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INFLUENCE OF OFFLOADING DEVICES' SIZE AND INDUCED LIMB LENGTH DISCREPANCY UPON GAIT AND PERCEIVED COMFORT OF INDIVIDUALS AT RISK OF DIABETIC FOOT ULCERATION

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INTRODUCTION

Offloading devices help heal diabetic foot ulcers by taking mechanical pressure off the injured foot during weight bearing activities [1]. While offloading devices are an effective treatment measure, their designs give little consideration to the gait alterations or postural instability they induce [1, 2]. Although less frequently used than removable cast walkers (RCW), non-removable cast walkers have been shown to be a better treatment option for diabetic foot ulcers simply because compliance is increased with the non-removable cast walkers. One likely reason for poor compliance with RCW is the decreased postural stability associated with offloading devices [1, 2]. Some of this instability may be attributed to induced limb length discrepancies (LLD), which are a common problem with offloading walkers. In addition to causing gait and balance difficulties, LLD cause several musculoskeletal problems such as joint pain [1, 3-6]. The large size and weight of most RCW also likely impede compliance. The purpose of this study was to evaluate how 1) using an elevating device (lift) on the contralateral foot and 2) modifying RCW size, will impact detrimental changes in gait and comfort associated with RCW use.

METHODS

Twenty-five adults with a risk grade of 1 or higher on the *Diabetic Foot Risk Classification System of the International Working Group on the Diabetic Foot* [7] were recruited. All subjects were capable of ambulating without assistive devices such as canes or crutches. None of the subjects had an active diabetic foot ulcer at the time of testing. All subjects read and signed an institutional review board approved consent form prior to participation.

Subjects walked a 20m walkway in five different footwear conditions (Figure 1): control (bilateral athletic shoes), short RCW with and without contralateral lift, tall RCW with and without contralateral lift. For each subject the RCW was worn on the subject's foot at highest risk for ulceration or the right foot if both feet were at the same risk. The order of footwear conditions was randomized for each subject. In each footwear condition, subjects walked for 2-3 minutes to acclimate themselves prior to data collection. Subjects walked each trial at a self-selected speed. No efforts were made to ensure a subject walked at equivalent speeds with each device. Although speed and

stride length influence ground reaction forces generated during walking, the intent of this study was to assess the difference in gait parameters associated with the different footwear conditions. If walking speed were controlled, the results obtained would not represent the gait that subjects would exhibit if they weren't being observed.

For each trial a 7.3m GaitRite mat (CIR Systems, Inc., Sparta, NJ) recorded spatial and temporal parameters of steps and Pedar-X in-shoe pressure insoles (Novel Inc., St. Paul, MN) recorded bilateral pressure data at 100Hz. As diabetic foot ulcers are most common in the forefoot, pressure analyses focused on the hallux and metatarsal heads regions. In addition to the instrumented assessments, subjects were asked to rate the comfort of each footwear condition by use of a 12cm visual analog scale.



Figure 1: Footwear utilized for study. A) Tall RCW; B) short RCW; C) Standardized shoe w/ lift; D) Subject walking with tall RCW and lift

RESULTS AND DISCUSSION

A one-way repeated measures ANOVA revealed significant ($p < .05$) differences in the comfort ratings of the different footwear (Figure 2). The short walker with lift was the only offloading condition to not be significantly less comfortable than the control condition.

In order to look at both the main effect and interaction of the two independent variables of RCW size and lift usage, gait and plantar pressure values were converted to relative values by calculating the percentage change from the control condition. This allowed for two-way repeated measures of ANOVA's to be used to compare the gait and plantar pressure data.

Only the effect of RCW height was found to significantly modify gait velocity. In comparison to the control condition the short RCW had a smaller reduction in velocity than the tall RCW ($9.5 \pm 2.8\%$ vs. $15.1 \pm 3.0\%$). Thus the subjects felt comfortable walking faster in the short RCW than in the tall RCW. These results match trends observed in a previous study of 11 subjects looking at RCW size [8].

The plantar pressure data had mixed results. There were significant findings with both main effects. In general the tall RCW and no lift conditions yielded better offloading of the offloaded foot, however, the difference was not significant at all anatomical regions of interest. Significant differences ranged from approximately 5-9%. Some of the diminished offloading seen with the short walker was likely attributable to the increased walking velocity seen with the short RCW. In contrast to the offloaded foot, the contralateral foot fared better in the short RCW and lift conditions. Nearly all of the foot regions of interest indicated significantly improved results with the short RCW and lift.

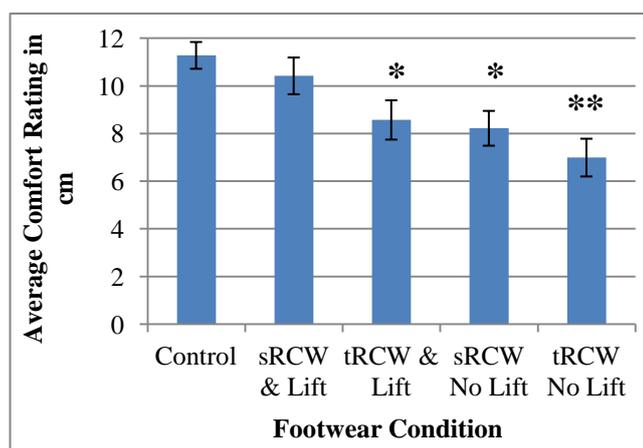


Figure 2. Average Comfort Ratings of Footwear Conditions. (note: sRCW= short RCW; tRCW= tall RCW; each star above a footwear condition indicates a successively lower mean value ($p < .05$))

CONCLUSIONS

Both the comfort ratings and walking velocity indicate patients preferred the short RCW in conjunction with the contralateral foot lift. The short RCW in combination with the contralateral foot lift also resulted in the best loading profile of the contralateral foot, thereby reducing the likelihood of a subject developing a new ulcer on that foot while using an RCW to offload an active ulcer. However,

the foot utilizing the RCW had the best offloading outcome while using the tall RCW without the contralateral lift.

At this time it is not certain if the reduced loading of the contralateral foot and improved patient comfort (which may lead to improved RCW compliance) associated with the lift plus short RCW combination, outweigh the drawback of reduced offloading of the foot using the RCW. Additional research in patients with active diabetic foot ulcers is warranted.

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