EFFECTS OF RESTRICTED ANKLE DORSIFLEXION ON PLANTAR PRESSURE DISTRIBUTIONS

Paul M. Malloy, Mary B. Becker, and Neil A. Sharkey

Center for Locomotion Studies and Department of Kinesiology
The Pennsylvania State University, University Park, PA
Email: celos@psu.edu Web: www.celos.psu.edu

INTRODUCTION

Foot ulceration in patients with peripheral neuropathy due to diabetes mellitus produces significant morbidity. In addition to loss of protective sensation, limited joint mobility and motor neuropathy may also play important pathogenic roles by increasing the plantar pressure exerted on the forefoot during gait. Specifically, we hypothesize that restricted ankle dorsiflexion will increase the magnitude and duration of plantar pressure in the forefoot. To examine this hypothesis, we measured dynamic plantar pressures during walking in normal healthy subjects with the ankle unconstrained and under conditions of limited dorsiflexion.

PROCEDURES

Ten subjects participated in this study; 5 females and 5 males, mean age of 30.7. The subjects had no history of lower extremity pathologies.

Two identical, mechanical ankle-foot orthoses (AFOs) were specifically designed and fabricated to manipulate and set maximum ankle dorsiflexion to pre-selected limits. The AFOs consisted of an anterior tibial brace and a dorsal midtarsal brace that were mechanically linked via a sliding crank mechanism. The linkage was freely adjustable to allow for unlimited positioning of the midtarsal brace against the dorsum of the foot, after which it could be rigidly locked to prevent further dorsiflexion. The anterior tibial brace was secured to the subject with Coban™ (3M Health Care, St. Paul, MN). Identical AFOs were secured to both anterior tibial borders of each subject.

Six conditions of restricted ankle dorsiflexion were examined in randomized sequence: unconstrained (AFOs attached but not set to limit dorsiflexion), 10 degrees dorsiflexion, 5 degrees dorsiflexion, 0 degrees (neutral), 5 degrees plantarflexion, and 10 degrees plantarflexion.

Right foot plantar pressures were measured with an in floor EMed SF plantar pressure plate (Novel Elect. Inc., St. Paul, MN). Five trials per condition were performed for a total of 30 trials per subject. Relative normal gait speed was determined beforehand with the AFOs secured in the unconstrained position. Subject gait speed was maintained throughout the experiment within ±5% of the mean normal gait speed.

Plantar pressure data was collected at 67 Hz and processed using software provided by the manufacturer. Analyses of variance were used to examine the effect of limited dorsiflexion on plantar pressures.

RESULTS

Restricting maximum ankle dorsiflexion to the neutral or dorsiflexed positions did not have a significant effect on plantar pressure. Limiting dorsiflexion to 5 and 10 degrees of plantarflexion significantly altered the magnitude, distribution, and temporal progression of plantar pressure from heel to forefoot. The inability to produce a plantargrade foot shifted pressure laterally,
and from the heel into the midfoot and forefoot. These overall shifts are illustrated by the changes in the pressure-time integrals at the lateral heel and lateral metatarsal region (Fig. 1) and the peak pressures at the midfoot (Fig. 2).

Figure 1: Mean plots of the changes in the pressure time integrals for the lateral heel and three lateral metatarsal heads as a consequence of limited dorsiflexion (n = 10, error bars = 1 SD).

DISCUSSION

Limited joint mobility leading to diabetic foot pathology is often relieved surgically by a tendo-Achilles lengthening (TAL). Anecdotal data exists supporting the procedure but little systematic research has been conducted to elucidate the effectiveness of TAL, or delineate its indications for use in the diabetic patient. Baseline information on the effects of limited joint mobility on forefoot pressure is necessary to determine the significance of this condition on diabetic forefoot ulcerations and the utility of TAL.

Our data indicate that limited ankle dorsiflexion produces significant shifts in the distribution of plantar pressure during gait. In particular, it was found that pressure was shifted laterally and dwelled for more time in the forefoot rather than the heel. Increasing the time integral of pressure at the metatarsal heads may further predispose patients already at risk for plantar ulceration due loss of protective sensation. These findings indicate that tendo-Achilles lengthening may be indicated in patients with recurrent ulceration of the lateral forefoot who are unable to achieve neutral dorsiflexion due a contracted heel cord. Investigations of the affects of limited dorsiflexion on temporal and kinetic parameters of ground reaction force are underway.

REFERENCES


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