THE EFFECT OF PERIPHERAL ARTERIAL DISEASE ON GAIT

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INTRODUCTION

Peripheral Arterial Disease (PAD) is the result of atherosclerotic occlusion of the leg arteries affecting more than 8.4 million people in US[1]. For PAD patients, walking is a difficult task because the increased metabolic demand of the leg muscles is not satisfied due to the decreased blood flow. The result is claudication, which is defined as pain in the leg muscles during ambulation. When ambulation stops, the muscle is reperfused and the pain subsides. Recent research has examined PAD and the associated claudication as a primary gait disability[2]. However, this work has performed evaluations using only temporal and spatial gait parameters, such as stride length and step time. As a result, these evaluations have been limited in their ability to describe in detail the true gait handicap of PAD patients[1]. For further advancement of the understanding of PAD, kinetics (i.e. ground reaction forces) and kinematics (i.e. joint angles) are warranted[3]. The purpose of this investigation is to examine the ambulatory dysfunction of the PAD claudicating, PAD healthy contralateral, and the healthy control legs using selected kinematic and kinetic parameters

METHODS

Fifteen PAD patients and 5 age-matched (age 45-60 yrs) healthy controls walked through a 10m walkway while kinematic (60Hz) and kinetic (600Hz) data were collected both before and after the onset of claudication symptoms. The patients performed 5 trials at a self-selected pace with each leg while pain free (pre-pain), or with no claudication symptoms. Then patients were asked to walk on a treadmill at 1.5 mph (10% grade) until the onset of pain. After pain was induced, patients completed 5 more trials at a self-selected pace for each leg. The legs of the study participants were divided into 3 groups: PAD claudicating (CL, n=20), PAD healthy contralateral (CO, n=4), and control (HC, n=10). Statistics of selected measures were performed using 2x2 Mixed ANOVA (CL/CO vs HC, pre-pain vs post-pain) and 2x2 repeated measures ANOVA (CL vs CO, pre-pain vs post-pain).

RESULTS AND DISCUSSION

The configuration of the vertical ground reaction force (VGRF) curve depicts a "flatter" configuration (Figure 1) for the CL and CO than the HC. Statistical analysis showed that the minimum values of VGRF (Fmin) for the CL (p=.02) and CO (p=.03) were significantly larger than the HC. The differences of the VGRF maximums to Fmin (F1-Fmin, F2-Fmin) for CL (p=.04,p=.04) and CO (p=.01,p=.01) legs were significantly smaller than the HC. CO revealed larger braking impulse than the HC (p=.02). For all legs, braking impulse significantly increased when comparisons included the CO legs from the pre-pain to the post-pain condition (HC:p=0.01,CL:p=0.02). The stance time for CL (p=.01) and
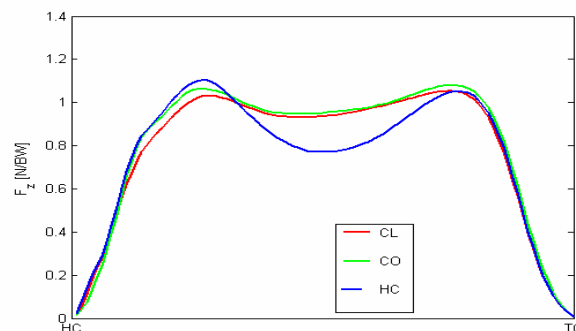

Figure 1. Mean VGRF for CL, CO, and HC legs.

CO (p=.04) was found to be larger than the HC. Kinematic results indicated that CL had greater maximum plantar flexion at toe off (p=.033) and ankle range of motion during stance than HC. At the knee, maximum flexion during stance decreased for CL from the pre-pain to the post-pain conditions while it increased for the HC (p=.02). At the hip, CL had increased maximum hip extension during stance between the pain conditions while in CO decreased (p=.01).

CONCLUSIONS

The flatter configuration found in the VGRF curve may represent an attempt by the PAD patients to diminish any vertical fluctuations of the center of gravity and/or inability to accomplish proper knee extension during stance. This may offer a more stable gait to the PAD patient. The decreased knee flexion by CL and the slower walking pace (i.e. higher stance time) of the CL and CO may also indicate an effort toward a more stable gait pattern. In the majority of the patients, the most affected muscles reported were the foot plantarflexors. This may be the reason for the differences noted at the ankle. In addition, the decreased knee flexion observed may have resulted in the compensations found at the ankle. The increased braking impulse of the CO may be an adaptive pattern to slow the system early in stance phase in compensation for the CL. This is also evident by the changes in hip extension between conditions for the CL and CO legs. This again supports the idea of finding a more stable pattern as the gait of the patient slows down. In summary, PAD patients have altered their gait to (1) create a more stable gait and (2) to compensate for the pain induced during walking. Future directions for this investigation include examining stability directly via nonlinear tools.

REFERENCES
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