INTRODUCTION
A high maximum adduction moment at the knee during walking has been associated with the severity, rate of progression, and treatment outcome of medial compartment osteoarthritis (OA) of the knee (1,2,3,4). Consequently, many interventions for knee OA are aimed at reducing the maximum knee adduction moment. While footwear modifications using wedged insoles or shoes with variable stiffness have been shown to reduce the knee adduction moment after a short term of usage in the gait laboratory, it has not been shown that these interventions are successful at maintaining the reduced adduction moment over a long-term period of wear (5,6).

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 symptoms of medial compartment knee OA, compared to the subjects’ personal shoes and control shoes at an initial gait test, and (2) the reduction in knee adduction moment with the variable stiffness shoe will be sustained after six months of shoe wear.

METHODS
37 subjects (32 male, 25 female; age: 60.3 ± 10.1 yrs; height: 1.70 ± 0.08 m; mass: 80.3 ± 13.5 kg) with symptoms of medial compartment knee OA, participated in this study after giving written consent in accordance with the Institutional Review Board. At the initial visit, each subject performed 3 walking trials at a self-selected normal speed in each of 3 shoes: their personal walking shoe (comfortable walking shoe frequently used by patient), a control shoe (constant-stiffness sole), and an intervention shoe (variable-stiffness sole). In the intervention shoe the lateral sole stiffness was greater than the medial sole stiffness. A subgroup of the population (6 male, 5 female; age: 61.5 ± 12.1 yrs; height: 1.67 ± 0.07 m; mass: 71.9 ± 16.6 kg) was followed after wearing either a control (4 subjects) or intervention (7 subjects) shoe as their main walking shoe (at least 4 hours wear per day) for 6 months (± 1 month), and the gait tests were repeated.

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 (7). For both the initial and 6 month data, 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). Paired one-tailed Student’s T-tests were used to compare the different shoes (α = 0.05). For the 6 month group, the percent differences between the study shoe and personal shoe knee adduction moments at both the 6 month and initial time points were also calculated and compared.

RESULTS
At the initial gait test, the knee adduction moment of the subjects’ more affected leg was reduced for both the intervention vs. control (average reduction = 3.9%; p = 0.036) and intervention vs. personal shoe cases (average reduction = 1.5%; p = 6.8*10^-6). For the intervention vs. control shoe case, the percent reduction in knee adduction moment ranged from a 23% reduction to a 17% increase, with 45 subjects having a reduction in knee adduction moment, and 12 subjects having an increase in knee adduction moment. For the intervention vs. personal shoe case, the percent reduction ranged from a 36% reduction to a 24% increase, with 36 subjects having a reduction in knee adduction moment, and 21 subjects having an increase in knee adduction moment.

At the 6 month gait test, the knee adduction moment of the subjects’ more affected leg was again significantly reduced when walking in the intervention shoe vs. the control shoe (average reduction = 5.7%; p = 0.015), and intervention vs. personal shoe (average reduction = 4.0%; p = 0.05).

Figures 1 and 2 show the percent changes in the knee adduction moment with the study shoe worn for the 6 month period, intervention or control, respectively, compared to the subject’s personal shoe at both the initial and 6 month time points.

DISCUSSION
The intervention shoes successfully reduced the knee adduction moment in the subjects with symptoms of medial compartment knee OA compared to the subjects’ personal and control shoes at the initial and 6 month time points, supporting both hypotheses 1 and 2.

As can be seen in Figure 1, while 3 of the 7 intervention group subjects initially had an increase in knee adduction moment with the intervention shoe vs. their personal shoe, only 2 subjects had an increase at the 6 month time point. Furthermore, 5 of the 7 subjects (2 with initial increases with the intervention shoe) had a decrease in knee adduction moment after 6 months of intervention shoe wear. From the data, it appears that the effect of reducing the knee adduction moment with the intervention shoe seen at the initial time point is stronger after 6 months. Figure 2 shows that the 3 of the 4 control group subjects had percent decreases in knee adduction moment with the control shoe vs. their personal shoe at both the initial and 6 month tests, with 50% subjects having an increase in knee adduction moment after 6 months of shoe wear vs. the initial time point.

This study supports the conclusion that wearing an intervention shoe can reduce the knee adduction moment, and possibly slow the progression of knee osteoarthritis, in subjects with symptoms of medial compartment knee OA after long-term wear. The results suggest that some patients may need an extended wear period to adjust to an intervention.

REFERENCES
6 Fisher DS et al. (2002) 48th Meeting of the ORS, 27, 0700.

AFFILIATED INSTITUTIONS FOR CO-AUTHORS
** VA Palo Alto Health Care System, Palo Alto, Ca

ACKNOWLEDGEMENTS
This study was supported by VA grant # A02-2577R.