Variable-stiffness walking shoe lowers knee adduction moment, reduces pain, and improves function in patients with osteoarthritis after one year

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Introduction: An increased rate of progression of osteoarthritis (OA) of the medial compartment as well as poorer treatment outcome have been associated with a high adduction moment at the knee during walking [1,2]. Consequently interventions that reduce the adduction moment during walking offer a unique treatment alternative to conventional methods. Footwear modifications using laterally-wedged insoles and variable-stiffness soles have been shown to reduce the knee adduction moment in both healthy and osteoarthritic populations [3-6]. However, there have been mixed results regarding the reduction in pain and improvement in function with lateral wedges in subjects with OA. Several studies found improvements in pain when using both lateral wedges and analgesics in comparison to analgesics alone [7,8]. However when the potential of a placebo effect was introduced in randomized control studies, the lateral wedges failed to produce such reductions in pain [9,10]. Furthermore, it is not known if the reduction in adduction moment with the variable-stiffness shoes is sustained after 12 months of wear in an osteoarthritic population, or if it is accompanied by a reduction in pain and improvement in function. The purpose of this study was to test the following hypotheses: (1) variable-stiffness shoes will lower the knee adduction moment in the affected leg of individuals with medial compartment knee OA, compared to the subjects’ personal shoes after 12 months of shoe wear, and (2) the reduction in knee adduction moment with the variable-stiffness shoe will be accompanied by a reduction in pain and improvement in function relative to a placebo control.

Materials and Methods: 35 subjects with symptoms of medial compartment knee OA participated in this prospective placebo-control study after giving written consent in accordance with the Institutional Review Board. At an initial visit, subjects were randomly assigned to either a uniform stiffness control shoe (16 subjects, 7 male, 9 female; age: 61.8 ± 11.3 yrs; height: 1.71 ± 0.08 m; mass: 83.6 ± 13.5 kg) or a variable-stiffness intervention shoe (19 subjects, 11 male, 8 female; age: 62.5 ± 9.8 yrs; height: 1.70 ± 0.08 m; mass: 81.6 ± 16.6 kg) to wear as their main walking shoe (at least 4 hours wear per day) for 1 year. Subjects were blinded as to their shoe type. The variable-stiffness intervention shoe had a lateral sole stiffness 2.5x greater than the medial sole stiffness, with the medial sole stiffness equal to the stiffness of the control shoe. Subjects completed WOMAC functional improvement-based ratings specific to osteoarthritis to assess pain and function [11] at the baseline and 12 month time points. At the 12 month time point, subjects performed 3 walking trials at a self-selected normal speed in their personal walking shoe (comfortable walking shoe used by patient) and their study shoe (control or intervention). Kinematic and kinetic data were collected using an 8-camera optoelectronic motion capture system. External inter-segmental forces and moments were calculated for the lower limb using previously described methods [12]. The first peak knee adduction moment was calculated for each trial. Average values for each shoe and subject were determined for each subject’s more affected leg, and paired two-tailed Student’s T-tests were used to compare the different shoes (α= 0.05). Paired two-tailed Student’s T-tests (α= 0.05) were also used to compare the WOMAC ratings between the baseline and 12 month time points.

Results: The knee adduction moment of the subjects’ more affected leg was significantly reduced for the intervention group (p<0.01) with the variable-stiffness shoe versus the subjects’ own personal walking shoes after 12 months of wear, ranging from a 21% reduction to a 7% increase, with an average reduction of 5.7%. Eighty percent of subjects had a reduction in knee adduction moment with the intervention shoe. For the control shoe group, there was an increase in knee adduction moment (p<0.01) with the control shoe versus the subjects’ own personal shoes after 12 months of wear, ranging from a 3% reduction to a 33% increase, with an average increase of 8.8% (Figure 1). Eighty percent of subjects had an increase in knee adduction moment with the control shoe.

Discussion: The use of a variable-stiffness intervention shoe successfully reduces the knee adduction moment in subjects with symptoms of medial compartment knee OA compared to the subjects’ personal shoes after 12 months of wear, supporting hypothesis 1. The majority of subjects experienced a reduction with the intervention, with the greatest reduction exceeding 20%. Furthermore, this reduction in knee adduction moment was accompanied by a reduction in pain and improvement in function in the intervention group. These results contrast those of randomized control studies of lateral wedges, which did not find reductions in pain after long-term use [7,8]. It is possible the dynamic action of the variable-stiffness shoe may be more effective at reducing pain and improving function than the static action of a lateral wedge. This study supports the conclusion that wearing an intervention shoe can reduce the knee adduction moment, reduce pain and improve function, and possibly slow the progression of knee osteoarthritis in subjects with medial compartment knee OA after long-term wear.


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