HEELSTRIKE DYNAMICS DURING 6 MINUTE WALK TEST AMONG END STAGE KNEE OA PATIENTS

[1]Danielle Biton, [1]Peter M. Quesada, [2]John Nyland, [3]Michael Durham, [4]Claudia A. Angeli, [3]Robert V. Topp and [5]Ann Swank
[1]Department of Mechanical Engineering, University of Louisville, Louisville, KY: email: d0bito01@gwise.louisville.edu
[2]Orthopaedic Surgery Dept., UofL; [3]School of Nursing, UofL; [4]Frazier Rehab. Inst.; [5]Ex. Phys. Lab., UofL, Louisville, KY

INTRODUCTION

Osteoarthritis (OA) is one of the most common chronic conditions among older adults with the knee joint being the most commonly affected joint. Symptoms of the disease involve gait alterations and difficulty completing activities of daily living. The involvement of mechanical factors in OA is widely recognized. Heelstrike phenomenon can reflect abnormal loading patterns that standard kinematic variables are unable to detect.

This study investigated the effect of performing a 6 minute walk on gait speed, vertical velocity of the ankle marker just prior to heelstrike, and maximum ankle vertical displacement during swing.

METHODS

Data from thirteen subjects recruited for a larger overall research project were collected and analyzed. All subjects signed a consent form approved by an IRB. Our study population consisted of 6 men, and 7 women, ages 54 to 70 years old (61.38 ±6.25). Patients were diagnosed with unilateral end stage knee OA and scheduled for TKA. Only subjects capable of walking at a velocity greater than 0.75m/s for 6 minutes were included in this study to limit the influence of speed on gait parameters.

Each patient was asked to perform a 6 minute walk along a 35 meter loop and was instructed to cover as much distance as they could in 6 minutes. One side of the walkway was instrumented with an 8-camera motion tracking system (Hawk system; Motion Analysis Corp.) Patients had reflective markers placed on their body in a Helen Hayes marker arrangement. Markers trajectories were recorded while walking and data for the first and last loops (beginning and end of the 6 minute walk) were retained for analysis. Motion data were collected at 100 Hz.

Gait speed (GS) was calculated as an average over one loop, for the first and last loops. Maximum ankle vertical displacement (Z_{max}) during swing prior to heelstrike for the affected leg (i.e. limb not scheduled for surgery) was considered for analysis. Vertical velocity of the ankle marker was derived from marker vertical displacement data, and the the peak, occurring prior to heelstrike ($\dot{Z}_{max}$) for the affected leg, was retained for analysis.

Paired t-tests were used to assess the differences in these parameters, between the beginning and end of the 6 minute walk, for the involved limb.

RESULTS AND DISCUSSION

No significant difference was found in gait speed (p=0.72) between the beginning and end of the 6 minute walk (figure1). Significant differences were found for the vertical velocity of the ankle marker prior to heelstrike (p=0.012), and the maximum vertical displacement of the ankle during swing (p=0.019) between the beginning and end of the 6 minute walk (figure1). Means, standard deviations and t-test values are reported in table 1.

Table 1: Mean, standart deviation and t-test value for GS, Z_{max}, and $\dot{Z}_{max}$ at the beginning and the end of the 6 min walk.

	Mean	Std Dev	t-test
GS_0	1.25 m/s	± 0.30	P = 0.72
$GS_{6\ min}$	1.24 m/s	± 0.27	
$Z_{max\ 0}$	226 mm	± 22	P = 0.019
$Z_{max\ 6\ min}$	220 mm	± 21	
$\dot{Z}_{max\ 0}$	0.219 m/s	± 85	P = 0.012
$\dot{Z}_{max\ 6\ min}$	0.265 m/s	± 75	

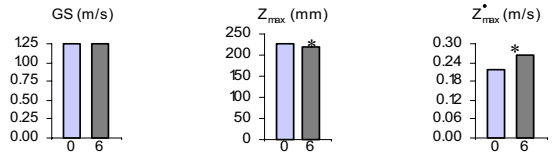

Figure 1: GS, Z_{max}, and $\dot{Z}_{max}$ at the beginning and the end of the 6 min walk. (* P≤0.05).

While gait speed remains unchanged, between the beginning and end of the 6 minute walk test, subtle changes in GS, Z_{max}, and $\dot{Z}_{max}$ are noticeable. At the end of the 6 minute walk, the vertical velocity of the ankle marker prior to heelstrike increases and patients don't lift their ankle as high in preparation for heelstrike. Gill et al. [1] in a study among healthy adults demonstrated that higher heelstrike ankle vertical velocity and lower ankle rise in preparation for heelstrike are associated with higher loading rate at heelstrike. These findings suggest that in order to maintain their gait speed throughout the 6 minutes, patients develop compensatory mechanisms modifying their loading pattern, possibly due to fatigue. These subtle changes are not noticeable with usually reported gait variables but as suggested by Gill et al. [1], can be responsible for large differences in impulse loading experienced at heelstrike and cause one's knee OA condition to worsen.

The results of this study may need to be interpreted with caution, at this time, since the sample size is still somewhat small. Subject recruitment, however, is continuing. Future investigation in this area hopes to establish means for utilizing these biomechanical variables as fatigue indicators, which could help assess end stage knee OA treatment outcomes.

REFERENCES

1. Gill HS, et al. *J Biomech*, **36**, 1625-31, 2003.