GAIT RETRAINING TO REDUCE THE KNEE ADDUCTION MOMENT THROUGH REAL-TIME FEEDBACK OF DYNAMIC KNEE ALIGNMENT

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INTRODUCTION

Varus knee alignment has recently been shown to be a risk factor for the development of medial knee osteoarthritis (OA) (1). This alignment is associated with high knee adduction moments (KEAM), which are also hallmark of medial knee OA. Therefore, a reduction in the KEAM in varus-aligned individuals with otherwise healthy knees may reduce their risk for developing OA. Retraining gait patterns to reduce dynamic knee alignment may reduce the KEAM. With habitual use of such a gait pattern, the onset of OA may be deterred.

Therefore, the purpose of this study was to investigate the effects of a gait retraining program using real-time feedback on reducing the KEAM in healthy, varus-aligned individuals without evidence of knee OA. It was expected that reductions in the KEAM would be associated with increases in hip adduction and internal rotation angles, and reduced knee adduction. We expected these changes to persist at a one month follow up. Further, it was expected that the new gait pattern would become more natural and require less effort with training.

METHODS

1 female and 7 male subjects (age 21.4 +/- 1.6 yrs) with varus knees were recruited for the study. The frontal plane mechanical axis of the tibia was measured using a caliper-inclinometer device (2) to determine knee alignment. A value of ≥ 11° from vertical was needed to qualify for the study. To determine knee joint function, all subjects completed the Sports and Recreational Activities subscale of the Knee Injury and Osteoarthritis Outcome Score Knee Survey (3). A score of ≤ 2/20 (where 20/20 means extreme symptoms) was needed to qualify. Finally, subjects had to rate their comfort for treadmill walking as > 8/10, with 10 being completely comfortable.

A baseline gait analysis was first conducted. 3D motion analysis was performed at a controlled speed at 1.46 m/s (± 2.5%) along a 25 m walkway. Kinematic data were captured using an 8-camera VICON motion analysis system (120 Hz), and kinetic data using a Bertec force platform (1080 Hz). Five usable trials were processed using Visual 3D and custom Labview software.

Subjects then underwent 8 sessions of gait retraining. Real-time kinematic feedback (Visual 3D, VICON) of knee adduction during stance was provided. Subjects were instructed to lower the stance-phase trace into a normative band, derived from a database of age-matched, healthy walkers (Figure 1).

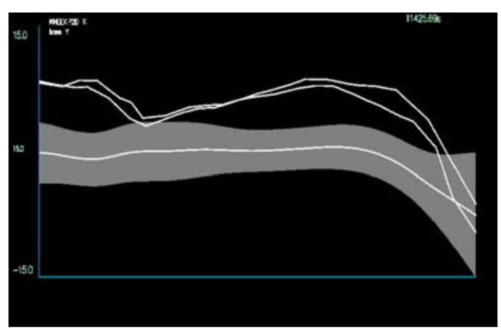

Figure 1. Actual screenshot of knee adduction angle data from two consecutive footstrikes and the target band of normative data presented to the subject.

The kinematic feedback was gradually removed in the later sessions using a fading feedback paradigm. At the end of each session, subjects were asked to rate the effort and naturalness of the gait modification on a verbal analog scale.

Immediately following the final training session, an overground gait analysis was conducted as in the baseline collection. All subjects returned for a one month follow up, again using the same overground methods.

RESULTS

Following the retraining, the peak KEAM was significantly reduced by 20% ($p=0.027$) (Figure 2) and knee adduction was decreased by 2° ($p=0.071$). These knee changes were accomplished through a 10° increase hip internal rotation ($p=0.001$) and a 3° increase in hip adduction ($p=0.073$). These mechanics were maintained at the one month follow-up.

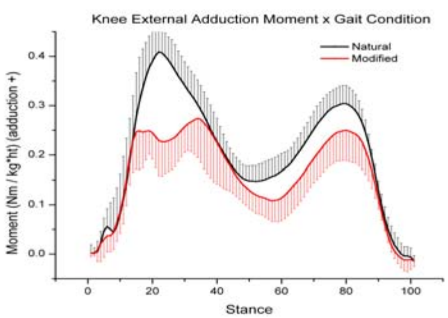

Figure 2. Comparison of baseline KEAM during natural walking to the modified gait pattern. Note that the KEAM was attenuated throughout stance.

The perceived effort associated with modified pattern decreased during the training protocol from 6.6/10 to 2.9/10 ($p<0.001$). Similarly, the pattern became more natural at the end of the protocol (7.1/10 to 3.9/10) ($p=0.001$).

DISCUSSION

This is the first systematic training study that demonstrates the effects of a gait retraining program on reducing the KEAM. The baseline KEAM value was similar to that of individuals with medial knee OA (4). This suggests the individuals in this study were at increased risk for developing OA. With the 20% reduction of KEAM, the value fell within the normal range. This was accomplished through a combination of hip internal rotation and adduction. These hip changes resulted in improved dynamic knee alignment. However the changes at the knee were smaller than those at the hip, likely due to the structural constraints of the knee. The reduction in KEAM seen in other interventions, such as laterally wedged foot orthoses, is approximately half of that seen with the retraining (4). This suggests that the training may be a more effective intervention.

With training, the modified pattern required less effort to execute, and felt more natural. Continued reinforcement of the pattern could lead to a pattern that is effortless and feel completely natural. This would be integral to a learned pattern becoming a preferred walking pattern over time.

Similar to 'medial thrust' gait (5), knee flexion excursion increased by ~10° in order to allow for a reduction in peak KEAM. This flexion may increase patellofemoral joint forces. While there were no complaints of pain over the course of the study, the long-term effects of this increased knee flexion are not known.

SUMMARY

The results of this suggest subjects with knee varus can reduce their KEAM, a likely precursor to knee OA, through gait retraining. The ability to perform this modified pattern was sustained at a one month follow-up.

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