Clinical Biomechanics 29 (2014) 650–656

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

The use of a lateral wedge insole to reduce knee loading when ascending and descending stairs in medial knee osteoarthritis patients

Amneh Z. Alshawabka [a], Anmin Liu [b], Sarah F. Tyson [c], Richard K. Jones [b,*]

[a] Faculty of Rehabilitation Sciences, University of Jordan, Jordan
[b] School of Health Sciences, University of Salford, UK
[c] Stroke & Vascular Research Centre, University of Manchester, UK

ARTICLE INFO

Article history:
Received 3 December 2013
Accepted 17 April 2014

Keywords:
Knee osteoarthritis
Adduction moment
Stair climbing
Lateral wedge insole

ABSTRACT

Background: Stair climbing is a challenging task to the elderly being the task with the first complaint in patients with mild to moderate knee osteoarthritis. Stair climbing results in around six times more compressive load transmitted through the knee joint than walking on level ground. The purpose of this study was to assess whether lateral wedge insoles would reduce medial compartment knee loading when ascending and descending stairs in patients with medial knee osteoarthritis.

Methods: Eight patients with medial knee osteoarthritis were tested in random order with and without a pair of 5° off-the-shelf lateral wedge insoles for two separate activities (stair ascent and stair descent). Kinematic and kinetic data were collected for the lower extremity using a sixteen camera motion capture system and two force plates. Primary outcome measures were the external knee adduction moment and the knee adduction angular impulse.

Findings: During stair ascent and descent, lateral wedge insoles significantly ($P < 0.05$) reduced the 1st peak external knee adduction moment in early stance (ascent 6.8%, descent 8.4%), the trough in mid stance (ascent 13%, descent 10.7%), 2nd peak in the late stance (ascent 15%, descent 8.3%) and the knee adduction angular impulse compared to the control (standard shoe) with large effect sizes (0.75–0.95).

Interpretation: In this first study on stairs, lateral wedge insoles consistently reduced the overall magnitude of medial compartment loading during stair ascent and descent. Further research is needed to determine the relationship of this with clinical results when ascending and descending stairs with lateral wedge insoles.

1. Introduction

Stair climbing is a common and frequent dynamic activity in daily living which is more biomechanically and physiologically challenging than typical walking tasks and is considered as one of the most difficult tasks for the elderly (Hemenway et al., 1994; Tinetti et al., 1994). Moreover, stair climbing was reported as the first complaint task in patients with mild to moderate knee osteoarthritis (OA) with the highest pain score (Costigan et al., 2002). Stair climbing demands, compared to walking on level ground, a greater range of motion in the lower extremity accompanied by about six times more compressive load on the knee joint (Andriacchi et al., 1980). During walking gait, greater loading is seen in the medial compartment of the knee with the asymmetric load distribution due to the external knee adduction moment (EKAM). There is increasing evidence that the EKAM is a reliable predictor of osteoarthritis progression and severity (Bennell et al., 2011; Miyazaki et al., 2002) and can be used as an indirect measure of medial joint loading (Zhao et al., 2007). During walking, individuals with knee OA have shown 35% higher peak EKAM as compared with healthy subjects (Thorp et al., 2006). Additionally, in patients with knee OA, the first peak of EKAM was 19%, 18%, and 36% higher than the second peak of EKAM in walking, ascending, descending stairs, respectively (Guo et al., 2007), with the largest peak of EKAM recorded during descending stairs followed by ascending stairs and then level walking (Guo et al., 2007). In a longitudinal study, 39% higher EKAMs were present during stair descent in individuals who developed knee OA 3–5 years later (Amin et al., 2004). Therefore, reducing the EKAM has become the objective of early and conservative treatment in an attempt not only to reduce pain and maintain function but also to attempt in arresting disease progression.

A lateral wedge insole is a cheap and simple intervention (Kerrigan et al., 2002), and it has been found that it offers reduced medial compartment loading between 5.3% and 9% in the affected and contralateral knee in patients with medial knee OA (Hinman et al., 2008; Jones et al., 2013a; Kakihana et al., 2007). Lateral wedges are theorised to modify

* Corresponding author at: Room PO42 Brian Blatchford Building, School of Health Sciences, University of Salford, UK.
E-mail address: r.k.jones@salford.ac.uk (R.K. Jones).

http://dx.doi.org/10.1016/j.clinbiomech.2014.04.011
0268-0033/

load by changing the kinematics and kinetics of the ankle/subtalar joint. Previously, investigators have reported that a lateral wedge insole increases foot pronation which aligns the tibia and femur into a more upright position (Crenshaw et al., 2000; Jones et al., 2013b; Kerrigan et al., 2002; Maly et al., 2002). This along with an increased lateral centre of pressure and valgus ankle moments at the ankle resulted in less medial knee loading (Kakihana et al., 2005; Sasaki and Yasuda, 1987; Yasuda and Sasaki, 1987).

Whilst there is a plethora of studies on walking, there are limited studies investigating the effect of lateral wedge insoles on stair climbing with only one previous study investigating the immediate (after 1 week) and short term effects (after 12 weeks) of customised lateral wedge insoles with a neutral insert during stair descent. No reductions in EKAM were seen when using the lateral wedge insole but they did report an increase in EKAM at week 1 and week 12 with the lateral wedge insoles (Wallace et al., 2007).

To the author's knowledge, the effects of using a lateral wedge insole on the external knee adduction moment for patients with medial knee OA during ascending stairs have not been evaluated, nor fully evaluated for descending stairs. In the current study, an off-the-shelf lateral wedge insole (prefabricated according to fixed moulds independent of the variability amongst patients) was used to cancel out the variability of person-specific lateral wedge insoles which results from the inability of the manufacturing orthotist to accurately reproduce insoles with the same characteristics. Therefore, the purpose of this study was to determine whether an off-the-shelf lateral wedge insole reduced knee loading in the medial compartment during ascending and descending stairs in patients with medial knee OA.

2. Methods

This study was a randomised crossover design study comparing two conditions whilst ascending and descending stairs.

The Research Ethics Panel at the University of Salford approved the study. The inclusion criteria for participation were: over 40 years of age, medial knee osteoarthritis grades 2–3 (Kellgren and Lawrence, 1957) with greater medial narrowing than lateral, ability to walk and ascend and descend stairs without aids and/or assistance, no musculoskeletal complaints in the lower limb and has not worn assistive devices for medial knee OA. Patients with symptomatic evidence of lateral compartment or patellofemoral OA, rheumatoid arthritis, surgery within the past six months, previous stroke, hip or ankle symptoms, or a body mass index of above 35 were excluded. A sample of eight patients with medial knee OA (5 females, 3 males), age (47.38 (SD 3.02) years), height (1.69 (0.85) metre), body mass (66.13 (11.49) kg), Kellgren–Lawrence Scale (6 patients grade II, 2 patients grade III) participated in the study and all the patients had greater medial than lateral joint space narrowing.

To minimise the influence of footwear, all subjects wore the same type of standard shoe (ECCO Zen) which provided a baseline dataset for the footwear conditions. Two conditions were assessed, a control condition (with a neutral flat insert) and a lateral wedge insole. The lateral wedge insoles (Fig. 1) are off-the-shelf insoles made from a comfortable and flexible material (SureStep-Control™, with a medium density Shore A 70, SalfordInsole, Nuneaton, UK). The insoles (SalfordInsole, Nuneaton, UK) were full length lateral wedge insoles constructed with a medial arch, with a 5° lateral wedge used in previous studies (Forghany et al., 2010; Jones et al., 2013a,b).

Kinematic data were collected for the lower extremity using a 16 camera Qualisys OQUS motion capture system (Qualisys, Gothenburg, Sweden) sampling at 100 Hz. Passive retro-reflective markers were placed at the following anatomical sites: anterior superior iliac spine, posterior superior iliac spine, greater trochanter, medial and lateral femoral epicondyle, head of fibula, tibial tuberosity, and medial and lateral malleloli. Markers were glued to the heel and forefoot of the shoe. The CAST protocol (Cappozzo et al., 1995) was used to allow for segmental kinematics to be tracked in six-degrees of freedom and all cluster markers on the shank, thigh and pelvis stayed in place throughout each data collection session.

Kinetic data (200 Hz) were collected using two AMTI (BP400600) (AMTI, Boston, USA) force plates. The custom stairs (AMTI stairs (Della Croce and Bonato, 2007)) were securely fixed to the two force plates with bolts. This allows independent measurement of forces on each stair separately without the need to modify the existing setup in the laboratory. For example, when a contact is made on the first stair, data is recorded from the second force platform; when a contact is made on the second stair, data is recorded from the first force platform; and when a contact is made with the third stair, data is recorded from the second force platform (Fig. 2). This allowed gait events to be determined from the force platform data. A force structure was built within Visual 3D and CalTester (Holden et al., 2003) was performed ensuring that the force plates' location and laboratory frame were coincident to ensure accurate calculation of joint kinetics.

Prior to data collection, all subjects had the opportunity to become familiar with the interventions, and they were asked to walk and climb stairs for 10 min to ensure proper fit (of the shoes and lateral wedge insole) and comfort level. Each participant performed five trials

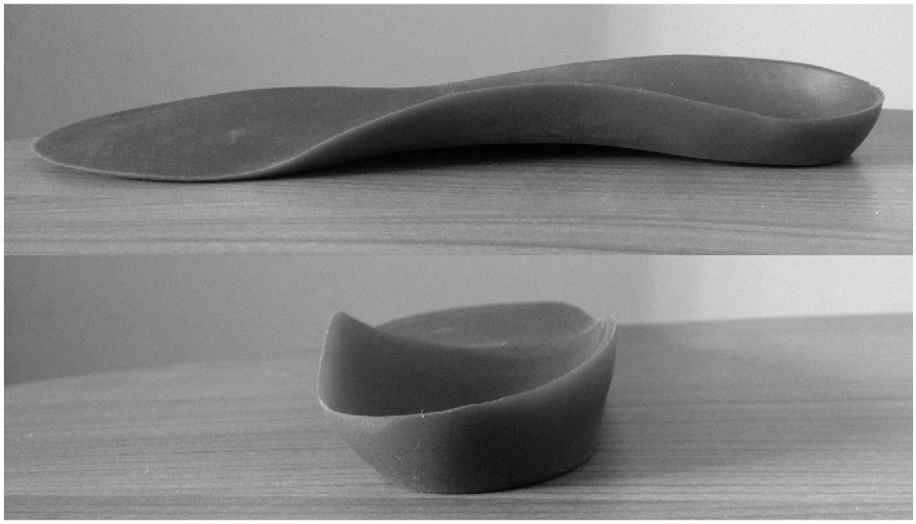

Fig. 1. Lateral wedge insole.