The Knee 19 (2012) 163–175

Contents lists available at ScienceDirect

The Knee

Review

Effect of footwear on the external knee adduction moment — A systematic review ☆

Andy Oliver Radzimski [a], Annegret Mündermann [b], Gisela Sole [a,*]

[a] Center for Physiotherapy Research, University of Otago, P.O. Box 56, Dunedin, New Zealand
[b] University of Constance, Universitätsstraße 10, D-78464 Constance, Germany

ARTICLE INFO

Article history:
Received 2 November 2010
Received in revised form 25 May 2011
Accepted 30 May 2011

Keywords:
Osteoarthritis
Knee adduction moment
Footwear
Orthoses
Barefoot

ABSTRACT

Context: Footwear modifications have been investigated as conservative interventions to decrease peak external knee adduction moment (EKAM) and pain associated with knee osteoarthritis (OA).
Objective: To evaluate the literature on the effect of different footwear and orthotics on the peak EKAM during walking and/or running.
Methods: A systematic search of databases resulted in 348 articles of which 33 studies were included.
Results: Seventeen studies included healthy individuals and 19 studies included subjects with medial knee OA. Quality assessment (modified Downs and Black quality index) showed an (average ± SD) of 73.1 ± 10.1%. The most commonly used orthotic was the lateral wedge, with three studies on the medial wedge. Lateral wedging was associated with decreased peak EKAM in healthy participants and participants with medial knee OA while there is evidence for increased peak EKAM with the use of medial wedges. Modern footwear (subjects' own shoe, "stability" and "mobility" shoes, clogs) were likely to increase the EKAM compared to barefoot walking in individuals with medial knee OA. Walking in innovative shoes ("variable stiffness") decreased the EKAM compared to control shoes. Similarly, shoes with higher heels, sneakers and dress shoes increased EKAM in healthy individuals compared to barefoot walking.
Conclusions: Further development may be needed toward optimal footwear for patients with medial knee OA with the aim of obtaining similar knee moments to barefoot walking.

Contents

☆ Conflict of interest: The authors state that there are no conflicts of interest, which might have influenced the preparation of this manuscript.

* Corresponding author. Tel.: +64 3 479 7936; fax: +64 3 479 8414.
E-mail address: gisela.sole@otago.ac.nz (G. Sole).

0968-0160/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.knee.2011.05.013

1. Introduction

Osteoarthritis (OA) of the knee is one of the most common rheumatic diseases with an estimated 12% of the American population over the age of 60 years being affected [1]. It is commonly associated with substantial pain and immobility [1]. More recently, the lifetime risk of symptomatic knee OA has been found to be nearly 1 in 2 overall, more than 1 in 2 for those with a history of a knee injury, and nearly 2 in 3 for obese people [2].

It is widely accepted that biomechanical forces are associated with the pathogenesis of OA [3–5]. In healthy subjects, the peak medial knee compartment load during early stance of walking is 2.3–2.6 times the bodyweight (BW) [6–9], while the lateral compartment is subjected to a peak load of 1.7 times BW [9]. The higher bone mineral density of the subchondral bone of the proximal medial tibia compared to the lateral side supports the difference in mechanical stress between both knee compartments [10]. These findings may explain the higher prevalence of medial knee OA, which is estimated to be 10 times more frequent than lateral knee OA [11].

Since direct measurement of knee joint load is invasive, gait analysis has been used as an indirect method to quantify forces acting upon the lower extremity. The external knee adduction moment (EKAM) is a valid and reliable representative of the medial-to-lateral knee load distribution [7,12]. This varus torque shows a typical pattern of a higher first peak and a lower and less distinct second peak during early and late stance, respectively, in both healthy and symptomatic subjects [13,14]. There is evidence showing that patients with medial knee OA have a significantly higher first peak EKAM compared to a healthy population [14–22].

The EKAM during walking has been linked to the symptoms, initiation and progression of knee OA [23–26]. Consequently, the first peak EKAM has become an important variable in research to determine the risk and progression of medial knee OA, and to evaluate the effects of interventions, such as surgery, in the management of patients with this disorder. Further, other lesions of the lower limb, such as an anterior cruciate ligament (ACL) or meniscal injury have also been associated with increased peak EKAM during walking [27,28]. As these injuries form a high risk for the development of future knee OA, [5,29,30] it may be important that rehabilitative strategies are implemented with the goal of decreasing EKAM during activity.

Over the past two decades, modified footwear has been investigated as potential conservative management of knee OA. More specifically, lateral wedging has been used with the goal of reducing symptoms associated with medial knee OA, hypothetically by reducing the peak EKAM in these patients [4]. If specific footwear interventions are associated with decreased EKAM during walking and other physical activity, these may be useful toward the management of symptoms of patients with medial knee OA, and potentially to reduce the risk of future OA in people who are at increased risk, such as those with knee injuries. This review aims to evaluate the current knowledge on various footwear interventions in relation to the peak EKAM in healthy and subjects with disorders of the knee.

2. Methods

2.1. Search strategy

An electronic search was undertaken without language restriction of Medline, PubMed, AMED, CINAHL, EMBASE and Scopus databases from their original available dates to January 2011. The search strategy included a combination of keywords for inclusion and exclusion factors (Appendix A). These were followed by hand searches relevant journals. Finally, the citation lists of included studies were screened for additional relevant articles via the database Web of Science.

2.2. Inclusion criteria

i. Peer-reviewed and published randomized controlled trials, quasi-randomized controlled trials, laboratory based trials, case series and case reports.
ii. Human participants with or without disorders of the knee, defined as ligamentous or meniscal injury, or as OA.
iii. Independent variables included footwear, such as different shoes, insoles or foot orthotics, and/or barefoot.
iv. Dependent variables included EKAM (or defined as knee varus moment) during daily physical activities such as walking, stair climbing or running.

Papers testing participants with lower limb fractures, systemic diseases such as rheumatoid arthritis, or neurological disorders such as stroke were excluded.

2.3. Study selection

After exclusion of duplicates, the principal investigator (AOR) screened all titles and article types for relevance. Irrelevant articles, such as animal studies or unrelated clinical conditions were excluded. Two independent assessors (AOR and GS), blinded to authors and journals, screened all potentially relevant titles and abstracts for inclusion criteria. Full articles were retrieved if no abstract or insufficient information from title and abstract was available. In case of disagreement the two assessors' consensus was reached following discussion, or after full article assessment.

2.4. Risk of bias

As this systematic review included mainly laboratory-based biomechanical studies, a modified Downs and Black quality checklist was used [31]. Twelve questions (items 4, 8, 9, 13, 14, 17, 19, 21, 22, 24, 25 and 26) from the original checklist were excluded as they were irrelevant to non-randomized studies. Thus, the modified checklist included 15 questions from the following sub-groups: reporting (items 1, 2, 3, 5, 6, 7 and 10), external validity (items 11 and 12), internal validity — bias (items 15, 16, 18 and 20), internal validity — confounding (selection bias) (item 23) and power (item 27). Questions five and 27 were adapted, as the majority of studies investigated different footwear conditions in one group of subjects. The reliability and validity of the modified Downs and Black quality checklist used in this review were not assessed as similar modified versions have already been published [32,33]. Walking speed was considered as the most important principal confounder to be reported, as this variable has shown to be correlated with the EKAM [34].

Two reviewers (AOR and GS) independently assessed the quality of all included articles. Items on the statistical tests used for the main outcomes and the accuracy of main outcome measures were also scored by a third reviewer (AM). If the quality scores differed among the assessors, consensus was reached through discussion. For the