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Original research

Reproducibility of a battery of commonly used clinical tests to evaluate lumbopelvic motor control

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ABSTRACT

Objective: To determine reproducibility of a battery of clinical tests for evaluating lumbopelvic motor control (LMC).
Design: Test-retest design.
Participants: Fifty healthy subjects.
Outcome Measures: Two raters independently examined performance on 12 clinical tests for evaluating LMC. All tests were scored on a seven-point scale, based on qualitative and quantitative performance. Subjects were measured twice, with a two week interval between examinations. Intra- and inter-rater reproducibility of each test were determined using intraclass correlation coefficients (ICCs), standard error of measurement, smallest detectable change (SDC) and limits of agreement.
Results: Reliability of the tests ranged from poor to excellent. Intra-rater ICCs ranged from 0.00 to 0.82, whereas inter-rater ICCs varied from 0.00 to 0.96. SDC values were smallest for supine leg raising, bent knee fall out, prone bridge and unilateral prone bridge (<2 points).
Conclusion: This study shows limited reproducibility of a battery of 12 clinical tests for the evaluation of LMC in a healthy population. Supine leg raising, bent knee fall out, prone bridge, and unilateral prone bridge showed the smallest measurement errors. The other 8 tests were found to have large measurement errors. Based on these results, dichotomization of the rating method might be considered in order to improve reproducibility values.

1. Introduction

Low back pain (LBP) is a major health problem, with a high lifetime prevalence rate and substantial economic consequences for society (Heneweer, Staes, Aufdemkampe, Van Rijn, & Vanhees, 2011). In the last few decades, spinal stability is proposed as an important factor in relation to LBP (O'Sullivan, 2000; Panjabi, 2003). This was originally described by Panjabi and White as the ability of the spine to maintain its patterns of displacement under physiologic loads so there is no initial or additional neurologic deficit, no major deformity, and no incapacitating pain (White & Panjabi, 1990). Whilst this definition has been widely adopted, the term "stability" can be argued. From a biomechanical point of view, a system is either stable or unstable; different degrees of stability cannot be distinguished. However, concerning lumbar spine stability, the situation may be less straightforward. For example, an external force may lead to a small perturbation of the lumbar spine, but as long as it returns to its original position without injury, one could say that the spine is still stable. Therefore, Reeves, Narendra, and Cholewicki (2007) have recently proposed the term 'robustness' instead of stability, as this term refers to the ability of a system to change stiffness for both small and large perturbations, and maintain stable behavior in this manner.

The lumbopelvic musculature plays a vital role in providing support to the lumbar spine. Lumbopelvic muscle groups must

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have sufficient strength and endurance for optimum spine function, but their efficacy largely depends on appropriate control from the central nervous system (CNS). The CNS must continuously interpret afferent input from peripheral mechanoreceptors and other sensory systems, and then generate a coordinated response so that the muscular system is activated at the correct time and with the correct intensity (Hodges & Moseley, 2003). This is referred to as spinal or lumbopelvic motor control (LMC), which both describes the involved anatomical structures and underlying mechanisms (Briggs, Givens, Best, & Chaudhari, 2013). Research has consistently demonstrated several changes in motor control in patients with LBP, such as altered (delayed) muscle activation patterns (Dankaerts, O'Sullivan, Burnett, & Straker, 2006; Hodges, 2001; Hodges & Richardson, 1998), decreased cross-sectional area of the paraspinal musculature (Hides, Stokes, Saide, Jull, & Cooper, 1994) and loss of ability to dissociate movement of the lumbopelvic region from that of the thoracic spine (Wallwork, Stanton, Freke, & Hides, 2009). Although these motor changes may provide protection from further injury in the acute phase of LBP, in the chronic phase they may become less relevant and can even lead to loss of control of intervertebral motion and pain.

Several tests have been proposed for the assessment of LMC, but there is still need for a generally accepted, reliable and valid clinical test (Borghuis, Hof, & Lemmink, 2008). Such a clinical test must meet several criteria. First, it should focus on neuromuscular performance rather than pure strength or endurance. For optimal performance, it is important that the appropriate muscle is recruited at the correct moment and intensity for optimum stability of the lumbar spine and pelvis. This is supported by Borghuis et al. (2008) who have stated that "sensory-motor control is much more important than the role of strength or endurance" (Borghuis et al., 2008). Second, a test should assess all relevant muscle groups of the lumbopelvic complex in various positions, as no single muscle group can be designated as the most important to enhance lumbopelvic stability (Cholewicki & VanVliet, 2002; Kavcic, Grenier, & McGill, 2004). Third, it should consist of commonly prescribed exercises that clinicians are familiar with, and should be easy to apply.

We have developed a test battery for evaluating LMC, based on previous tests and exercises that have been investigated in electromyographic studies (Bjerkefors, Ekblom, Josefsson, & Thorstensson, 2010; Clark, Manini, Mayer, Ploutz-Sneider, & Graves, 2002; Crossley, Zhang, Schache, Bryant, & Cowan, 2011; Demoulin, Vanderthommen, Duysens, & Crielaard, 2006; DiMattia, Livengood, Uhl, Mattacola, & Malone, 2005; Ekstrom, Donatelli, & Carp, 2007; Enoch, Kjaer, Elkjaer, Remvig, & Juul-Kristensen, 2011; Imai et al., 2010; Marshall & Murphy, 2005; Souza, Baker, & Powers, 2001; Stevens et al., 2006; 2007). These exercises challenge the neuromotor control of the lumbopelvic complex in different positions. It is important to observe both quantitative (e.g. task duration, amount of repetitions) and qualitative performance (i.e. how is the exercise performed and which motor patterns are used?) of these exercises (Borghuis et al., 2008). We hypothesize that decreased LMC may lead to compensatory movement patterns that can be visually observed (Chmielewski et al., 2007; Comerford & Mottram, 2001; Ekegren, Miller, Celebrini, Eng, & Macintyre, 2009). However, the reproducibility of visual observation of the current test battery is unknown. Therefore, the aim of this study was to determine the intra- and inter-rater reproducibility of a test battery commonly used in clinical practice for the evaluation of LMC. In this study, LMC was defined as the neuromuscular ability of the lumbopelvic complex to maintain stable behavior during perturbations (Reeves et al., 2007; Willson, Dougherty, Ireland, & Davis, 2005).

2. Materials & methods

2.1. Study design

In a test-retest study, the intra- and inter-rater reproducibility of each separate test was assessed. Subjects were independently examined by two raters (physiotherapy students in the final year of their study). They assessed the qualitative and quantitative performance of the subjects on twelve different tests, using visual observation, palpation, and a stopwatch. During the tests, subjects were verbally instructed by a third investigator, who also controlled the duration of the test with a stopwatch (Catiga Electronics Co. Ltd., Kowloon, HongKong). This investigator was not involved in rating the subject's performance. Within two weeks, the subjects were re-tested in the same manner (T1). They were asked not to practice the test exercises during the period in between, but they were allowed to perform their regular sport activities.

Prior to the actual test, typical compensatory movement patterns were discussed. Both raters practiced the test protocol three times on other members of the research team to become familiar with the test procedure and the rating criteria.

The study was approved by the Medical Research Ethics Committee of the Radboud University Nijmegen (registration number 2013/176). All subjects received information on the study aim, and signed written informed consent prior to their participation.

2.2. Subjects

Healthy subjects were recruited from the HAN University of Applied Sciences by oral and written requests to students and employees. We aimed to include a minimum of 50 subjects (Terwee et al., 2007). Eligibility criteria were an age between 18 and 75 years and good understanding of the Dutch language. Exclusion criteria were: a history of low back pain, injuries to the upper or lower extremity in the year prior to testing, spinal surgery, serious spinal pathology (such as non-healed fractures or tumors), central neurological disorders, and other pathologies that could influence the test.

2.3. Testing protocol

Subjects wore a t-shirt tucked in their shorts during the test, and they were assessed on bare feet. The subjects received a standardized verbal instruction from the third investigator prior to the performance of each test. To support this verbal instruction, pictures of the start and end position of a test were shown on a large screen in the testing area. Tests that required a dynamic performance were practiced three times before the test was rated, so that the subjects could familiarize themselves with the exercise. Static tests were only shown on the screen, without practice trials. In agreement with clinical practice, all tests were performed in a fixed sequence (as given below), without any additional rest in between (except for the verbal instruction). Total time needed for the full test protocol was approximately 30 min.

Before the start of testing, subjects were verbally instructed to maintain a neutral lumbar lordosis during the test and to keep their pelvic girdle in a neutral position. A neutral lordosis was defined as the midway between anterior and posterior pelvic tilt, and this was practiced in four-point kneeling prior to testing, until the subjects showed proper performance. A change from the neutral position was accepted, as long as it was quickly resumed. Subjects were not corrected during their performance.

All tests were rated both quantitatively and qualitatively, and for the total duration of the task. The raters used a standardized score