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Test–retest reliability and responsiveness of centre of pressure measurements in patients with hip osteoarthritis

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S U M M A R Y

Objective: The aim of this study was to determine a set of measures for the evaluation of balance in patients suffering from hip osteoarthritis (OA) that were both reliable and responsive to change.
Design: Three groups of subjects; Healthy, hip OA patients without surgery, and hip OA with surgery (pre and post-surgery) were included in this study. Subjects had to perform balance tests in two positions: standard and narrowed stance. CoP-based measures test–retest reliability was assessed in hip OA without surgery group, responsiveness were assessed between all groups and between pre and post-surgery.
Results: Intraclass Correlation Coefficient (ICC) values from hip OA without surgery ranged from −0.03 to 0.9 for only five parameters (CoP path length, SD velocity, mean velocity, and antero-posterior Root Mean Square (RMS_{AP})) having values over 0.7. SD velocity and RMS_{AP} showed significant differences between healthy and surgery group in standard stance whereas narrowed stance revealed most differences between all groups. RMS_{AP} showed the best responsiveness (Standardized Response Mean ~0.5) between pre vs post-surgery in both conditions. RMS_{AP} was also capable of discriminating between hip OA with surgery vs without surgery groups with good sensitivity and specificity.
Conclusions: Our results showed there to be reliability and responsiveness of five postural parameters in hip OA patients in two conditions of standing balance. More parameters were significantly different in narrowed stance whereas sensitivity was better in standard stance. SD velocity and RMS_{AP} discriminate between degrees of OA severity and highlight potential balance deficits even after arthroplasty. Selected parameters during standing balance could be assessed to complete the set of quantitative measures to quantify hip OA patient deficiencies.

Introduction

Osteoarthritis (OA) of the hip is a common musculoskeletal disease affecting many individuals causing pain and a decrease in physical function, thus limiting an individual's participation in society and reducing their Quality of life (QoL)[1,2].

Measurement of functional impairment is a critical component of research and clinical practice because it drives the choice of therapy prescribed[3–5]. Measurement of physical function is complex however, as it is a multi-dimensional construct[6–8]. A range of both self-reported and performance-based measures should be used to assess physical function[5]. Performance-based measures are defined as assessor-observed measures of tasks classified as “activities” using the ICF model[8] and are usually assessed using quantifiable measurements. Increasing evidence suggests that

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performance-based measures capture a different construct of function and are more likely to fully characterize a change in body function than self-reported measures alone[9,10].

The integrity of balance function is critically linked to falls in older people[11]. Balance control allow one to move or to efficiently stabilize our center of mass during daily activities, such as lower body dressing, ambulating, reaching to grasp and manipulate objects, or even climbing stairs; all essential activities that become increasingly challenged with aging[11,12]. Indeed, falls occur mainly during activities of dynamic equilibrium[13]. Nonetheless, postural instability during quiet stance should not be ignored since it constitutes an underlying risk factor for falls[14–17]. Within this context, two main points must be considered. First, the hip joint is a critical source of somatosensory inputs[18] contributing to both static and dynamic balance control. Indeed, the hip joint plays an important role in maintaining balance[19], particularly in the frontal plane[18,20,21]. Other evidences of the hip acting as an important stabilizing joint has arisen through the study of the deleterious effects of fatiguing the hip muscles upon postural control[22,23]. Second, hip OA is itself considered a risk factor for falls in elderly adults[24–26]. Taken together, these considerations warrant a detailed assessment of standing balance in the management of hip OA.

The variables most commonly used to describe postural stability (e.g., path length, area, mean velocity, *etc*.) are derived from the spatiotemporal patterns of the center of pressure (CoP), the barycenter of all forces acting downwards on the body[27,28]. Conclusions about stability from CoP displacements are possible as they are directly proportional to ankle torque[29], which is regulated via descending motor commands, mechanical properties of the surrounding ankle musculature[30,31] and the cutaneous sensory input[32,33]. Importantly, recent evidence has suggested that the excursion of the CoP within the base of support (BoS) reflects an exploratory mechanism that enables humans to acquire and use sensory information, indicating that postural sway may actually be important for balance control[34,35].

Thus, the manner in which hip OA modifies the characteristics of sway is essential to understand, as it has implications not only for these patients' ability to conserve their balance, but also in their ability to use excursions of the CoP to improve balance control, post-surgery. However, the precise selection of sway measures for clinical use should be motivated primarily by their reliability and responsiveness[36]. The objective of this study was therefore to determine using a stepwise method, a set of measures that were reliable and responsive to change, for the evaluation of postural steadiness in patients suffering from hip OA.

Methods

Study design and settings

This study incorporated three stages; the first was to identify a set of reliable parameters from those recommended in the literature. The second was to select only those parameters in terms of their responsiveness to differences in the patient groups and the third was to quantify the construct and convergent validity. Thus, this study assessed postural steadiness of hip OA patients of different severities (indication of surgery or not) compared to healthy controls. All participants were recruited by an experienced rheumatologist (PO, JFM). The inclusion period extended from January 2008 to December 2013. Protocols were approved by the local ethics committee (CPP Est I, Dijon, France) and conformed to the Declaration of Helsinki. All patients signed an informed voluntary consent form prior to their participation. Trials were registered on Clinicaltrials.gov (NCT02042586 and NCT01907503).

Participants

The CONSORT diagram (Supplementary Materials) describes the recruitment process and the sample sizes for the participants in this study. Three groups of participants, aged 40–80 years, were recruited for this study. (1)HEA: healthy persons without symptomatic musculoskeletal disease; (2)COX: patients with unilateral symptomatic hip OA, defined using the American College of Rheumatology criteria[37]. Other inclusion criteria were Kellgren and Lawrence stages (II–IV)[38], and no indications of surgery. (3)SURG: patients with unilateral symptomatic hip OA with indication of total joint replacement. Patients in this group were evaluated 15 days before ($SURG_{M0}$), and 6 months after surgery ($SURG_{M6}$). The surgical approach was chosen by an experienced surgeon between antero-lateral-type (Rottinger) or posterior approaches (Moore), depending on each patient's hip OA feature. Indication of surgery was defined as severe hip pain and/or functional limitation despite conservative treatments (including analgesics, NSAIDs) and rehabilitation, according to the surgeon's opinion.

Exclusion criteria were: secondary hip OA, inflammatory hip OA, significant painful ankle, knee or foot disorders, chronic back pain, Parkinson's disease, motoneuronal disorders, non-stabilized diabetes mellitus, cardiac or respiratory insufficiency and an inability to understand the procedures.

Functional self-reported instrument

The Hip disability and Osteoarthritis Outcome Score (HOOS)[39,40], a well-validated, self-administered questionnaire developed and validated as an extension of the Western Ontario and McMaster Universities Arthritis Index (WOMAC)[41] for hip OA patients, regardless of the degree of disease severity was used. The HOOS includes five domains, i.e., pain, other symptoms, activities of daily living (ADL), sport and recreation function (SP), and hip related QoL, Standardized answer options are given (five Likert boxes) and each question gets a score from 0 to 4. A normalized score (from 0-worst) to (100-best) for each HOOS subscale was calculated for both OA groups.

Data collection

Patients were required to stand as still as possible on a force platform for trials lasting 54 s (SOFPEL guidelines[42]), in two different BoS configurations. A first, standard position corresponded to a mediolateral distance between the feet that was the same as shoulder width (standard BoS). The distances were controlled by a 3D optoelectronic system (Vicon, Oxford, UK), by real-time measurements of the inter-acromial and inter-external malleolus distances with reflective markers positioned on such landmarks. A second position required participants to stand with their feet together (narrowed BoS). An experimenter stood beside the participant at all times for safety. Standardized oral instructions to "stand quietly, with the arms by the sides of the body and to focus on a target placed on the wall at eye level" were given to the participants before each trial.

Data analysis

Force-platform data were recorded using an AMTI platform (AMTi®, USA). In order to comply with the SOFPEL recommendations for signal processing[42] all signals were first recorded at 1000 Hz then downsampled to 40 Hz. We then removed 1.2 s from the beginning and end of each trial to keep 51.6 s of data. Signals were filtered with a low-pass zero-phase shift Butterworth filter