DIABETIC NEUROPATHY IS RELATED TO JOINT STIFFNESS DURING LATE STANCE PHASE

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INTRODUCTION

It has been reported that as many as 35% of ulcers in individuals with diabetes occur on the plantar surface of the first metatarsal head (Birke and Sims, 1986). Increased plantar pressures beneath the metatarsal heads in individuals with diabetes are predictive of ulceration in this region (Veves et al, 1992). Increased plantar pressures are present in individuals with peripheral neuropathy. Since neuropathy affects both sensory and motor function in the diabetic patient (Reiber et al, 1999), neuromuscular compromise likely results in changes in lower extremity biomechanics. It has been previously reported that persons with diabetic neuropathy have demonstrated alterations in general gait parameters (Katoulis et al, 1997). Since the highest forces and pressures are present beneath the metatarsal heads during the second half of the stance phase of the gait cycle, differences in biomechanics should be evaluated during this time. General stiffness is common, especially in the feet, in the diabetic population and has been evaluated statically (Glasoe et al, 2004). Since joint stiffness is a contributor to total lower extremity stiffness, it is possible that individuals with peripheral neuropathy would have increased joint stiffness during gait. Therefore, the purpose of this investigation was to demonstrate differences in ankle and knee joint stiffness between type 2 diabetic individuals with and without peripheral neuropathy.

METHODS

22 subjects were tested and placed in two groups (Non-neuropathic and neuropathic). All subjects were between the ages of 32 and 70 years and had a current diagnosis of type 2 diabetes. Sensation on the plantar surface of the feet was determined using the method described by Birke and Sims (1986). Kinematic and kinetic data were collected using a 6-camera, motion analysis system combined with a force plate. Each subject was asked to walk along a 60-foot walkway at a speed of 1.25 m/s (± 5%). Ten foot strikes were collected and averaged for each subject.

The three-dimensional coordinates of each marker were reconstructed using a direct linear transformation method. Joint moments were calculated employing a standard inverse-dynamic calculation method. Ankle and knee joint stiffness were calculated using the method described by Hansen et al. (2004) during walking. Specifically, ankle joint moment was plotted against ankle joint angle in the sagittal plane during the stance phase of gait. The slope between successive points was determined, averaged over the periods of 50 to 65% and 65 to 80% of stance and compared between groups. 80% is consistent with the propulsive peak of the vertical ground reaction force. Comparisons between neuropathic and non-neuropathic subjects were made using a one-tailed Student's t-test (p≤0.05).
RESULTS AND DISCUSSION

Ankle joint stiffness for both neuropathic and non-neuropathic subjects is shown in Figure 1. From 50% to 65% of the gait cycle there is no significant difference in ankle stiffness between the groups. Although there was no group difference for peak dorsiflexion, the peak occurred significantly earlier for the non-neuropathic group.

![Figure 1: Ankle joint motion, moment and stiffness. Note the bimodal nature of the ankle stiffness in the non-neuropathic group.](image1)

Unlike the ankle, the pattern of knee moments and joint angle at the knee, and therefore stiffness (Figure 2), are similar for both groups. However, there was a trend for peak knee extension to occur earlier in stance for the neuropathic group. Therefore, knee stiffness becomes negative prior to 65% of stance in the neuropathic group.

![Figure 2: Knee joint motion, moment and stiffness. There was no difference in stiffness between groups.](image2)

SUMMARY/CONCLUSIONS

The current data demonstrates clear differences in knee and ankle stiffness between subjects with and without peripheral neuropathy related to type 2 diabetes. The different patterns in joint motion dictated differences in joint stiffness.

REFERENCES