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The biomechanical effects of a new design of lateral wedge insole on the knee and ankle during walking

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ABSTRACT

Lateral wedged insoles are a common treatment in individuals with medial tibiofemoral osteoarthritis of the knee joint. One concern has been the potential for increased foot and ankle pain due to increased eversion. The purpose of this study was to assess the biomechanical effectiveness of a typical lateral wedged insole and a combined insole with a lateral wedge and off-the-shelf anti-pronatory device in shoes while walking. A cross-over randomized design was used where each insole was worn by fifteen healthy subjects while three-dimensional motion data were collected in three different conditions: (1) control condition (with standard shoes), (2) with an insole with a lateral wedge and additional off-the-shelf anti-pronatory support (supporting), and (3) with an insole with a lateral wedge with no additional support (unsupported) in the standard shoes. The unsupported insole significantly increased the amount of ankle/subtalar joint complex eversion than the other experimental conditions, with the supporting insole reducing the ankle/subtalar joint complex eversion, and was found to be more comfortable. Both the supporting and unsupported lateral wedged insoles significantly reduced knee loading (external knee adduction moment reduction 8.5% and 9.1%, respectively), the knee adduction angular impulse. This new design of lateral wedge may offer increased adherence in future osteoarthritis population studies while offering reductions in joint loading.

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1. Introduction

Knee osteoarthritis is a chronic and widely prevalent degenerative disease that commonly affects older people (Felson et al., 2000). While knee osteoarthritis can affect the medial and lateral tibiofemoral and patellofemoral joints, the medial tibiofemoral compartment of the knee is more commonly affected, up to 10 times more frequent than the lateral compartment (Ahlback, 1968). It has been demonstrated that around 70% of the load goes through the medial tibiofemoral compartment (Schipplein & Andriacchi, 1991) during walking. This disproportionate load distribution is to be expected since there is an external adduction moment at the knee throughout stance, which has been commonly used as an indirect measure of medial joint loading (Prodromos, Andriacchi, & Galante, 1985; Zhao et al., 2007). In addition, there is increasing evidence that the external knee adduction moment in medial tibiofemoral osteoarthritis may be a reliable predictor of osteoarthritis progression (Miyazaki et al., 2002) and medial and lateral tibial bone distribution (Hurwitz, Sumner, Andriacchi, & Sugar, 1998). The link between disease severity and progression of knee osteoarthritis has been found to correlate with the external knee adduction moment (Miyazaki et al., 2002; Mundermann, Dyrby, Hurwitz, Sharma, & Andriacchi, 2004; Sharma et al., 1998) and also the knee adduction angular impulse (Thorp et al., 2006). Therefore, an approach that aims to reduce this external knee adduction moment and the knee adduction angular impulse is an important treatment option, given the lack of structure modifying treatments.

In the management of knee osteoarthritis, surgical treatments such as total knee replacements have been of great success, but conservative treatment continues to be important. In a conventional regime, analgesics and NSAIDS have been advocated extensively. However, Schnitzer et al. (1993) studied the effects of piroxicam on osteoarthritis knees and found that although symptomatic pain was relieved, the loading (external knee adduction moments) of the knee increased. Lateral wedged insoles are suggested as a conservative management method for the individual with medial tibiofemoral osteoarthritis as they are very cheap, simple and safe. The clinical findings with lateral wedged insoles are inconsistent with authors (Barrios, Crenshaw, Royer, & Davis, 2009; Toda & Tsukimura, 2004) showing significant pain reductions, whereas others have demonstrated no difference in pain scores (Baker et al., 2007; Bennell et al., 2011; Pham et al., 2004), although the latter did demonstrate a reduced analgesia intake in their subjects. Lateral wedged insoles are designed to reduce the external knee adduction moment by altering the path of the centre of pressure laterally with respect to the defined knee centre or origin (Yasuda & Sasaki, 1987) and thus altering loading at the knee. Various authors have investigated knee loading and demonstrated a reduction in the external knee adduction moment in healthy subjects (Kakihana, Akai, & Yamasaki, 2004; Kakihana et al., 2005; Kerrigan et al., 2002), and in individuals with medial tibiofemoral osteoarthritis (Kakihana, Akai, Nakazawa, Naito, & Torii, 2007; Butler, Marchesi, Royer, & Davis, 2007; Hinman, Payne, Metcalf, Wrigley, & Bennell, 2008; Hinman, Bowles, & Bennell, 2009). However, even though the lateral wedged insole has been reported as a very effective and viable solution to reduce the external knee adduction moment during walking, some patients have complained of decreased comfort and even stopped wearing them due to pain in the ankle/subtalar joint complex and other joints (Bennell et al., 2011; Kakihana, Akai, & Yamasaki, 2004). In the recent randomized study (Bennell et al., 2011) 47% of individuals had problems with their unsupported lateral wedge insole through discomfort. A possible explanation for increased discomfort and pain in the ankle/subtalar joint complex may be as a consequence of the increased eversion moments that are acting on this joint, due principally to the design of typical lateral wedge insoles (Kakihana et al., 2004). The single piece of lateral wedge material itself would increase ankle/subtalar joint complex eversion to a greater extent and may increase stress on these joints, which is a concern for clinicians. Therefore, an intervention that helps to reduce the external knee adduction moment but also prevents or limits deleterious movements of the ankle/subtalar joint complex would be perceived as a better intervention.

A recent study demonstrated that a medial arch support can provide improved biomechanical effectiveness in healthy subjects (Nakajima et al., 2009). However, this study has two methodological limitations; first the insoles were strapped to the subject's barefeet, which makes it difficult for subjects to walk, with insole effectiveness shown to be significantly affected by the footwear worn (Johnson, 1998). Second, the medial arch support was bespoke to the individual but there is a trend developing