

# LOAD-MODIFYING FOOTWEAR INTERVENTION LOWERS KNEE ADDUCTION MOMENT, REDUCES PAIN, AND IMPROVES FUNCTION IN SUBJECTS WITH MEDIAL COMPARTMENT KNEE OSTEOARTHRITIS

Jennifer Erhart<sup>1,2</sup>, Nicholas J. Giori<sup>1,2,3</sup>, and Thomas P. Andriacchi<sup>1,2,3</sup>

<sup>1</sup> Department of Mechanical Engineering, Stanford University, Stanford, CA, USA

<sup>2</sup> Bone and Joint Center, Palo Alto VA, Palo Alto, CA, USA

<sup>3</sup> Department of Orthopedic Surgery, Stanford University, Stanford, CA, USA

E-mail: [jerhart@stanford.edu](mailto:jerhart@stanford.edu)

Web: [www.stanford.edu/group/biomotion](http://www.stanford.edu/group/biomotion)

## INTRODUCTION

A high maximum adduction moment at the knee during walking has been associated with an increased rate of progression (Miyazaki et al. 2002) and worse treatment outcome (Andriacchi 1994) of medial compartment osteoarthritis (OA) of the knee. Consequently, many interventions for knee OA attempt to reduce the maximum knee adduction moment. Wedged inserts have been shown to reduce the knee adduction moment in healthy and osteoarthritic populations (Krenshaw et al. 2000, Kerrigan et al. 2002). However, randomized control studies of laterally wedged insoles in subjects with medial compartment knee OA have failed to show reductions in pain compared to control after both 6 and 24 months of use (Maillefert et al. 2001, Pham et al. 2004). Variable-stiffness shoes with greater lateral sole stiffness than medial sole stiffness have also been shown to reduce the knee adduction moment in healthy individuals (Fisher et al. 2007). However, it is not known if this reduction occurs in an osteoarthritic population, or if this reduction is associated with a decrease in pain. The purpose of this study was to test the following hypotheses: (1) the knee adduction moment will be reduced in subjects with medial compartment knee osteoarthritis after six months of variable-stiffness shoe wear (2) the reduction in knee adduction moment will be accompanied by a reduction in pain and improvement in function.

## METHODS

24 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 constant-stiffness control shoe (12 subjects; 5 male, 7 female; age:  $63.3 \pm 8.5$  yrs; height:  $1.66 \pm 0.08$ ; mass:  $73.6 \pm 16.1$  kg) or a variable-stiffness intervention shoe (12 subjects; 5 male, 7 female; age:  $65.5 \pm 11.3$  yrs; height:  $1.71 \pm 0.08$ ; mass:  $85.1 \pm 15.4$  kg) to wear as their main walking shoe (at least 4 hours of wear per day) for 6 months. Subjects were blinded as to their shoe type. The variable-stiffness intervention shoe has a lateral sole stiffness 2.5x greater than the medial sole stiffness, which is equal to the stiffness of the control shoe sole. Subjects also completed WOMAC functional improvement-based patient ratings specific to osteoarthritis to assess pain and function (Bellamy et al. 1988). At the 6 month time point, subjects again completed WOMAC questionnaires and performed 3 walking trials at a self-selected normal speed in their study shoe (control or intervention) and their own personal walking shoe (comfortable walking shoe used by the patient).

Kinematic and kinetic data were collected using an 8-camera optoelectronic motion capture system (Qualisys) and reflective markers. External inter-segmental forces and moments were calculated for the lower limb

using previously described methods (Andriacchi et al. 2004). 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 (determined by self-reported pain), and paired two-tailed Student's T-tests were used to compare the different shoes ( $\alpha=0.05$ ). Paired two-tailed Student's t-tests ( $\alpha=0.05$ ) were also used to compare the functional-improvement based ratings at the initial and 6 month time points.

## RESULTS AND DISCUSSION

The knee adduction moment of the subjects' more affected leg was significantly reduced for the intervention group ( $p<0.01$ ) with the variable-stiffness shoes versus the subjects' own personal walking shoes after 6 months of wear, with an average reduction of 6.4%. For the constant-stiffness control shoe group, there was no significant difference in knee adduction moment with the control shoes versus the subjects' own personal walking shoes after 6 months of wear.

For the intervention group, there was a significant improvement in WOMAC score ( $p<0.01$ ) from the initial to 6 month time point, with an average absolute reduction in WOMAC score of 31 points. For the control group, there was no significant change in WOMAC score from the initial to the 6 month time point (Figure 1).

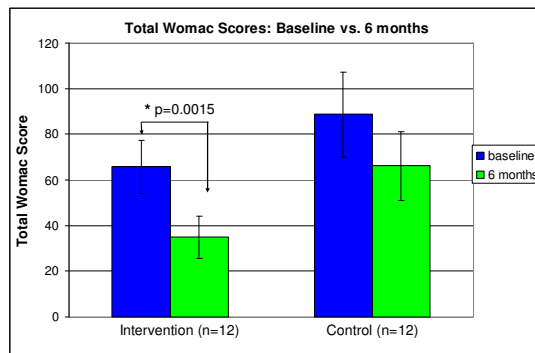


Figure 1: Average WOMAC scores ( $\pm$ SEM) at the initial and 6 month time points for the intervention and control groups.

## SUMMARY/CONCLUSIONS

The use of a variable-stiffness shoe significantly reduces pain and improves function after 6 months of shoe wear. This finding is in contrast to studies of lateral wedges, which did not find reductions in pain after long-term use. It is possible that the dynamic action of the variable-stiffness shoe is more effective at reducing pain and improving function than the fixed foot position of a lateral wedge. Furthermore, the reduction in pain is accompanied by a reduction in knee adduction moment; thus the variable-stiffness shoes provide both reduced load and reduced pain, and may slow the rate of progression of medial compartment knee OA.

This study supports the conclusion that wearing a variable-stiffness shoe can reduce the knee adduction moment, significantly reduce pain and improve function, and possibly slow the progression of knee osteoarthritis, in patients with symptoms of medial compartment knee osteoarthritis.

## REFERENCES

- Andriacchi TP et al. (1994) *Orthop Clin North Am* **14**, 289-295.
- Andriacchi TP et al. In *Basic Orthopaedic Biomechanics*, 3rd ed., 91-121, 2004.
- Bellamy N et al. (1988) *J Rheumatol* **15**,1833-1840.
- Crenshaw SJ et al. (2000) *Clin Orthop* **375**, 185-192.
- Fisher DS et al. (2007) *J Orthop Res* **25(4)**, 540-546.
- Kerrigan DC et al. (2002) *Arch Phys Med Rehabil* **83**, 889-893.
- Maillefert JF et al. (2001) *Osteoarthritis Cartilage* **9**, 738-745.
- Miyazaki T et al. (2002) *Ann Rheum Dis* **61**, 617-622.
- Pham T et al. (2004) *Osteoarthritis Cartilage* **12**, 46-55.

## ACKNOWLEDGEMENTS

Study supported by VA grant # A02-2577R.