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Review article

A systematic review and meta-analysis of the reliability and validity of sensorimotor measurement instruments in people with chronic low back pain

Katja Ehrenbrusthoff[a,b,*], Cormac G. Ryan[a], Christian Grüneberg[b], Denis J. Martin[a]

[a] Health and Social Care Institute, Teesside University, Middlesbrough, Tees Valley, TS1 3BX, United Kingdom
[b] Hochschule für Gesundheit, Department of Applied Health Sciences, Gesundheitscampus 6-8, 44801, Bochum, Germany

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ABSTRACT

Background: Deficits in the sensorimotor system and its peripheral and central processing of the affected body part might be a contributing factor to chronic low back pain (CLBP). Hence, sensorimotor assessment is important. Valid and reliable sensorimotor measurement instruments are needed.
Objective: To investigate the reliability and validity of sensorimotor measurement instruments for people with chronic low back pain (CLBP).
Design: Systematic review and meta-analysis.
Methods: The review was undertaken using the COSMIN guidelines. Databases were searched for studies investigating the clinimetric properties of sensorimotor tests in people with CLBP. The methodological study quality was rated by two independent reviewers using the COSMIN 4-point rating checklist.
Results: Ten studies were included covering six sensorimotor measurement instruments with findings for reliability/measurement error, known-groups validity and convergent validity. The methodological quality ranged from poor to good, with only one study rated as good. There was insufficient evidence of enough quality to assess reliability/measurement error or convergent validity. Two-point discrimination, laterality judgement and movement control tests had moderate evidence supporting their ability to distinguish between healthy people and those with CLBP.
Conclusions: Two-point discrimination, laterality judgment and movement control tests demonstrate the greatest level of known-groups validity for people with CLBP. However, as the reliability of these measurement tools has yet to be established, this validity data should be interpreted cautiously. Further research is warranted to investigate the clinimetric properties of these sensorimotor techniques.

1. Introduction

Chronic low back pain (CLBP) is a major public health problem, with a lifetime prevalence of ~84% (Denteneer et al., 2016, Murray et al., 2013). It is a leading cause of disability worldwide (Murray et al., 2013). Many factors contribute to the development and/or maintenance of CLBP (Denteneer et al., 2016). It has been proposed that deficits in the sensorimotor system (sensorimotor dysfunction) could be a contributing factor (Apkarian et al., 2011; Catley et al., 2014; Moseley and Flor, 2012). As such, there is growing interest in outcome measures and interventions that attempt to measure and improve sensorimotor function in people with CLBP (Ehrenbrusthoff et al., 2016; Elgueta-Cancino et al., 2015; Louw et al., 2015, 2016; Villafane et al., 2015; Vuilleumier et al., 2015).

Sensorimotor function encompasses all sensory and motor elements necessary for an individual to interact with their environment (Shumway-Cook and Woollacott, 2007). This includes the output from the nervous system contributing to motor function and any sensory input contributing to the interpretation of body position and movement (Hodges and Falla, 2015). A range of sensorimotor measurement instruments (SMIs) exist that attempt to measure the construct of sensorimotor dysfunction, defined as a process of altered motor behavior, and/or distorted interpretation or inaccurate input of afferent sensory information (Hodges and Falla, 2015; Pelletier et al., 2015). Some SMIs require expensive specialist equipment and highly skilled technical staff, such as functional magnetic resonance imaging (fMRI). Such

* Corresponding author. Hochschule für Gesundheit, Department of Applied Health Sciences, Gesundheitscampus 6-8, 44801, Bochum, Germany.
E-mail addresses: katja.ehrenbrusthoff@hs-gesundheit.de (K. Ehrenbrusthoff), c.ryan@tees.ac.uk (C.G. Ryan), christian.grueneberg@hs-gesundheit.de (C. Grüneberg), d.martin@tees.ac.uk (D.J. Martin).

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techniques are beyond the capacity of routine clinical practice. Thus, there is a need for simple SMIs that are clinically practicable to facilitate sensorimotor assessment and intervention.

There are a number of clinically practicable SMIs such as two-point discrimination (TPD), laterality judgement and movement control tests (MCTs) (Catley et al., 2013; Luomajoki, 2012; Moseley, 2006). An essential prerequisite for any clinical test is that it demonstrates sound clinimetric properties (De Vet et al., 2011), particularly, reliability and validity (Atkinson and Nevill, 1998; De Vet et al., 2011). The clinimetric properties of some SMIs have been investigated in healthy people and an array of patient groups (Auld et al., 2011; Stanton et al., 2013; Wand et al., 2014a). The clinimetric properties of some of these SMIs have been explored in people with CLBP but the extent and the quality of the work has not been systematically reviewed. Such a review is needed to guide research and clinical practice in the field. Thus, the aim of this study was to systematically investigate the reliability and validity of simple SMIs in people with CLBP.

2. Methods

The search strategy was developed in accordance with COSMIN recommendations (Terwee et al., 2011) and the PRISMA guidelines (Moher et al., 2010). This systematic review is registered on PROSPERO (Registration number: CRD42015026880).

Structured search strategies were designed using search terms appropriate for each database. Standardised database subject headings such as MeSH terms (in MEDLINE) and Subject Headings (in CINAHL) were used in each database, as appropriate. For the MEDLINE search, the sensitive PubMed search filter proposed by COSMIN for measurement properties was used (Terwee et al., 2009). Search terms and synonyms were searched separately in four main categories and finally combined into one search string per database. The categories complied with COSMIN guidelines (Terwee et al., 2009) and were defined as:

1. Construct: tactile acuity OR sensorimotor dysfunction OR cortical reorganization
2. Target population: chronic low back pain
3. Measurement instrument: sensorimotor test
4. Measurement properties: sensitive COSMIN search filter for measurement properties in MEDLINE

Electronic searches of databases were conducted by one author (K.E.) until March 30th, 2015 using MEDLINE via PubMed, CINAHL via EBSCO, Embase via Ovid and Central via Wiley. The search was updated with a time restriction from March 30th, 2015 to April 30th, 2016 to identify relevant studies published ad interim. A full description of the search strategies can be found in the supplementary data (Appendix 1: Search strategies for all databases). Identified records were screened by K.E. by title-abstract initially and then by full-text screening. Hand searching of key reference lists was also conducted.

2.1. Eligibility criteria

Studies were included if: 1) their target population were individuals with CLBP, defined as pain between the 12th rib and the buttock creases, persisting for ≥ 3 months (Savigny et al., 2009); 2) the SMI investigated claimed to measure a component of sensorimotor dysfunction; 3) the SMI investigated was practicable without sophisticated/expensive instrumentation (e.g. a functional Magnetic Resonance Imaging (fMRI) machine) not easily accessible in a routine clinical setting: an example of an unsophisticated and inexpensive piece of equipment would be a goniometer; 4) the aim was to investigate one or more measurement properties of the SMI under investigation; 5) the study was designed to investigate reliability or validity of the SMI, in accordance with the COSMIN taxonomy (Mokkink et al., 2009); 6) the study was published as a full original article in English or German.

Studies were excluded if: 1) they were of an intervention based or single-case design; 2) the SMI investigated required extensive technical skills and/or equipment not found in routine clinical practice (e.g. fMRI, motion analysis systems).

2.2. Data extraction

According to the COSMIN recommendations for data extraction, the generalisability box of the COSMIN tool was used to extract data on characteristics of the study sample (median/mean age, distribution of sex, important disease characteristics, setting, country, language, sampling strategy, percentage of missing responses). In addition, details of each SMI data collection protocol were summarised and the measurement property results per SMI were extracted separately (De Vet et al., 2011). The extraction process was carried out by the lead author (K.E).

2.3. Methodological quality evaluation

The COSMIN four-point scoring checklist (Terwee et al., 2012) was used to assess the methodological quality of included studies. The checklist is a validated tool comprising 10 sections, each assessing a separate measurement property (Mokkink et al., 2010a, 2010b). Two reviewers (C.R. and K.E.) with prior experience in using the checklist rated each study. Each item for methodological quality within each section was scored from excellent to poor. The overall score for the measurement property within the study was defined as the lowest rating among all response options within one section, termed as “worst score counts” (Terwee et al., 2012). Where multiple measurement properties were assessed within one study, this study received multiple methodological quality evaluations.

2.4. Evaluation of measurement properties

In the studies included in the review, the results for each SMI measurement property were evaluated against the pre-defined quality for good measurement properties (Terwee et al., 2007), (see Table 1 for details). For validity, we investigated the construct validity sub-categories known-groups validity and convergent validity. Known groups validity was defined as an instrument's ability to discriminate between people with and without the target condition or between people having different manifestations of the target condition, respectively (De Vet et al., 2011). Convergent validity was defined as the expected relationship between instruments measuring related constructs (De Vet et al., 2011).

2.5. Data synthesis: meta-analysis and best evidence synthesis

Where multiple studies with comparable study designs investigated the same SMI and measurement property, a meta-analysis was conducted. For known-groups validity, mean scores and standard deviations from healthy and patient groups were pooled using the statistical package RevMan (Version 5) by means of forest plots (fixed effects model) to establish a pooled difference between groups. Heterogeneity was quantified using the I^2 (Higgins et al., 2003). Following the COSMIN recommendations, studies with a poor methodological score were excluded from quantitative pooling (Mokkink et al., 2009). Where quantitative pooling was not appropriate, a ‘best evidence synthesis” approach was used, (see Table 2) (Guyatt et al., 2011; Schünemann et al., 2011).

3. Results

3.1. Study selection

Initially, 4285 studies were identified, of which 407 were excluded as duplicates and another 3839 were excluded following title and