Journal of Orthopaedics 13 (2016) 220–224

Contents lists available at ScienceDirect

Journal of Orthopaedics

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

Original Article

The effects of a semi-rigid soled shoe compared to walking barefoot on knee adduction moment

Koushik Ghosh [a], Shibby Robati [b,*], Olivia Sharp [b]

[a] Frimley Park Hospital, Portsmouth Road, Frimley, Surrey GU16 7UJ, UK
[b] Conquest Hospital, The Ridge, Saint Leonards-on-Sea, East Sussex TN37 7RD, UK

ARTICLE INFO

Article history:
Received 28 February 2015
Accepted 3 May 2015
Available online 2 March 2016

Keywords:
Gait
Knee joint
Shoes
Mechanobiological phenomena

ABSTRACT

Background/Purpose: On a background of literature suggesting that certain rigid soled shoes may increase the knee adduction moment during gait this study was performed to look at specific postoperative shoe – the Medishoe. This shoe is used on a daily basis in a district general hospital orthopaedic department for patients post-operatively to protect wounds and fixations.
Methods: Using force plates and an opto-electronic motion capture system with retroreflective markers the knee adduction moment was estimated in ten healthy subject both with and without the shoe during normal gait. The angle at which the ground reaction acted with respect to the ground in the coronal plane as well as the tibiofemoral angle were also calculated using the Qualsys software – both with and without the Medishoe.
Results: Two-tailed paired t-tests using a 95% confidence interval showed that there was no significant difference between the two groups in the estimated knee adduction moment ($p = 0.238$), tibiofemoral angle ($p = 0.4952$) and the angle of the ground reaction force to the ground ($p = 0.059$).
Conclusion: There was no significant difference in the estimated knee adduction moment between the two groups, although there was a statistical trend to an alteration in the angle of the ground reaction force. Further work involving a greater number of subjects and a three dimensional model would further answer the question as to whether these or other post-operative shoes have a significant effect on the knee adduction moment.

1. Introduction

Knee osteoarthritis is a widespread and debilitating disease that can have potentially devastating effects on peoples work and quality of life. Choice of footwear is playing a crucial role in the prevention of arthritis progression. Footwear and its vast variety of modifications has long been thought to be related to certain orthopaedic problems.[1] Recent studies have looked at the effect of a variety of different types of shoes had on the peak knee adduction moment,[2] with clogs and stability shoes leading to greater knee adduction moments which has been shown to increase in the progression of osteoarthritis.[3]

The knee adduction moment is defined as the product of the ground reaction force (GRF) and its perpendicular distance from the centre of rotation of the knee. Its value varies during the different phases of the gait cycle (Fig. 1).

In order to reduce the knee adduction moment, there must be either a reduction in magnitude of the ground reaction force, or a reduction in length of the moment arm.

It is common practice for shoes to be used post-operatively following foot or ankle surgery in order to encourage mobilization and make early weight-bearing comfortable. However, in post-operative patients who also happen to have pre-existing knee medial compartment osteoarthritis, any potential increase in knee adduction moment could exacerbate their condition. This effect could be augmented even further if the patients had a pre-existing varus deformity, which would further increase the moment arm of the ground reduction force. The use of inexpensive, minimalistic and flexible shoes as close to barefoot in design have been suggested,[5,6] but even these could be detrimental to any pre-existing osteoarthritis when compared to walking purely barefoot.[7] In the post-operative patient, a compromise must be made between controlling the knee

* Corresponding author.
E-mail address: srobati@nhs.net (S. Robati).

http://dx.doi.org/10.1016/j.jor.2015.05.001

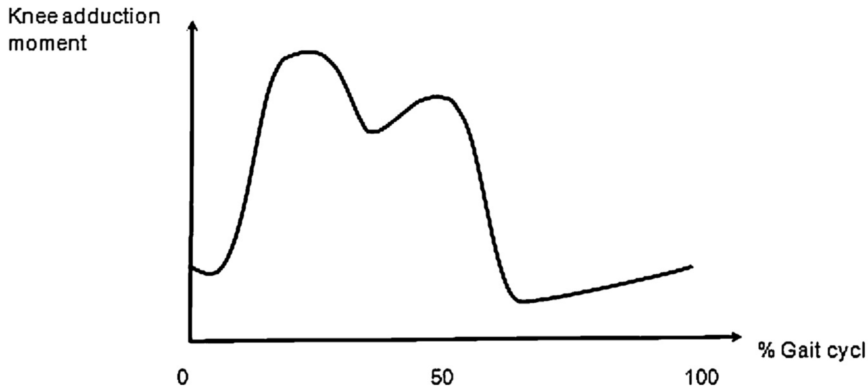

Fig. 1. Dynamic variation of the knee adduction moment during the gait cycle. Simplified from Deluzio et al.[4]

adduction moment and protecting the surgical wound and fixation.

This study looks at a specific post-operative shoe (Medishoe, Promedics Orthopaedics) which is a semi-flexible, rigid non-slip sole (Fig. 2). The aim was to see whether the shoe had an effect on the knee adduction moment in normal subjects. Knee adduction moments were compared in subjects walking barefoot and then with the shoe.

2. Methods

Ethical approval was obtained for this study from the University of Surrey. Ten healthy volunteers were recruited. The entry criteria for the study were males and females between the ages of 18 and 60 who had no previous history of lower limb operations or pathology. Written consent was obtained from all subjects.

For each subject the gait was analysed with and without the Medishoe. This was done with motion capture 3D with 10 high resolution cameras (ProReflex, Qualisys, Göteborg, Sweden) and two force-platforms (AMTI Force and Motion, Massachusetts, USA). Each camera had an array of diodes that were able to emit infrared radiation that can be reflected back off spherical reflective markers. The cameras capture the movement of the reflective markers at a frequency of 100 Hz in two-dimensions.

An optoelectronic system was used to measure the peak knee adduction moment with retro-reflective markers on subjects arranged in a particular configuration, to create a model consisting of rigid bodies moving with six degrees of freedom. When used in conjunction with force plates, the knee adduction moment could be calculated by exporting data into software that is able to analyse and interpret moments in any desired plane. The set-up was similar to that previously described with three retro-reflective skin markers were attached to the greater trochanter, lateral epicondyle of the femur and the lateral malleolus of the ankle.[9] All markers were attached directly on skin using hypoallergenic double-adhesive tape. Markers were attached directly onto skin as opposed to trousers or clothes in order to prevent their relative movement with respect to the bony landmarks.

A simple three-marker technique was used as shown in Fig. 3. Once the trials were completed, a statistical analysis was performed to see how peak knee adduction moment, defined as the varus/valgus alignment of the femur with respect to the tibia, changed with the use of the Medishoe. Using trigonometry the angle at which the peak ground reaction force in the coronal plane acts to the horizontal was then calculated, to see whether the direction of the force was changed by a shoe - a possibility that was suggested by Lidtke.[10]

Prior to the experiments, a calibration frame was used for static calibration of the system and to define the co-ordinates of the system. They consisted of an 'L'-shaped metal limb with the reflective markers pre-attached. Each limb of this calibration frame represented the 'x', 'y' and 'z' axes. The frame was placed so the long limb of the 'L' was parallel to the long axis of the force platforms and the position of the markers were recorded with the cameras. Dynamic calibration was then performed by waving a 'T'-shaped wand with reflective markers attached within the work space. This was done so as to allow the camera to view the wand in as many orientations as possible, to allow each camera to be individually calibrated in all directions. This was done for ten seconds at a camera capture frequency of 100 Hz in order for each camera to capture 1000 frames. Prior to beginning the experiments it was checked that the calibration test was passed.

Fig. 2. The Medishoe (Promedics Orthopaedic).[8]

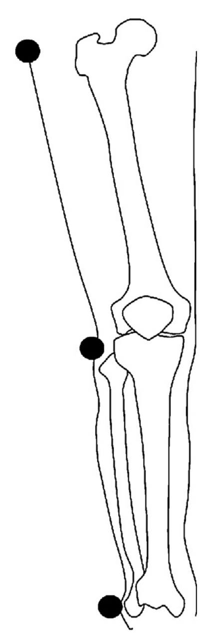

Fig. 3. Figure showing markers on the greater trochanter, lateral condyle of tibia and lateral malleolus.