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Brief report

Effect of tibial re-alignment surgery on single leg standing balance in patients with knee osteoarthritis

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ABSTRACT

Background: Standing balance is impaired in individuals with knee osteoarthritis and is associated with disease severity. The effects of surgical interventions on standing balance have received little attention. The purpose of the present study was to examine measures of balance during tests of single-limb standing before and after medial opening wedge high tibial osteotomy – a lower limb re-alignment procedure for those with varus alignment and knee osteoarthritis.

Methods: Standing balance was assessed in 49 individuals prior to and 12 months following medial opening wedge high tibial osteotomy. Participants performed three trials of single-limb balance lasting 10 s each while standing on a force platform. Anteroposterior and mediolateral coordinates of the centre of pressure were obtained from the force platform and used to calculate the total centre of pressure path length as well as the range and variability (standard deviation) of the anteroposterior and mediolateral coordinates.

Findings: Though all centre of pressure measures were lower following high tibial osteotomy, none reached statistical significance ($P > 0.05$) and effect sizes were small ($d < 0.34$). The largest mean improvement was 7.6% (95% confidence interval: −0.7–15.8%).

Interpretation: Results indicate that standing balance in individuals with knee osteoarthritis is not significantly different following high tibial osteotomy surgery. Standing balance in this patient population is a complex process not entirely dictated by disease symptoms or structural factors such as alignment.

1. Introduction

Standing balance is the result of sensory input, centralized processing, and neuromuscular responses. Sensory input involves integration of visual, vestibular, and proprioceptive information while the neuromuscular responses require activation of appropriate muscles needed to exert forces required to maintain upright posture or to respond to internal and external perturbations. All of these functions have been found to be diminished with age (Andrews et al., 1996; Bohannon, 1997; Vandervoort, 2002; Vereeck et al., 2008), and more dramatically with chronic musculoskeletal disorders such as osteoarthritis (OA) (Hurley et al., 1997; Slemenda et al., 1998; Hassan et al., 2001).

Osteoarthritis involves the degeneration of articular cartilage. The knee is the weightbearing joint most commonly affected and occurs primarily in the medial compartment of the tibiofemoral joint. This typically results in pain and impaired physical function. Though the mechanisms governing reductions in proprioception and muscle strength in this patient population are unclear, previous authors have consistently reported impaired standing balance in individuals with knee OA compared to those without (Hurley et al., 1997; Wegener et al., 1997; Hassan et al., 2001; Hall et al., 2006; Masui et al., 2006), quantified as increased centre of pressure (COP) movement. There have been mixed reports regarding the effects of various interventions on measures of standing balance with improvements found after applying elastic bandaging (Hassan et al., 2002b) and aerobic or resistance training (Messier et al., 2000), while no changes have been found after valgus knee bracing (Birmingham et al., 2001a) or intra-articular injections of pain medication (Hassan et al., 2002a). The effects of surgical interventions on standing balance has received much less attention (McChesney and Woollacott, 2000).

Associations between measures of single-limb standing balance and disease severity suggest standing balance may be particularly important for patients with varus alignment and medial compartment knee osteoarthritis (varus gonarthrosis) (Birmingham et al., 2001b). Medial opening wedge high tibial osteotomy (HTO)

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surgery is a lower limb re-alignment procedure aiming to decrease pain and improve function in those with varus gonarthrosis. Changes in the anatomical alignment of the tibia can be large and cause alterations in overall lower limb anatomy and soft tissue length and structure. Therefore, there is a potential for substantial changes in the nature of proprioceptive feedback and muscle function following surgery, which may impact standing balance. To-date, no studies have investigated the effect of HTO surgery on measures in standing.

Therefore, the aim of the present study was to examine measures of balance during tests of single-limb standing, in particular the movement of the COP, before and after medial opening wedge HTO for knee OA.

2. Methods

2.1. Participants

A total of 49 (5F, 44 M) patients (mean age 46.0, SD 9.1 years; mean BMI 28.6, SD 4.5 kg/m^2) diagnosed with medial knee OA (Altman et al., 1986) and genu varum and who were scheduled for medial opening wedge HTO were recruited for this study. Participants were excluded if they had any previous lower limb surgery except for arthroscopy or mensicectomy; exhibited greater signs of radiographic OA in the lateral tibiofemoral compartment than the medial; had valgus lower limb alignment; or reported no pain at the pre-operative testing session. All participants provided informed consent before testing. The study was approved by the institution's Research Ethics Board for Health Sciences Research Involving Human Subjects.

2.2. Procedures

All participants were tested on two occasions. At each session lower limb radiographs were acquired, standing balance was measured, and participants completed the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Bellamy et al., 1988). Testing occurred a mean of 0.5 (SD 0.8) months prior to and 12.3 (SD 0.9) months following surgery. All participants underwent HTO performed by one of four surgeons from the same orthopaedic injuries clinic. All surgeons used the operative technique described by Fowler et al. (2000) which used a medial opening wedge osteotomy system with internal fixation. Following surgery, patients remained non-weightbearing for a minimum six weeks. Partial weightbearing was permitted until there was evidence of bony union on radiographs (typically at the 3 month follow-up clinical visit with the orthopaedic surgeon).

2.3. Radiographic measurements

Bipedal standing, full length, anteroposterior radiographs were obtained from all participants at both test sessions. The joint centres of the hip, knee, and ankle were identified on each radiograph. The centres of the hip and knee were identified using criteria established by Moreland et al. (1987). The centre of the hip was denoted as the geometric centre of the femoral head which was found using a circular template, while the centre of the knee was identified as the midpoint of the tibial spines extrapolated inferiorly to the surface of the intercondylar eminence. The centre of the ankle was defined as the mid-width of the tibia and fibula at the level of the tibial plafond (Paley, 2002). The mechanical axis angle of the lower limb was measured on each radiograph and was defined as the angle formed at the knee between lines connecting the centres of the hip, knee, and ankle (Brown and Amendola, 2000).

2.4. Balance tests

Balance was measured during tests of single-limb standing, and was quantified by the movement of the COP coordinates sampled at 60 Hz from a single, floor mounted force platform (Advanced Mechanical Technology Inc., Watertown, MA, USA). During each trial, participants were barefoot with their arms placed at their sides and instructed to lift one foot off the ground by flexing the knee to approximately 90° and maintaining balance on the other foot (Fig. 1). Vision was allowed for each trial, and a cross on the wall, at eye level approximately 3 m in front of the participant, was used as a visual reference point. Three standing balance trials on the limb scheduled for surgery were completed and COP data were collected for 10 s. If participants were unable to complete a trial for the entire 10 s, it was repeated and the number of repeated trials was recorded.

The following measures of COP movement were calculated and averaged over the three trials to quantify standing balance: total path length, absolute range of the anteroposterior (AP) and mediolateral (ML) components, and variability in the AP and ML components (reported as standard deviations).

2.5. Statistical analysis

COP data, lower limb alignment, WOMAC values before and after HTO were compared using paired *t*-tests. Given the multiple comparisons used, an alpha significance level of $P = 0.01$ was used. The Statistical Package for the Social Sciences (SPSS vs.16) was used for all statistical analyses.

Fig. 1. Patient positioning during tests of standing balance.