as disc hydration, as well as for clinicians examining changes in their patients, the use of stadiometry may be of value as an outcome measure.

A number of studies have used stadiometry, both standing and seated, to examine the effects of different variables upon spinal height. There is a well-documented effect of time of day (diurnal variation) upon stature (Reilly et al., 1984; Tyrell et al., 1985) similar in both standing and seated stadiometry, suggesting most stature loss comes from the spine (McGill et al., 1996). Using MRI, research confirms a diurnal loss in disc height to support this (Paajanen et al., 1994). Changes in stature have been used to examine the effects of loading patterns upon changes in spinal height also. Resistance type exercise elicits a reduction in spinal height (Wilby et al., 1987; McGill et al., 1996), as do plyometric drop jump and pendulum based exercises (Fowler et al., 1997). Changes in recovery postures, such as lying supine with or without hyperextension, have also been shown to elicit recovery of stature loss from loading (Magnusson et al., 1996; Healey et al., 2004; Kourtis et al., 2004). In turn, recovery of stature has been shown to be associated with recovery of disc height via MRI also (Kourtis et al., 2004).

In addition to indirect determination of disc hydration, shrinkage in stature over time during a measurement trial is a well observed phenomenon also that represents the deformation in both discs and musculo-ligamentous tissue (Stothart and McGill, 2000). It is often used as a measure of the spinal 'creep' (i.e. change in spinal height over time) that occurs due to its visoelastic properties and may reflect the potential for structures of the spine to experience time related changes in biomechanical stresses (Magnusson et al., 1996; Van Dieen and Toussaint, 1993). Kanlayanaphotporn et al. (2003) have shown that, although measures of spinal creep using seated stadiometry differ between CLBP participants and asymptomatic controls (older CLBP participants showing greater creep), it is a reliable measure in both groups (Kanlayanaphotporn et al., 2002). They reported a standard error of measurement (SEM) of ~1–2 mm using a custom built stadiometer designed to control for participant posture during testing using pressure transducers at various anatomical landmarks (Kanlayanaphotporn et al., 2002). Thus they concluded that a change in shrinkage in excess of 2 mm was needed to confidently state that an applied intervention had been responsible for the observed change.

Use of stadiometers to examine factors relating to spinal height has potentially valuable application in examination of both acute and chronic occupational loading or ergonomic factors that might impart stresses to the spine and increase the risk of injury (McGill et al., 1996). Indeed such measures may offer indirect measurement of the overall robustness of the spine to resist such loading as it has been found there is a correlation between trunk strength and stature loss (Wilby et al., 1987). Methods such as those described by Kanlayanaphotporn et al. (2002; 2003) are arguably quite robust as they are able to control for spinal posture using pressure transducers. However, stadiometers such as this, specifically designed for accurate measurement of stature as an outcome measure, are often expensive or are custom built for purely research purposes. Alternatively many laboratories and clinical facilities have access to wall mounted stadiometers typically used for measuring standing stature as a participant demographic characteristic. A set of simple wall mounted postural rods were custom produced (Southampton Solent University, Southampton, UK) for use with a wall mounted stadiometer in order to control for posture whilst taking seated measurements. However, in order for custom built apparatus to be considered useful the reliability of the system requires investigation and the determination of measurement error in order to differentiate it from changes as a result of intervention. The value of such a system might be determined further by whether it could reliably detect the typical magnitudes of stature changes seen from conditions investigated in the extant literature (Voss et al., 1990). Indeed the value of stadiometer use in general for ergonomics research has been argued to be dependent primarily upon its reliability (McGill et al., 1996).

The feasibility of this simple custom set-up to be used within a research or clinical setting for examining changes in seated stature or shrinkage has not yet been determined. Thus the present study sought to investigate the between-day reliability of the device through calculation of the SEM of seated stature and shrinkage over consecutive measurements.

2. Material and methods

2.1. Participants

Twelve participants (males n = 7, females n = 5) were recruited through posters, group email and word of mouth from Southampton Solent University. Inclusion criteria were as follows: participants had to have suffered from non-specific low back pain for longer than 12 weeks (Frymoyer, 1988). Exclusion criteria included: acute (not re-occurring) low back injury occurring within the last 12 weeks, pregnancy, evidence of sciatic nerve root compression (sciatica), leg pain radiating to below the knee, paraesthesia (tingling or numbness), current tension sign, lower limb motor deficit, current disc herniation, previous vertebral fractures or other major structural abnormalities. All participants were screened for exclusion criteria by either their General Practitioner or a Chiropractor in the research group and provided written informed consent. The study was approved by the ethics committee at Southampton Solent University and conducted within the Sport Science Laboratories at Southampton Solent University.

2.2. Equipment

Participants' standing stature (for demographic purposes) and seated stature (for determination of spinal height) were measured using a wall mounted stadiometer (Holtan Ltd, Crymych, Dyfed). Details of seated stature measures are detailed below. Body mass was measured using scales (SECA, Germany) and Body Mass Index (BMI) calculated. Pain was measured using a 100 mm point visual analogue scale (VAS; Ogon et al., 1996), and disability measured using the revised Oswestry disability index (ODI; Fairbank et al., 1980). A customised wooden seat in addition to custom built wall mounted adjustable postural rods (Fig. 1; Southampton Solent University, Southampton) were used with the wall mounted stadiometer for seated stature measurements in order to ensure participants adopted the same posture within the sagittal plane for each retest trial. The back rest of the wooden seat was removed and replaced with a short solid wooden backboard for positioning of the sacral crest and a similar wooden board placed across the rear of the seat's legs to position and secure it against the foot board of the wall mounted stadiometer. The placement of the postural rods mounted to the wall was noted as the vertical distance measured from the floor to the top of the mount and was also traced as a line on the wall with the participants ID noted next to it. This was to ensure that the vertical position of the postural rods was the same for each test. The horizontal distance of the postural rods was ensured by measuring and recording the horizontal distance of the