

BIOMECHANICAL EVALUATION OF DIABETIC FOOTWEAR UNDER LABORATORY AND EVERYDAY LOADING CONDITIONS

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INTRODUCTION

Diabetes mellitus leads to peripheral neuropathy and microangiopathy, which results in structural and morphologic alterations of the feet. In New Zealand 39% of all non-trauma induced amputations are diabetes related (Moore & Lunt, 2000). Cavanagh et al. (2000) have stressed the importance of offloading modalities in the prevention and during healing of neuropathic ulcers. A number of studies have quantified the effects of offloading modalities using in-shoe pressure distribution measurements and have demonstrated significant peak pressure reductions. Typically these tests are conducted in the laboratory during level walking. Only few studies have focused on foot pressures in conjunction with full body dynamics or muscular activation of the lower leg muscles (Abboud et al., 2000). No information is available on how footwear works under typical everyday loading conditions.

The aim of this ongoing study is to quantify mechanical effects of six different offloading modalities as currently used in New Zealand. Footwear will be tested during level walking and selected everyday activities. Muscle activations during these types of activities will be included. Results may assist in the selection of adequate footwear for neuropathic feet in diabetics.

METHODS

Surface EMG of six muscles of both legs was recorded by using differential amplifiers (Biovision, 1200 Hz). The data of two force platforms (Bertec™, 400 * 600 mm) embedded into a 10 m walkway were collected (1200 Hz). Three-dimensional kinematics were recorded using an eight-camera system (Motion Analysis Corp., Eva HiRes with Falcon cameras, 60 Hz). A modified Helen-Hayes marker set was chosen. Inverse dynamics were performed using Orthotrak (Motion Analysis). A pressure distribution measuring system was used to collect in-shoe pressures (PEDAR, Novel). Systems were synchronized using the PEDAR synchronization output. Subjects had to perform five successful crossings over the force platforms at self-selected walking speed. Following this test a simulated staircase (Figure 1) was placed inside the calibrated volume. Subjects had to climb four steps up and down. For these trials no inverse dynamics calculations were performed.

Four subjects (age: 54.5±7.3 y, BW: 84.5±6.4 kg, height: 171.4±7.1 cm) took part in this investigation. Subjects had to provide their written consent prior to the experiment according to the Auckland Ethics Committee regulations.



Figure 1: Subject on simulated staircase.

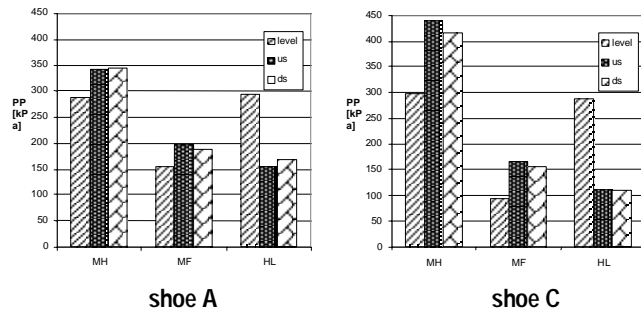


Figure 2: Example of peak pressures for level, upstairs (us) and downstairs (ds) walking for one subject determined for three areas: Metatarsals (MH), Midfoot (MF), Heel (HL).

RESULTS AND DISCUSSION

Preliminary results reveal only marginal differences for hip, knee and ankle kinematics during level walking, except for foot eversion during ground contact. Significant differences were observed for certain footwear types. Joint torques at the knee and hip

joint remained unchanged under most footwear conditions. Muscle activation revealed unsystematic differences when compared to the Auckland Gait Clinic reference data pool. All of the footwear modifications reduced the peak pressures and pressure time integrals between 19 to 35% and 11 to 18% respectively.

Dramatic differences were observed between footwear during stair climbing. All models demonstrate higher pressures when walking upstairs as well as downstairs. This may be caused by a different foot placement on stairs as a direct result of geometrical constraints. Figure 2 gives an example of peak pressures during level, upstairs and downstairs walking for two different footwear types.

SUMMARY

This study compared the effect of specialized diabetic footwear during level walking and walking on stairs, a typical loading situation encountered during everyday usage of such footwear. No statistically significant trends could be demonstrated regarding joint loading and muscular activations, presumably due to a limited sample size. Clear differences were demonstrated for pressure distribution parameters during changes in level. Since only a few overloading events have been speculated to trigger ulcer development this area of research warrants further exploration.

REFERENCES

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