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Review

A structured review of spinal stiffness as a kinesiological outcome of manipulation: Its measurement and utility in diagnosis, prognosis and treatment decision-making

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ABSTRACT

Purpose: To review and discuss the methods used for measuring spinal stiffness and factors associated with stiffness, how stiffness is used in diagnosis, prognosis, and treatment decision-making and the effects of manipulative techniques on stiffness.

Methods: A systematic search of MEDLINE, EMBASE, CINAHL, AMED and ICL databases was conducted. Included studies addressed one of four constructs related to stiffness: measurement, diagnosis, prognosis and/or treatment decision-making, and the effects of manipulation on stiffness. Spinal stiffness was defined as the relationship between force and displacement.

Results: One hundred and four studies are discussed in this review, with the majority of studies focused on the measurement of stiffness, most often in asymptomatic persons. Eight studies investigated spinal stiffness in diagnosis, providing limited evidence that practitioner-judged stiffness is associated with radiographic findings of sagittal rotational mobility. Fifteen studies investigated spinal stiffness in prognosis or treatment decision-making, providing limited evidence that spinal stiffness is unlikely to independently predict patient outcomes, though stiffness may influence a practitioner's application of non-thrust manipulative techniques. Nine studies investigating the effects of manipulative techniques on spinal stiffness provide very limited evidence that there is no change in spinal stiffness following thrust or non-thrust manipulation in asymptomatic individuals and non-thrust techniques in symptomatic persons, with only one study supporting an immediate, but not sustained, stiffness decrease following thrust manipulation in symptomatic individuals.

Conclusions: The existing limited evidence does not support an association between spinal stiffness and manipulative treatment outcomes. There is a need for additional research investigating the effects of manipulation on spinal stiffness in persons with spinal pain.

1. Introduction

Spinal pain is a common problem in Western cultures, associated with high healthcare and societal costs (Hansson and Hansson, 2005; Martin et al., 2008). Symptoms can be disabling and have a marked detrimental effect on quality of life (Roux et al., 2005), with persons with low back and/or neck pain reporting more comorbid conditions and exhibiting more psychological distress and risky health behaviours than those without symptoms (Strine and Hootman, 2007). Despite extensive healthcare expenditure on treatments for patients with spinal pain (estimated at $86 billion annually in the US) (Martin et al., 2008), many do not achieve resolution of their symptoms (Haldeman et al., 2008).

One common treatment strategy for patients with spinal pain is manipulative therapy, described broadly as hands-on techniques generating movement in body structures (Maitland et al., 2005). It is non-invasive, low risk (Haldeman et al., 1999) and potentially cost-effective (UK BEAM Trial Team, 2004). When performing manipulative techniques, one of the aims of manual therapy is to change the function or biomechanics of the joint where the technique is applied (Maitland et al., 2005; Murtagh and Kenna, 1997). These potential changes to the treated joints can be described as kinesiological effects and are believed to contribute to symptom reduction after manipulative treatment (Bialosky et al., 2009). However, despite manipulation being practised for hundreds of years (Paris, 2000), there is little known about the kinesiological effects of manipulation. In order to select the manipulative treatments that will be the most effective for different spinal conditions, more needs to be known about the potential kinesiological effects of manipulative therapies.

Probably the most commonly discussed kinesiological parameter associated with manipulation is spinal stiffness. From the

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practitioner's perspective, spinal stiffness can be described as the perceived resistance of the spine during the application of a manually applied force (Petty, 2004). In the research context, spinal stiffness is usually described as the relationship between spinal movement or displacement and the force of the resistance to that movement; defined as the slope of the linear region of the force–displacement curve (Shirley, 2004; Snodgrass et al., 2006). Spinal stiffness has been measured using a variety of devices and methods which will be further discussed in this paper. However in practice, stiffness is usually assessed manually using practitioner judgment to determine whether a joint is hypo- or hypermobile. These judgments contribute to diagnosis, prognosis and treatment decision-making in the management of patients with spinal pain, and are also used to evaluate the outcomes of intervention, such as manipulation.

Though there are many individual studies about spinal stiffness and its measurement, a summative review of stiffness and how it is used to assess the effects of manipulative treatments has not been undertaken. This structured review will report the methods used for measuring spinal stiffness and factors associated with stiffness, and will discuss how spinal stiffness is being used in diagnosis, prognosis, treatment decision-making and the evaluation of the effects of manipulative techniques. These constructs were selected for their importance and relevance for practicing clinicians, in order to provide evidence to support their clinical decision-making.

2. Methods

2.1. Data sources and searches

A systematic literature search of MEDLINE, EMBASE, CINAHL, AMED and ICL databases was conducted, limited to articles available in English. A sensitive search strategy (Appendix A, online supplementary data) was employed utilising MeSH terms and keywords comprising the themes of spine, stiffness, measurement, diagnosis, prognosis and manipulation. Specific search strings and phrases were modelled from previous systematic reviews on similar topics (Carlesso et al., 2010; D'Sylva et al., 2010; Downie et al., 2010; Furlan et al., 2009). Citation tracking and hand-searching of relevant journals were used as supplemental search strategies.

2.2. Study selection

For a study to be included in the review it must have addressed at least one of four key research questions: (1) How is spinal stiffness measured, including the factors that affect its measurement? (2) How is spinal stiffness used in diagnosis? (3) How is spinal stiffness used in prognosis and treatment decision-making? and (4) What is the effect of manipulation on spinal stiffness? Manipulation was defined as thrust or non-thrust techniques where the intention was to affect the spinal joints. Studies reporting multimodal treatments were included and the isolated effect of manipulation was reported where possible. Massage and other soft tissue therapies were excluded, as were techniques applied to peripheral joints. Conference proceedings, dissertations, commentaries, editorials, letters and non-human studies were excluded. No restrictions were placed upon the study design.

Stiffness was operationally defined in this review as the relationship between force and displacement. This included both the explicit quantified measurement of this relationship, as well as the perception of the relationship between force and displacement as commonly assessed by manual therapy practitioners within the clinical examination. Studies that reported on the measurement of only force or only displacement were excluded. No restriction was placed upon the type of spinal displacement under investigation. Studies were included that reported either accessory movement (the manual or mechanical movement of a single spinal level on another) or physiological movement (the movement of a spinal region) (Maitland et al., 2005; Scaringe and Kawaoka, 2005). Studies that used stiffness in combination with other outcome measures and those reporting multimodal treatments were included. Finally, no restrictions were placed upon the setting, treating practitioner or type of participants under investigation in studies considered for eligibility.

Identified studies were downloaded into an electronic reference management system (EndNote, version X2.0.1) and duplicates were removed. The first-stage screening of titles and abstracts was performed by two independent reviewers based upon the stated eligibility criteria. Studies denoted eligible by either reviewer were progressed to the second-stage of eligibility screening, in which the full-text of eligible studies was obtained and examined by two independent reviewers. During this second-stage of screening, concordance between reviewers determined inclusion, with disagreements resolved by consensus or by a third reviewer if required.

2.3. Data synthesis and analysis

Between-rater agreement was evaluated for each stage of the screening process. The absolute and chance-corrected degrees of agreement (κ) with 95% confidence intervals were calculated for both stages of the screening procedure. Where data were available, point estimates and confidence intervals of the accuracy of spinal stiffness in the prediction of target diagnoses and prognostic outcomes are reported. Due to the anticipated heterogeneity of the included studies, no attempt was made to statistically pool the results of individual studies and standardised tools for evaluating study quality were inappropriate. Studies instead were classified according to the following variables: the investigation of symptomatic or asymptomatic participants, the measurement of spinal stiffness using instrumentation or practitioner-judged methods, the investigation of thrust or non-thrust techniques, and the region of the spine where a reported technique was applied or stiffness assessment occurred. In comparing findings between different studies, greater consideration was given to (1) studies deemed to have higher methodological quality by the control of confounders in both the quantification of spinal stiffness and the treatment outcome, and (2) those that were conducted using symptomatic participants. All statistical analyses were conducted using PASW Statistics (SPSS, version 18).

3. Results

3.1. Study selection

The database search strategy yielded 2874 unique studies. All of these studies were screened by title and abstract by the two independent reviewers with 148 progressing to the second stage of screening. The full-text copies of these studies were obtained and reviewed resulting in the exclusion of 35 studies. Reasons for exclusion are detailed in Fig. 1. A further 12 studies were identified via hand-searching of relevant journals and citation-tracking of included studies resulting in a total of 125 studies included in the review sample. The absolute agreement between raters for the first and second-stage screening procedures was 97.1% and 86.5% respectively. The chance-corrected degree of agreement for title and abstract screening was 'moderate' ($\kappa = 0.60$ (95%CI 0.52–0.68) and for full-text screening 'substantial' ($\kappa = 0.64$ (95%CI 0.50–0.78) (Sackett et al., 1991). Consensus between the two reviewers resolved all but three episodes of disagreement, with