SEGMENTAL FOOT MOBILITY IN INDIVIDUALS WITH AND WITHOUT DIABETES AND NEUROPTHY

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INTRODUCTION

Plantar ulcers develop in an estimated 15% of patients with Diabetes Mellitus (DM) (Gordois, Scuffham et al. 2003). Along with grave consequences in terms of health and functional abilities (Mueller, Sinacore et al. 2004), foot ulcers and amputation are often harbingers of personal and financial hardship. Factors contributing to increased loading on the plantar aspect of the foot and thus the potential development of foot ulcers are therefore of considerable interest.

Clinical studies have reported an association between factors intrinsic to the foot and plantar loading in subjects with DM. Limitations in subtalar (Delbridge, Perry et al. 1988) and first metatarsal mobility (Birke, Franks et al. 1995) have been reported in individuals with DM. However, evidence confirming the functional consequences of limited joint mobility in the foot is limited. The purpose of our study was to examine segmental foot mobility during gait in subjects with and without DM and neuropathy. These results are important because they may help uncover mechanisms underlying segmental foot function and plantar loading in individuals with DM.

METHODS

All procedures were approved by the Institutional Review Board at the University of Iowa Hospitals and Clinics. 15 subjects with DM and neuropathy and 15 non-diabetic control subjects (Ctrl) participated (Summarized in Table 1). Inclusion criteria for subjects with DM: diagnosis of DM (ADA criteria), no current foot ulcer, great toe or transmetatarsal amputation, absence of Charcot neuroarthropathy. Subjects in the control group were screened for diabetes and matched in age (58±11 and 56±12 years, DM and Ctrl) and gender to subjects with DM.

	DM	Ctrl
Height (m)	1.77±0.11	1.75±0.10
Mass (kg)	90.6±13.8	74.6±13.3
VPT	48±5	13±6
HbA1C	8.1±1.1	
Type 2	12 (80%)	
Duration (yrs)	19±6	

Table 1: Summary of Subject characteristics

A multi-segment kinematic foot model (Wilken, Saltzman et al. 2004) was used. Kinematic data were collected at 120 Hz using an active marker system (Optotrak, NDI, Waterloo, Canada) for each of the following segments: first ray, forefoot, calcaneus and leg. Kinetic data were collected at 360 Hz using a forceplate embedded in the walkway (Kistler Inc, NY). Motion of the distal segment was expressed relative to the proximal segment as well as to the lab and was calculated using Euler angles (Visual 3D, C-Motion Inc) with the following sequence of rotations: sagittal, frontal and transverse. A two-sample t-test was used to assess differences between the two groups (α=0.05).

RESULTS AND DISCUSSION

Subjects in both groups walked with similar speed (0.89±0.13 and 0.93±0.11 m/s, DM and Ctrl, *p*=0.169) and stride length (1.08±0.15 and 1.12±0.10 m, DM and Ctrl, *p*=0.166).

<u>Segmental kinematics expressed relative to the proximal segment:</u> Subjects with DM showed reduced sagittal and frontal plane excursion of the calcaneus relative to the tibia (Figure 1). Subjects with DM showed decreased excursion of the first metatarsal relative to the calcaneus in the frontal (9.8±3.6° and 12.3±3.2° degrees, DM and Ctrl, *p*= 0.03) as well as transverse (7.1±3.1° and 9.6±3.6°, DM and Ctrl, *p*= 0.03) plane.

<u>Segmental kinematics expressed relative to the lab:</u> The first metatarsal (68.8±12.5° and 81.1±8.8°, DM and Ctrl, *p*< 0.01) as well as the forefoot (68.4±12.4° and 81.4±8.7°, DM and Ctrl , *p*< 0.01) in subjects with DM showed less sagittal plane excursion through stance. In addition, the forefoot showed decreased frontal plane excursion (12.1±3.2° and 16.6±4.6°, DM and Ctrl , *p*<0.01) in subjects with DM. Subjects with DM showed less sagittal (64.1±10.4° and 72.8±7.2°, DM and Ctrl , *p*< 0.01) as well as frontal plane excursion (9.7±7.5° and 12.6±4.6°, DM and Ctrl , *p*= 0.02) of the calcaneus.

SUMMARY AND CONCLUSIONS

Our results revealed significant differences in patterns of segmental mobility between the two groups, with DM subjects showing lower magnitudes of motion. The reductions in motion were not generalized – they were particularly dramatic in the calcaneus (20%) compared to the forefoot and first metatarsal.

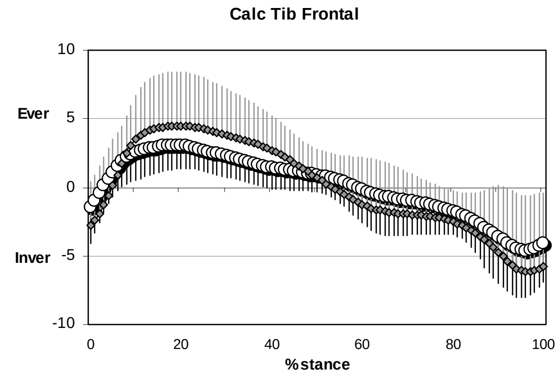

Figure 1: Ensemble averaged kinematics of the calcaneus relative t the tibia. Circles = DM, Diamonds = Ctrl; Error bars represent ±1SD.

Decreases in frontal plane calcaneal motion were accompanied by reduced midfoot mobility, discerned as reduced first metatarsal and forefoot motion. Our results underscore the complexity of segmental foot function during gait; motion at one joint has important consequences on motion at neighboring joints. Our findings provide new insights on the nature of impairments in segmental foot function in individuals with DM and indicate that there are dramatic differences in foot function in early stance in shock absorption and in propulsion in terminal stance.

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