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EFFECTIVE GAIT MODIFICATION STRATEGIES FOR OFFLOADING THE MEDIAL COMPARTMENT OF THE KNEE

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INTRODUCTION

Gait modification is a conservative, non-invasive treatment option for patients with medial compartment knee osteoarthritis. If proven effective for offloading the medial compartment, it may provide one of the few treatment options with disease modifying potential. Furthermore, it could fill an important therapeutic “hole” for patients in their 40’s and 50’s who no longer achieve sufficient pain relief through pharmacological means and yet are too young to receive a total knee replacement. A variety of gait modifications have been proposed for offloading the medial compartment, including toeing out [1], walking more slowly or with decreased stride length [2], walking with increased medial-lateral trunk sway [3], using lateral heel wedges [4], or walking with medialized knees [5]. These modifications have been proposed primarily based on their ability to reduce the external knee adduction torque. While this external measure is highly correlated with medial compartment contact force [6], the acid test is to demonstrate experimentally that a gait modification reduces medial contact force directly.

This study evaluates the ability of two gait modifications to reduce medial compartment contact force. The two gait modifications were a “medial thrust” gait pattern involving knee medialization during stance phase [5] and a “walking pole” gait pattern involving the use of bilateral walking poles commonly used by hikers. The effectiveness of both gait modifications was evaluated using internal contact force data collected from a single patient with a force-measuring knee replacement.

METHODS

One patient with force-measuring knee replacement (male, right knee, age 83, mass 68 kg) performed overground gait with simultaneous collection of internal knee contact force and external ground reaction force data. Institutional review board approval and informed consent were obtained. The subject performed five trials of three different gait patterns (normal, medial thrust, and walking pole) at his self-selected walking speed of 1.23 m/s. The subject was given approximately 10 minutes of verbal instruction and training to learn each of the modified gait patterns. For medial thrust gait, he was instructed to bring his stance leg knee toward the midline of his body by flexing his knee and internally rotating his hip slightly [7]. For walking pole gait, the subject used two walking poles and was instructed to place the contralateral pole on the ground just behind his stance leg heel at the instant of heel strike.

The effectiveness of the medial thrust and walking pole gait patterns was evaluated by comparing medial tibial contact forces with those generated by the patient’s normal gait pattern. For each trial, stance phase was identified using the time frames for which the vertical ground reaction force was non-zero. Load cell data from the instrumented implant were converted into medial contact force data using a previously validated regression equation developed for this particular implant [8]. Changes in medial tibial contact force relative to the patient’s normal gait pattern were analyzed using a two-tailed Student’s t-test with the level of significance set at 0.05. Changes were quantified at 25%, 50%, and 75% of stance phase and also for the average value over all of stance phase (i.e., 0 to 100%).

RESULTS

Medial thrust gait and walking pole gait both produced significant reductions in medial tibial contact force during stance phase, with walking pole gait being roughly twice as effective (Table 1). All quantified changes were statistically significant except medial thrust gait at 25% of stance phase. Percent reductions in medial tibial contact force at 25%, 50%, 75%, and 0 to 100% of stance phase were 7, 28, 17, and 16%, respectively, for medial thrust gait and 15, 45, 43, and 27%, respectively, for walking pole gait. As indicated by these values, the largest reductions occurred during mid and late stance with little reduction occurring in the first peak during early stance (Figure 1). Walking speed between normal and medial thrust and between normal and walking pole gait were not statistically different. The average value of the vertical ground reaction force was not statistically different between normal and medial thrust gait but was statistically different between normal and walking pole gait.

Percent Stance	Normal	Medial Thrust	Walking Pole
25	1233 ± 66	1143 ± 122	1052 ± 84*
50	815 ± 57	586 ± 103*	446 ± 81*
75	885 ± 27	731 ± 73*	502 ± 56*
0 to 100	764 ± 29	642 ± 59*	559 ± 42*

Table 1. Medial contact force (N) at different points during stance phase. Star (*) indicates a statistically significant difference from normal.

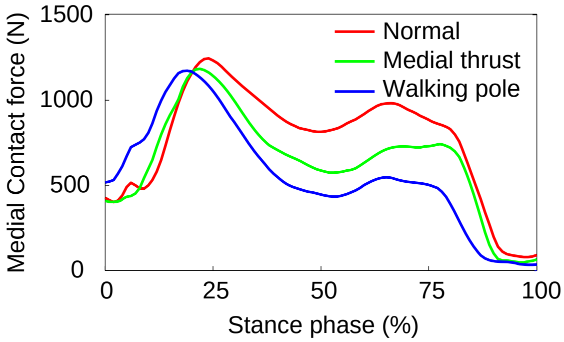

Figure 1. Medial contact force over stance phase averaged from 5 trials of each gait pattern.

DISCUSSION

This study investigated the effectiveness of two modified gait patterns for reducing medial compartment contact force in the knee. Both patterns produced significant reductions throughout stance phase, though walking pole gait was the most effective, and reductions in the first peak were limited. Since the subject trained with each modified gait pattern for only 10 minutes before testing, it is not known whether larger reductions in the first peak in particular could have been achieved with further habituation. Almost all quantified changes were statistically significant, and their magnitudes suggest that they are likely to be clinically significant as well. For individuals with total knee replacements, use of walking poles may significantly reduce the development of wear, while for individuals with medial compartment knee osteoarthritis, use of medial thrust gait or walking poles may minimize further damage of the articular surfaces.

A number of possible explanations exist for the reduced medial contact force achieved by both modified gait patterns. For medial thrust gait, the reduction was not due to placing an increased load on the contralateral leg, as no change in average vertical ground reaction force was observed between normal and medial thrust gait. When additional statistical analyses were performed on lateral and total knee contact force, no changes were found relative to normal except for a reduced total contact force at 75% of stance phase. However, there was a trend toward slightly increased lateral and slightly decreased total contact force. Thus, medial thrust gait appears to shift a portion of the contact load to the lateral compartment while simultaneously decreasing total contact force, possibly due to a more favorable geometric configuration of the leg or reduced muscle co-contraction.

For walking pole gait, the most likely explanation for reduced medial contact force is that the some of the ground reaction force was transferred through the walking poles. This explanation is supported by the fact that the average vertical ground reaction force was lower for walking pole gait than for normal gait. When changes in lateral and total knee contact force were analyzed statistically, both were found to be significantly reduced by walking pole gait. The average value of lateral contact force was reduced by 11% and total contact force by 21%. However, the largest average reduction was 27% in medial contact force. These observations suggest that walking poles offload all compartments of the tibiofemoral joint via two mechanisms: 1) bearing a portion of the external axial force, and 2) bearing a portion of the external adduction moment.

An advantage of the medial thrust gait pattern compared to other gait modifications is that it looks natural to the naked eye. Since no external devices (e.g., walking poles) are required, this gait pattern also has the advantage of being usable anywhere and at any time. These characteristics make it a good contender for clinical implementation. Though further investigation with additional instrumented knee patients is needed to determine the extent to which these results are generalizable, this study is the first to validate clinically promising gait modifications using in vivo tibial force data.

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