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Technical and measurement report

Within/between-session reliability and agreement of lumbopelvic kinematics in the sagittal plane during functional movement control tasks in healthy persons

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ABSTRACT

A lack of adequate lumbopelvic movement control has been suggested as an underlying mechanism contributing to the development and persistence of low back pain and lower limb pathologies. The purpose of this study was to assess the within and between session reliability (i.e. the ability to discriminate between subjects), and the agreement (i.e. whether scores are identical on repeated measures) of lumbopelvic kinematics in the sagittal plane during functional movement control tasks. Kinematics were measured with a portable inertial measurement unit system. Twenty healthy subjects (mean age = 22 (±3.6) years, 15 females) performed four tasks on two occasions, five to seven days apart: standing bow (SB), lifting a box from the floor (LIFT), stance-to-sit-to-stance (SIT) and placing a box on an overhead shelf (OVERH). Participants were asked to keep the lumbar spine in a neutral lordosis during the tasks. The maximal deviations from the neutral starting position for the lumbar spine and hip were calculated. Intraclass correlations (ICCs), standard errors of measurement (SEM), minimal detectable changes and 95% limits of agreement were used to assess reliability and agreement. SB and LIFT were substantially reliable (ICC = 0.89–0.96), SIT was moderately to substantially reliable (ICC = 0.69–0.92) and OVERH was fairly to moderately reliable (ICC = 0.40–0.67). SEMs ranged between 1.1° and 3.1° for the lumbar spine and between 0.7° and 4.8° for the hip. Based on the substantial reliability and acceptable agreement, SB and LIFT are most appropriate to quantify lumbopelvic movement control during functional tasks.

1. Introduction

A lack of adequate lumbopelvic movement control (MC) has been described in various populations, such as patients with low back pain (O'Sullivan, 2005) and lower limb pathologies (Roussel et al., 2009; Allison et al., 2016). Although the relationships have yet to be clarified, it is suggested that inadequate lumbopelvic MC may be an underlying mechanism contributing to the persistence of pain and suboptimal functioning (O'Sullivan, 2005). Therefore, it is essential to evaluate these aspects in the assessment of these patients (Sahrmann, 2001).

Lumbopelvic MC is typically being assessed by observation because this is an inexpensive and fast way of examining a patient. However, this method mostly uses a dichotomous outcome (correct/incorrect performance), which does not allow to quantify the performance on the test (Carlsson and Rasmussen-Barr, 2013). Kinematic measurements recorded with clinical (e.g. inertial sensors) or lab based (e.g. stereophotogrammetric) systems can be used to quantify aspects of lumbopelvic MC. However, such measurements are only of clinical and research value if kinematics can be obtained reliably and with sufficient agreement.

Studies investigating the reliability and agreement of lumbopelvic kinematics of MC tasks are scarce (Bauer et al., 2015, 2016). Moreover, only analytical MC tests have been described in these papers. This is a major shortcoming since it is recommended to include functional MC tasks into the physical examination of patients with MC problems (Hodges et al., 2013). These tasks may

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better identify aberrant movement patterns contributing to the patient's problem, as they assess the ability to control lumbopelvic movements during daily life activities, whereas analytical MC tests use movements not directly related to daily life (e.g. tests in prone lying).

The first aim of this study is to assess in healthy persons the within-session and between-session reliability of lumbopelvic kinematics in the sagittal plane during functional MC tasks, using wireless inertial measurement sensors. Secondly, the agreement and minimal detectable change between two sessions will be investigated.

2. Methods

2.1. Study design and population

This within -and between-session reliability study with agreement was conducted according to the GRRAS-guidelines (Kottner et al., 2011). Healthy subjects between 18 and 65 years old were recruited at the campus of Hasselt University, Belgium. Based on the number of repetitions in our protocol, 18.4 subjects allow reliability estimations of ICCs >0.9 (H1) with a type I error of 0.05, type II error of 0.20 and minimally acceptable ICC-value of 0.7 (H0). Because data might get lost because of technical problems, 20 subjects were included using consecutive sampling. (Walter et al., 1998). Subjects were excluded if they had low back pain in the past year, previous spinal surgery, a serious underlying pathology, physical impairments interfering with daily functioning or if they performed spinal MC exercises in the past year. The study was approved by the Ethical Committee of Hasselt University and the Jessa Hospital, Belgium. All subjects gave written informed consent before being included in the study.

2.2. Measurement procedure

Subjects were tested on two occasions at the same time of the day, five to seven days apart. They were asked not to practice the lumbopelvic MC tasks between the two test occasions or to perform strenuous activities at the day or the day before the testings. All measurements were performed by the same researcher (T.M.) who has 12 years of experience in lumbopelvic MC assessment.

Four different MC tasks were assessed: standing bow (SB), stance-to-sit-to-stance (SIT), lifting a box from the floor (LIFT) and placing a box on an overhead shelf (OVERH) (Fig. 1A–D). A detailed description of the tasks is provided in Appendix A. Each task started from a standing position, with the lumbar spine placed in a neutral lordosis. To find the neutral lordosis, the total range of pelvic motion was evaluated, after which the lumbar spine was placed in a midway position. Subjects were asked to maintain their neutral lumbar curvature while performing the tasks. Before the measurements, all tasks were explained and demonstrated in a standardized way, and subjects could practice these tasks until they felt familiar with it. During the actual assessment, each task was performed five times at a self-selected speed. All repetitions of a specific task were performed immediately after each other, while there was a resting period of three minutes between the different tasks. Before each repetition, subjects were placed in the neutral position by a research assistant. Real-time kinematic feedback was available for the researchers to ensure that subjects were placed in the same neutral position before each repetition. When the habitual standing position of a subject corresponded with a neutral position, no postural correction was made before the tests. No feedback was given to the participants during the assessment-trials. To avoid systematic learning effects, the task order was randomized for both test occasions. Each task was standardized for the subject's height (Appendix A).

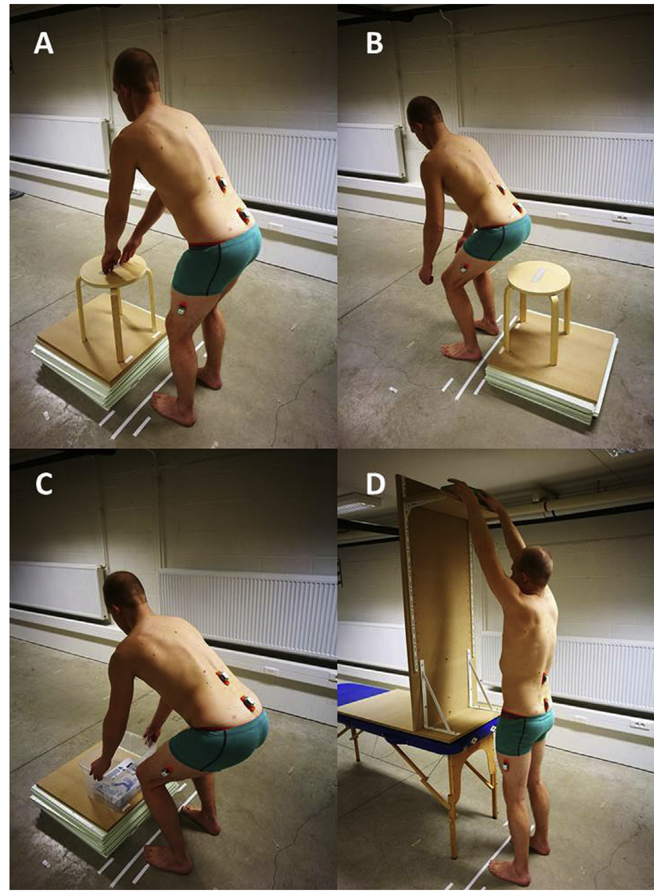

Fig. 1. Functional movement control tasks. A: Standing bow. B: Stance-to-sit-to-stance. C: Lifting a box from the floor. D: Placing a box on an overhead shelf.

2.3. Kinematic data acquisition

The Valedo®motion research tool (Version 1.2, Hocoma, Switzerland) was used to assess the sagittal plane lumbopelvic kinematics. The Valedo®motion consists of three wireless inertial measurement sensors that contain a triaxial magnetometer, gyroscope and accelerometer, and measures with an accuracy of 0.1° and a sampling rate of 50H. This instrument has a proven concurrent validity to measure lumbopelvic movements in the primary movement planes (Bauer et al., 2015). The sensors were placed on the spinous process of L1 and S1, and 20 cm above the lateral femoral condyle. It can be discussed whether it would be more appropriate to place the sacral sensor on S2 instead of S1, due to sacral morphology and because S2 is often referred to be level with the line between the posterior superior iliac spines. However, the accuracy of pelvic landmark palpation remains controversial (Chakraverty et al., 2007). Before the measurements, the sensors were calibrated to the magnetic north and the sagittal plane was defined. The latter was done by calibrating an additional sensor while it was placed in a specifically designed holder which was held exactly parallel with the tape on the floor. The angles were derived from quaternions using the tilt/twist method. This method is preferred over the Euler/Cardan method, because no specific order of rotations around movement axes is required for the calculation of joint angles and because tilt/twist angles only reach singularity at 180° (Crawford et al., 1999).