A MECHANISM TO REDUCE THE KNEE ADDUCTION MOMENT DURING WALKING

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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. Laterally-wedged inserts and shoes have been shown to reduce the knee adduction moment in healthy and osteoarthritic populations (Krenshaw et al. 2000, Kerrigan et al. 2002, Fisher et al. 2007). However, the mechanism of the effectiveness of such interventions is not well understood, since it is possible that the change in adduction moment could be affected by a change in foot contact patterns or alternatively, medio-lateral trunk sway has been shown to effectively reduce the knee adduction moment during walking (Mündermann et al. 2006). Thus it remains unclear whether the reduced adduction moment produced by a lateral wedge is influenced more by foot alignment changes or upper body movements.

The overall goal of this study was to gain a better understanding of the mechanism of reduction in the knee adduction moment. The following alternative hypotheses were proposed: (1) the change in knee adduction moment will be correlated with a change in pressure distribution of the foot, and (2) the change in knee adduction moment will be correlated with a change in hip adduction moment.

METHODS

Fifteen physically active subjects (6 male, 9 female; age: 31.9 ± 5.9 yrs; height: 1.74 ± 0.10 m; mass: 70.7 ± 15.9 kg) without pain or previous injury in their lower extremity participated in this study after giving written consent in accordance with the Institutional Review Board. Subjects performed 3 walking trials at a self-selected normal speed in each of 3 shoes with identical uppers: $0°$ lateral wedge (control); $4°$ lateral wedge; and $8°$ lateral wedge. 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). Pressure distribution data were collected synchronously using a pressure mat placed on the force plate level with the walkway. The pressure region was divided into four zones, medial and lateral heel and forefoot, respectively. The first peak knee adduction moment and peak hip adduction moment were calculated for each trial. The ratio between the medial and lateral maximum pressure values was calculated for the heel region. Average values for each shoe and subject were calculated. Differences in heel pressure ratio, peak knee adduction moment, and peak hip adduction moment for the $4°$ and $8°$ laterally-wedged shoes versus the $0°$ control shoe were detected using repeated measures analysis of variance (ANOVA) ($\alpha=0.05$). Upon

significant result of the ANOVA, Bonferroni adjusted t-tests were used for post hoc analyses. Linear regression analyses were used to determine correlations between changes in knee adduction moment with the 4° and 8° laterally-wedged shoes versus control and (1) heel pressure ratio and (2) hip adduction moment.

RESULTS AND DISCUSSION

The results of this study did not support the first hypothesis, since no correlation was found between knee adduction moment and heel pressure ratio. However, the second hypothesis was supported by the finding that the changes in knee adduction moment with the 4° and 8° laterally-wedged shoes versus control were significantly correlated with changes in hip adduction moment (Figure 1) ($R^2 = 0.57$; p<0.01 and R^2=0.45; p<0.01, respectively).

Interestingly, the heel pressure ratio was significantly increased with the 4° and 8° laterally-wedged shoes versus control (p<0.01), with average increases of 16.8% and 26.3%, respectively. However the magnitude of the pressure change did not predict the magnitude of the knee adduction moment change.
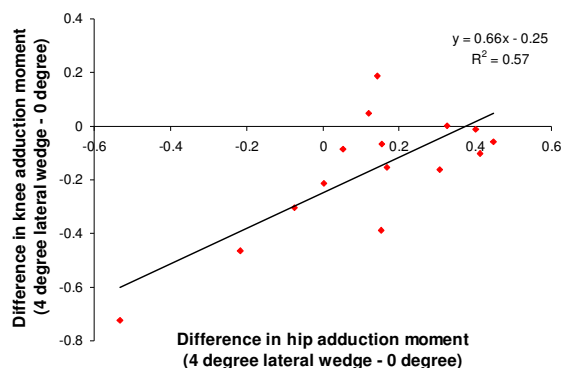

Figure 1: Difference in knee adduction moment vs. hip adduction moment with the 4° lateral wedge vs. control. Similar results were seen with the 8° lateral wedge.

SUMMARY/CONCLUSIONS

These results suggest that although the foot placement is changed with a load-altering intervention, the reduction in knee adduction moment may actually be caused by a change in upper body motion, as evidenced by a change in hip adduction moment. Thus, the mechanism of reduction in the knee adduction moment by laterally-wedged footwear interventions may be greatly influenced by upper body movement induced by a change of placement of the foot.

As expected, the laterally-wedged interventions successfully reduced the knee adduction moment during walking. However, the primary mechanism of the change appears to be related to dynamically changing upper body movement as reflected by changes in the hip adduction moment, rather than changing the static alignment of the limb caused by the lateral wedge. Thus the intervention appears to create a stimulus that produces overall changes in the pattern of locomotion. These results suggest that interventions directed towards stimulating changes in patterns of locomotion can be more effective than static interventions such as a lateral wedge.

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