Gait & Posture 62 (2018) 518–522

Contents lists available at ScienceDirect

Gait & Posture

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

Full length article

# The effects of three quarter and full length foot orthoses on knee mechanics in healthy subjects and patellofemoral pain patients when walking and descending stairs

J. Burston[a,b], J. Richards[b,*], J. Selfe[c]

[a] South West Yorkshire Foundation Trust, Barnsley, UK
[b] Allied Health Research Unit, University of Central Lancashire, Preston, UK
[c] Department of Health Professions, Manchester Metropolitan University, UK

ARTICLE INFO

*Keywords:*
Foot orthoses
Knee mechanics
Healthy subjects
Patellofemoral pain patients
Walking
Descending stairs

ABSTRACT

*Background:* An increased load of the patellofemoral joint is often attributed to foot function in patients with patellofemoral pain. Foot orthoses are commonly prescribed for this condition; however the mechanisms by which they work are poorly understood. The aim of this study was to investigate the kinematics and kinetics of the knee between patellofemoral pain patients and a group of healthy subjects when using a standardised foot orthosis prescription during walking and step descent.

*Method:* Fifteen healthy subjects and fifteen patients diagnosed with PFP with a foot posture index greater than 6, had foot orthoses moulded to their feet. They were asked to walk at a self-selected pace and complete a 20 cm step descent using customised orthoses with ¾ and full length wedges. Kinematic and Kinetic data were collected and modelled using Calibrated Anatomical System Technique.

*Results:* Significant differences were seen in both the kinematics and kinetics between the healthy group and the PFP patients at the knee. A significant reduction in the knee coronal plane moment was found during the forward continuum phase of step descent when wearing the foot orthoses; this was attributed to a change in the ground reaction force as there were no changes reported in the kinematics of the knee with the orthoses.

*Conclusions:* This study identified potentially clinically important differences in the knee mechanics between the PFP patients and the healthy group during walking and step descent. The foot orthoses reduced the coronal plane knee moment in the PFP patients to a value similar to that of the healthy subjects with no intervention.

## 1. Introduction

Patellofemoral pain (PFP) is one of the most common lower limb disorders seen in musculoskeletal clinics [1–3]. Consensus statements published from three International Patellofemoral Pain Research Retreats (IPFPRR) propose subgroups based on biomechanical risk factors described by anatomical location relative to the knee: Proximal, Local and Distal which referred to the lower leg and ankle. More recently Selfe et al. [4] identified 3 distinct patellofemoral pain subgroups, one of which was 'weak and pronated' defined by strength measurement of the quadriceps and hip abductors and a foot posture index (FPI) score over 6.

Currently there is no consensus about what is the best management for PFP, and a wide range of treatments have been suggested including foot orthoses, patellar taping, knee supports and physiotherapy [5]. Pitman and Jack [6] suggested that foot orthoses could be used as a first line treatment in PFP patients. While Gross and Foxworth [7] noted that the experimental evidence for using foot orthoses to combat PFP is "theoretical and circumstantial", however despite the variable results in the changes in mechanics with orthoses they concluded that PFP patients with pronated feet may benefit from the use of foot orthoses.

Barton et al. [12] explored the clinical responses when wearing foot orthoses were in 60 people with PFP. Significant improvements were seen after 12 weeks of use using the anterior knee pain scale and number of pain free step downs and single leg raises when wearing prefabricated foot orthoses. Further work on the clinical response was conducted by Collins et al. [8] who performed a randomised control trial on 179 participants with patellofemoral pain. They found that the prefabricated orthoses improved the subjects' pain scores in the short term compared to flat insoles but found no long-term benefit when combined with physiotherapy.

Powers [9] stated that orthoses were being provided without

* Corresponding author.
*E-mail address:* JRichards@uclan.ac.uk (J. Richards).

https://doi.org/10.1016/j.gaitpost.2018.04.018
Received 18 May 2017; Received in revised form 5 April 2018; Accepted 13 April 2018
0966-6362/ 

considering underlying biomechanics, therefore using orthoses to treat PFP is a "trial and error treatment", suggesting the link between patellofemoral joint function and foot pronation is tenuous. Powers et al. [10] later reported that there is some evidence to suggest foot orthoses are useful in the treatment of PFP, however a greater understanding is needed on how foot function affects the patellofemoral joint. Boldt et al. [11] suggested that medially wedged orthoses reduce retro-patellar stress by limiting calcaneal eversion and tibial rotation, however results across studies are inconsistent. In addition, little has been published different designs of orthoses which can include ¾ length and full-length foot orthoses, and whether these can have an influence on joint stability during different tasks is unknown.

Selfe et al. [13,14] highlighted that a dynamic "challenge" for the knee is needed to explore the effect of different treatment options in people with PFP. Step descent was proposed due to the increased eccentric control it requires over a greater knee range of motion in closed chain. Selfe, et al. used a 20 cm step descent task where participants were asked to descend as slowly as possible with no intervention, tape and a soft brace. They reported reductions in the range of coronal and transverse plane angles and moments, this was purported as an improvement in knee joint control. Selfe, et al. [13] concluded that coronal and torsional kinematics and kinetics must not be excluded when investigating step descent. However, to the authors knowledge, there have been no studies conducted exploring the biomechanical effects of foot orthoses during step descent.

Despite the amount of work that has been conducted on different interventions in patients with PFP, little data exists exploring the differences in knee kinematics between patients with PFP and healthy subjects, and whether interventions such as foot orthoses can have a differential effect. Therefore, the purpose of this study was to investigate if differences exist in the kinematics and kinetics of the knee between a group PFP patients and a group of healthy subjects and to identify if they reacted similarly to standardised foot orthoses prescriptions during walking and step descent at self-selected speeds.

The hypotheses were a) PFP patients have different knee biomechanics during walking and step descent to healthy subjects, b) foot orthoses change knee biomechanics during walking and step descent, c) PFP and healthy subjects react in a similar way to the different foot orthoses prescriptions.

## 2. Method

### 2.1. Participants

Fifteen healthy subjects and fifteen patients with a diagnosis of PFP were recruited from a University staff and student population. The healthy group consisted of 7 males and 8 females mean age 30.1 (s.d. 10.0), with a mean FPI score of 6.3 (+4 to +9). PFP patients consisted of 8 men and 7 women, mean age 28.6 years (s.d. 5.8), mean FPI score of 7.9 (+6 to +10) [15], and suffering with pain around the patella with visual analogue pain score of at least 3 on a regular basis following sport or descending stairs. Inclusion criteria included; pronated feet, no history of knee surgery or back pain. Three subjects did not meet the inclusion criteria; one with a supinated foot posture and two with back pain.

### 2.2. Procedures

Five repetitions of self-selected speed level walking and a 20 cm step descent task were performed under three conditions: no orthoses, ¾ length foot orthoses and full-length foot orthoses. The rationale for this was that full-length orthoses may provide greater stability during step descent over the more frequently provided ¾ length orthoses. The healthy subjects descended with their preferred limb, while the PFP group descended on their most affected limb. The orthoses were customised to each subject by using a correctly sized pair of Slimflex™

**Fig. 1.** Stages of insoles being supported with shore 30 EVA.

**Fig. 2.** customised insole fitted to longitudinal arch of each subject.

insoles. These were heated and moulded to the longitudinal arch profile of each subject (Fig. 1), and supported with low density EVA (shore 30) with no posting (Fig. 2). A standard 5° medially wedged EVA post of either ¾ length or full-length was placed under the moulded orthoses in the subjects own training shoes.

Kinetic data were collected at 200 Hz using four AMTI force plates. A series of three steps of heights 20 cm, 40 cm and 20 cm were placed on the force plates for the step-descent task. Kinematic data were collected using a ten camera infra-red Oqus motion analysis system (Qualisys medical AB, Sweden) at 100 Hz. Passive retro-reflective markers were placed on the lower limbs. To reduce measurement error reflective markers were positioned by a single experienced researcher with the participant in a relaxed anatomical standing position and all data were collected during a single visit [16]. Anatomical markers were positioned on the anterior superior iliac spine, posterior superior iliac spine, greater trochanter, medial and lateral femoral epicondyle, medial and lateral malleoli and over medial and lateral aspects of 1st and 5th metatarsal respectively. Additionally, clusters of non-collinear markers were attached to the shank and thigh using the Calibrated Anatomical System Technique [17]. Markers were also placed over forefoot, midfoot and rearfoot aspects of the shoes. Raw kinematic and kinetic data were exported to Visual3D (C-Motion Inc., USA). Kinematic and kinetic data were filtered using fourth order Butterworth filters with cut off frequencies of 6 and 25 Hz, respectively. Anatomical frames were defined by landmarks positioned at the medial and lateral borders of the joint, from these right handed segment co-ordinate systems were defined and the hip joint centre positions were calculated based on pelvic depth and width using the regression equations developed by Bell et al. [18]. Knee kinematics were calculated based on the cardan sequence of XYZ, equivalent to the joint co-ordinate system [19] and knee kinematic and kinetic data were quantified for stance phase during walking and from toe off and initial contact of the contralateral side for step descent.