SIX-WEEK GAIT RETRAINING PROGRAM FOR KNEE OSTEOARTHRITIS PATIENTS: LEARNING RETENTION AND SYMPTOM CHANGES

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INTRODUCTION

Gait modification has been proposed as a conservative intervention to slow the progression of medial compartment knee osteoarthritis (OA) by lowering the external knee adduction moment (KAM) [1]. Previous gait modification studies for knee OA patients have involved only a single gait retraining session [2,3]. It is not known if OA patients can learn and retain an altered gait pattern over time, and whether reducing the KAM will improve knee pain and function after prolonged training. The purpose of this study was to train medial compartment knee OA patients to adopt new gait patterns with a reduced KAM using real-time sensing and haptic (touch) feedback over a six-week period. We hypothesized that it would take patients four weeks to learn to retain an altered gait pattern and that the overall learning rate would follow an exponential trajectory. We also hypothesized that patients would show improvements in knee pain and function after six weeks of gait retraining.

METHODS

Seven subjects (2F/5M; age 64±12y; BMI 27±4) with medial compartment OA participated in this study. Subjects had radiographic evidence of medial compartment knee OA, symptoms of medial compartment pain during the previous six weeks, and could walk without assistance for at least 25 minutes. Gait retraining was focused on the leg with self-reported greatest knee pain. Three-dimensional lower extremity motion (60Hz) and forces (960Hz) were recorded as subjects walked at a self selected pace on an instrumented treadmill [4]. Subjects completed seven testing sessions spaced one week apart. During the initial visit, real-time sensing and haptic feedback were used to train tibia and trunk angle changes, and data-driven models linking empirical changes in tibia and trunk to changes in the KAM were used to predict new gait patterns [4]. Subjects then verbally reported whether gait patterns predicted by the model were comfortable and sustainable; this input was used to aid in determining the final new gait pattern. The gait retraining protocol during the next six visits involved a one minute retention trial followed by three training trials of three minutes each. During the training trials, subjects received real-time haptic feedback on the tibia and trunk [4] to aid in achieving the new gait pattern established during the initial visit. Subjects could disregard haptic feedback if the new gait pattern began to feel uncomfortable or unsustainable. During the final training session (week 6), no feedback training was given, and only a retention trial was performed.

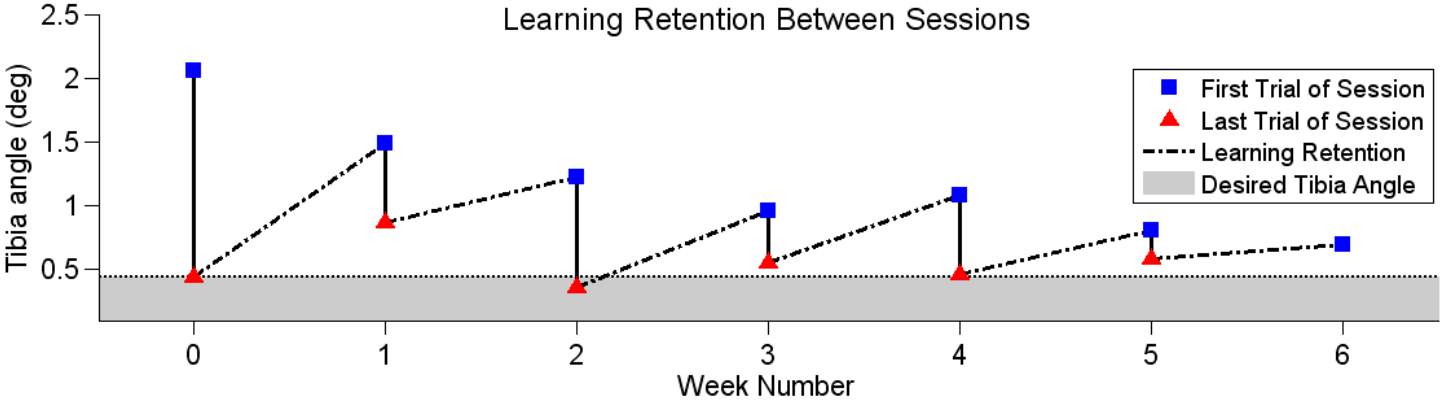

Figure 1: Mean tibia angle at the beginning and end of each training session. The first trial of week 0 is the baseline trial, and the first trial of weeks 1-6 are retention trials. Dotted lines show the degree of learning retention between sessions.

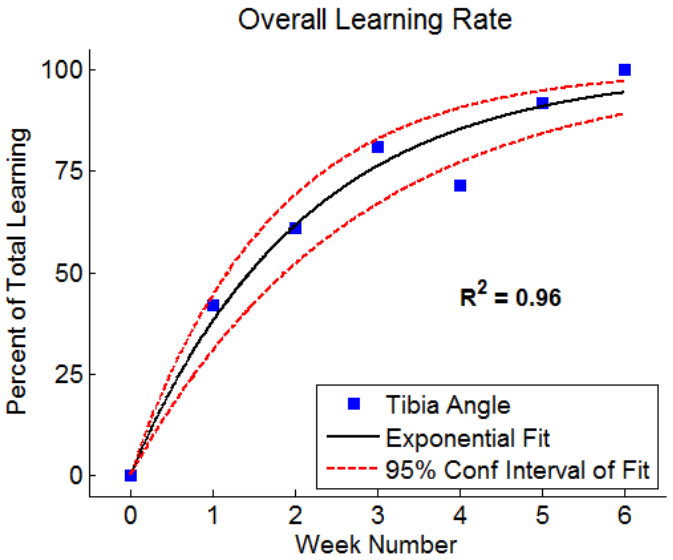

Figure 2: Mean tibia angle (first trial each session) as a percent of tibia angle on week 6. This followed an exponential trajectory, $y = 100*(1 - e^{(-0.48*x)})$.

Subjects filled out a WOMAC questionnaire at baseline and the beginning of the final training session to assess changes in pain and function. Paired t-tests were used to compare differences between gait parameters. The effect size of WOMAC pain and function for pre- and post-training was compared with the effect size expected from the placebo effect for OA treatments [5].

RESULTS AND DISCUSSION

Learning was not completely retained between sessions during the first four weeks ($p < 0.05$) as seen by an increase in tibia angle away from desired during each retention trial (Fig. 1). However, during the final two weeks, learning retention trials were not statistically different from the previous session's final trial ($p \geq 0.19$). Subject learning followed an exponential trajectory (Fig. 2). Approximately 90% of learning occurred during the first four weeks of training (evidenced in the retention trial on week 5, Fig. 2). Subjectively, patients began to internalize the new gaits by week 3 or 4 as evidenced by their more natural walking patterns and comments that walking in the new way now required, "less concentration." Gait patterns on the final session showed an average 22% KAM reduction as compared to baseline gaits ($p < 0.01$). Subjects reported improved knee pain and function. These improvements were statistically higher than

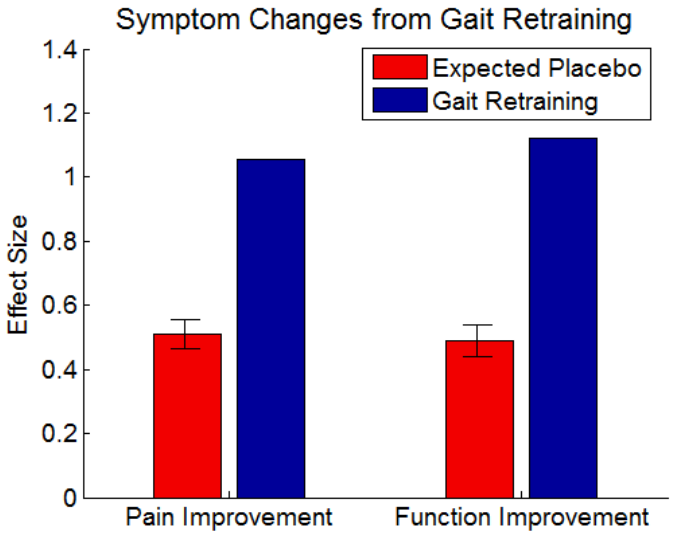

Figure 3: WOMAC knee pain and function effect size (mean difference between baseline and final divided by the standard deviation of the mean difference) of gait retraining compared to the expected placebo effect (compiled from 180 pain and 80 function OA placebo studies [5]). 95% conf interval for effect size of all placebo studies shown on expected placebo bar. Improvements for gait retraining are roughly twice as large as expected solely from the placebo effect.

expected improvements from the placebo effect ($p < 0.05$) (Fig. 3).

CONCLUSIONS

Subjects experienced exponential learning patterns over time that resulted in a reduced KAM, reduced knee pain and improved knee function. Future gait retraining interventions should train knee OA patients for at least four consecutive weeks to ensure learning retention.

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