

KINETICS OF A WEIGHTED CHALLENGE IN INDIVIDUALS WITH KNEE OSTEOARTHRITIS

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INTRODUCTION

The far reaching impact of knee osteoarthritis (OA) is well known. Biomechanical studies have indicated that individuals with OA walk more slowly [1], with less knee excursion [2], and with a higher knee adduction moment [1] compared to age-matched controls. Individuals with knee OA also use different strategies when challenged by different walking conditions. Walking while carrying a weighted backpack has been used to study the gait adaptations of adolescents [3], and young adults [4], as well as to assess physical performance gains in older adults [5]. The objective of our study was to investigate adaptations used by adults with knee OA during a weighted challenge. We hypothesized that there would be no differences in ground reaction forces (GRF), or hip, knee, and ankle moments, suggesting that healthy and OA subjects use similar strategies to carry load.

METHODS

Subjects were recruited from the community and gave written informed consent to participate in the study. Eight healthy subjects (age: 64.4 ± 5.9 yrs, BMI: 23.7 ± 3.8) and seven knee OA subjects (age: 63.6 ± 7.0 yrs, BMI: 31.1 ± 3.5 , K/L score ≥ 2) were analyzed. Subjects walked at 1.0 m/s on an instrumented, split-belt treadmill (1080 Hz, Bertec Corp., Columbus, OH). The weighted challenge was implemented using a front and back loaded weight vest equal to $1/6^{\text{th}}$ body weight.

To measure joint and limb positions, we used 23 retroreflective markers of the Helen Hayes marker set and a six camera motion capture system (60 Hz, Motion Analysis, Santa Rosa, CA). Five gait cycles were averaged for each subject to get one single curve that represents their gait pattern. Kinetic data were processed using a 4th order, phase corrected, Butterworth filter with a cutoff of 6 Hz. The kinetic data were normalized to the total weight (person

alone for unweighted or person + load for weighted) taken from a static standing trial on one force plate. Paired t-tests were used to determine within subject statistical significance and student's t-tests were used to determine statistical significance between the groups for the following variables of interest: peak A/P and VERT GRFs, and peak hip, knee and ankle moments. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

During unweighted walking, the knee OA group had significantly lower first and second peaks in their VERT GRF ($p=0.03$ and $p=0.004$) compared to the healthy group (Figure 1). This agrees with previous work that studied the biomechanics of walking with a diseased knee [6]. During the weighted challenge, the knee OA group had a significant decrease in the valley of their VERT GRF ($p=0.012$) and a significant increase in their peak braking force ($p=0.02$) compared to their unweighted condition. Knee OA subjects exhibit significantly smaller propulsive forces ($p=0.012$) compared to the healthy group during the weighted challenge.

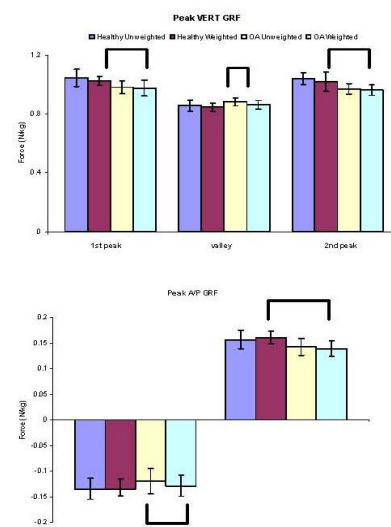


Figure 1. Peak VERT and A/P GRF.
Brackets: $p < 0.05$

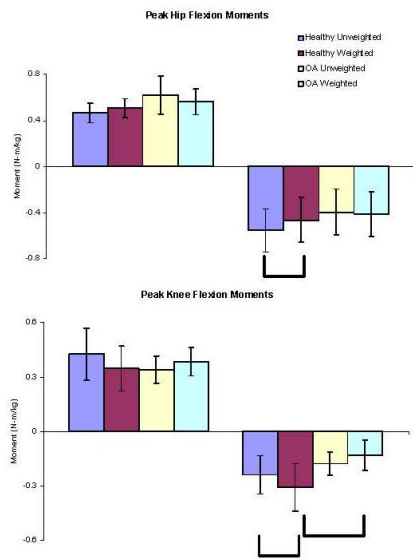


Figure 2. Peak knee and hip flexion moments.
Brackets: $p < 0.05$

In the healthy weighted condition, peak hip extension moment was significantly decreased ($p=0.018$) and the peak knee extension moment significantly increased ($p=0.022$) compared to their unweighted condition. The transferring of the moment from the hip to the knee could be a detrimental kinetic strategy when challenged with a weighted condition because it could lead to more knee joint loading during propulsion. The comparison between the healthy and knee OA groups during the weighted condition only led to a finding of significantly decreased knee extension moment in the knee OA group ($p=0.007$). This decrease in peak knee extension moment combined with the decrease in the propulsive force could be a strategy to decrease terminal joint loading to alleviate knee pain.

This is the first study looking at the effect of carrying weight in healthy vs. knee OA subjects. By normalizing kinetics to total weight carried, we can determine if different subject groups use similar kinetic patterns. Our data suggests slight changes in the kinetic strategy within subjects and between subjects when challenged with carrying a load while walking at a controlled speed. Hip, knee, and ankle angles associated with these peaks in kinetics as well as knee joint excursions may also be of interest. Previous work in our research group has

shown that individuals with knee OA walk with less knee excursion and more stiffness [2].

Study limitations include differences in demographics between the two groups. Specifically, the BMI of the healthy group is significantly lower ($p=0.002$) than OA subjects, but data are normalized to body weight plus load carried. However, the actual percentage of body weight added was significantly larger for the healthy group ($p=0.046$) with $17.7\% \pm 1.9$ for the healthy group and $15.8\% \pm 1.4$ for the knee OA group. We used the subjects' self-reported weight in order to load them, and was not always consistent with the weight obtained during data collection on the instrumented treadmill.

In the future, we plan to fully analyze the kinematic, kinetic, and spatiotemporal variables of this challenged walking condition within and between a knee OA group and an age-matched healthy control group to identify compensatory strategies that may influence OA progression.

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