

Orthopedic Walkers: Effect on Plantar Pressures

by James A. Birke, P.T., M.S.
Deborah A. Nawoczenski, P.T., M.Ed.

Introduction

Short leg (SLW) and patellar tendon bearing walkers (PTBW) are orthotic appliances[†] which have been recently designed as alternative devices to traditional plaster cast immobilization. The indications for use of lower leg walkers include severe ankle sprains, and ankle and foot fractures. Orthopedic walkers are convenient to use, lightweight, and removable to perform joint range of motion or inspect the extremity. Short leg walkers have been shown to be as effective as walking casts in healing stable ankle fractures, and patients treated with short leg walkers have shown significantly less edema, tenderness, and joint stiffness after six weeks of immobilization.¹³ The authors feel that orthopedic walkers may also prove to be a beneficial alternative to traditional management of neuropathic fractures and plantar ulcerations, which are commonly seen in diabetes mellitus and Hansen's disease.

Neuropathic foot lesions are the result of abnormal or repetitive stress.^{3,4,8,10,16} Treatment techniques for neuropathic foot conditions should be effective in reducing pressure and shear stress. Traditional methods of treating neuropathic foot lesions include walking casts, fixed ankle braces, and PTB braces.^{1,5,6,7,14,17} Plaster walking casts and PTB braces have been shown to significantly reduce pressure on the plantar surface of the foot during

walking.^{2,9,11,15} The total contact walking cast is considered effective in reducing pressure on the foot by redistributing forces on the plantar surface of the foot and lower leg. Several features of PTB orthoses shown to be important in achieving maximal weight bearing reduction on the foot include a rigid closure PTB shell, a heel-shoe clearance of $\frac{3}{8}$ " to 1", a fixed ankle joint, and a rocker sole.¹¹ Orthopedic walkers incorporate these same design features to varying degrees which has generated our interest in studying their effectiveness in reducing pressure on the foot.

The SLW has a fixed ankle joint, rocker sole, and a polyurethane liner which is snugly secured to the leg with Velcro® closures (Figure 1). The PTBW incorporates all the features of the SLW, as well as a non-custom molded, semi-rigid polyethylene PTB shell (Figure 2).

The effectiveness of the SLW or PTBW in reducing pressure or shear stress on the foot has not previously been studied. The potential value of these devices in managing the neuropathic foot may be evaluated by their effectiveness in reducing pressure and shear stress. Currently, there are unreliable methods for measuring shear stress. However, shear is directly related to the perpendicular forces acting on the foot. Pressure equals the perpendicular forces per unit area. Pressure transducers provide a repeatable measurement of relative pressure inside footwear when the material interfacing with the transducers is controlled.¹²

[†] 3D Orthopedics, Inc., 10520 Olympic Drive, Dallas, Texas 75220.



Figure 1. Short Leg Walker.

Purpose

The purpose of this study was to determine the effectiveness of SLW and PTBW in reducing the pressure distribution on the normal foot during walking.

Method

Ten subjects (6 male and 4 female) without a history of foot pathology participated in this study. Capacitive pressure transducers‡ 2mm thick and 1.5cm in diameter were taped to the first metatarsal head (MTH), third MTH, fifth MTH, and plantar heel of the right foot of each subject (Figure 3). The foot was covered with a thin cotton stockinette which remained undisturbed during the study. Transducers were calibrated according to the manufacturer's instructions prior to testing each subject. Pressure recordings were made using a four-channel capacitive impedance bridge amplifier‡ and oscillographic recorder††† while subjects walked in a cast shoe (CS-1) (Figure 4), short



Figure 2. Patellar Tendon Bearing Walker.

leg walker (SLW), patella tendon bearing walker (PTBW), and again in a cast shoe (CS-2). All the walking devices were fabricated by the same manufacturer.† The cast shoe was identical to the foot component of both the SLW and PTBW, utilizing identical rocker outsoles and 2.4mm polyurethane material insoles. SLW and PTBW were applied to the leg with a 3/8" heel-shoe clearance. Subjects walked a distance of 100 meters for each treatment condition. The testing order of treatments SLW, PTBW, and CS-2 was randomly assigned to eliminate systematic error.

Relative pressure was measured in millimeters of peak to peak chart deflection for 24 steps for each treatment condition. The middle distance of each run was used for analysis in order to eliminate pressure variations due to the acceleration and deceleration phases of each trial. Percent pressure change relative to CS-1

‡ Hercules Orthoflex Data System, Allegany Ballistics Lab, Cumberland, Maryland.

††† Gulton TR-400a, Gulton Industries, Inc., East Greenwich, Rhode Island.

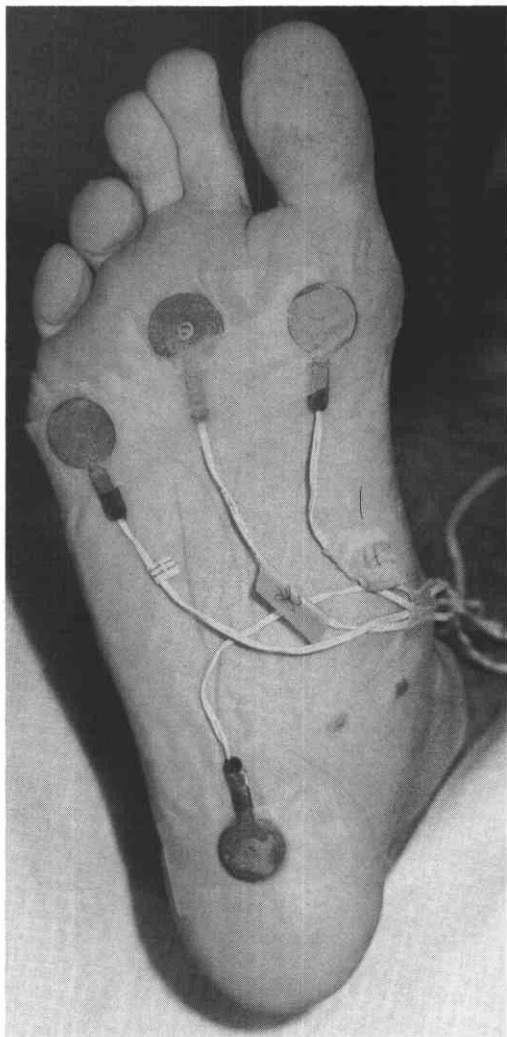


Figure 3. Pressure transducer placement on selected areas of the foot.

was calculated for treatments SLW, PTBW, and CS-2. Means and standard deviations were computed for treatments at each transducer site. An analysis of variance for repeated measures was used to determine whether treatment differences were significant within each site. Duncan's test was used for post-hoc analysis of means. A significance level of 0.05 was used for comparisons.



Figure 4. Cast Shoe.

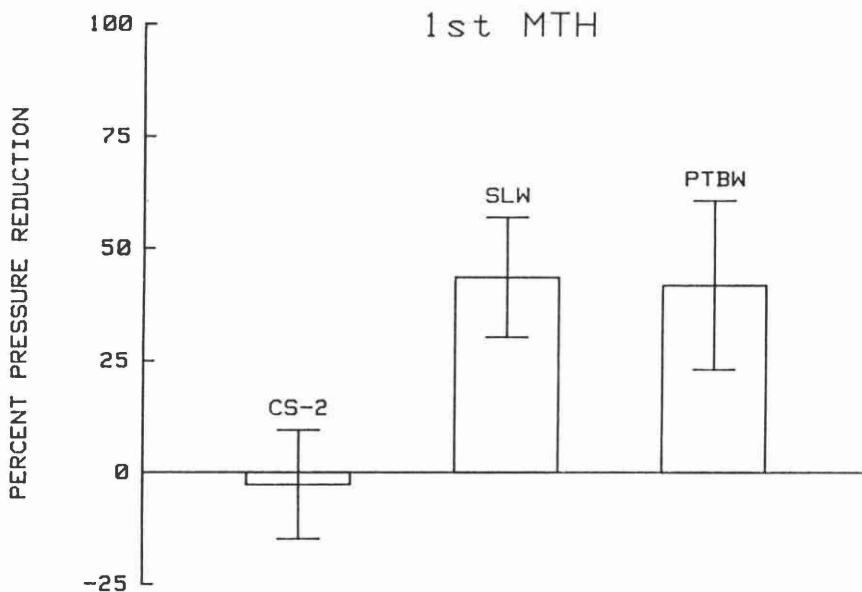
Results and Discussion

An analysis of variance (Table 1) for mean percent reduction in pressure was highly significant at all sites tested (Figures 5, 6, 7, and 8). Duncan's test was performed to establish which treatments differed. Significant differences were found between the percent reduction in pressure walking in SLW and PTBW as compared to the CS-2 at all sites. No difference was found between SLW and PTBW at any site. The percent pressure reduction using the walker devices was comparable at all the sites tested.

This study demonstrated the effectiveness of the short leg and patellar tendon bearing walkers as compared to the cast shoe in reducing plantar pressure on the foot. Since all the devices in this study had the same sole design and insole materials, treatment differences must be attributable to proximal orthotic components including the polyurethane liner, fixed ankle uprights, and Velcro® closures. The SLW and PTBW differed only by the polyeth-

Analysis of Variance of Percent Pressure Reduction

SITE	SOURCE	DF	SS	MS	F
1ST MTH	Treatments	2	1.378	0.689	187.08*
	Subjects	9	0.5468	0.0608	
	Error	18	0.0663	0.0037	
	Total	29	1.9912		
3RD MTH	Treatments	2	2.4045	1.2022	433.8666*
	Subjects	9	0.2841	0.0316	
	Error	18	0.0499	0.0028	
	Total	29	2.7385		
5TH MTH	Treatments	2	1.0142	0.5071	400.0744*
	Subjects	9	0.5052	0.0561	
	Error	18	0.0228	0.0013	
	Total	29	1.5422		
HEEL	Treatments	2	1.2276	0.6138	828.9806*
	Subjects	9	0.1868	0.0208	
	Error	18	0.0133	0.0007	
	Total	29	1.4278		

* $P < .001$.**Table I. Analysis of Variance of Percent Pressure Reduction.****Figure 5. Percent pressure reduction at the first metatarsal head (1 MTH) walking in cast shoe-2 (CS-2), short leg walker (SLW) and patellar tendon bearing walker (PTBW) compared to walking in cast shoe-1.**

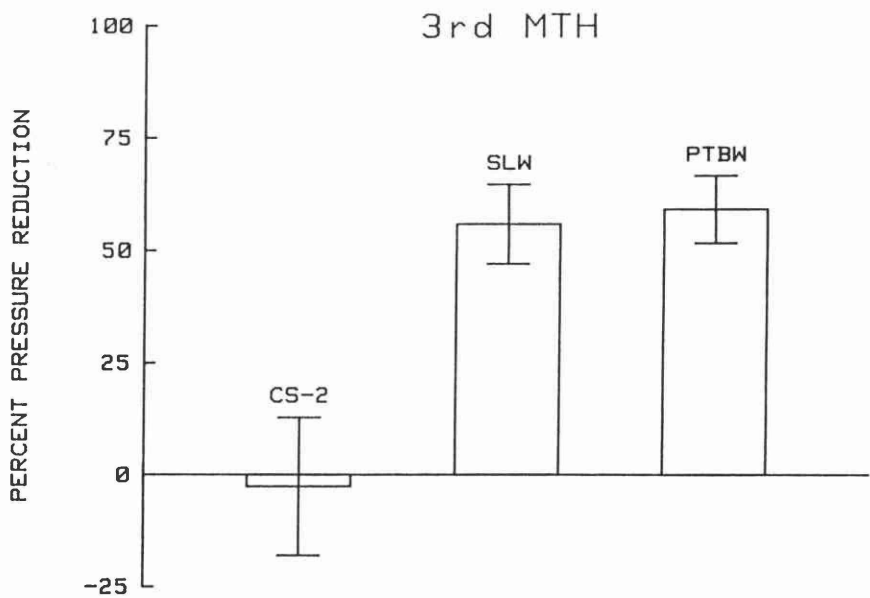


Figure 6. Percent pressure reduction at the third metatarsal head (3 MTH) walking in cast shoe-2 (CS-2), short leg walker (SLW) and patellar tendon bearing walker (PTBW) compared to walking in cast shoe-1.

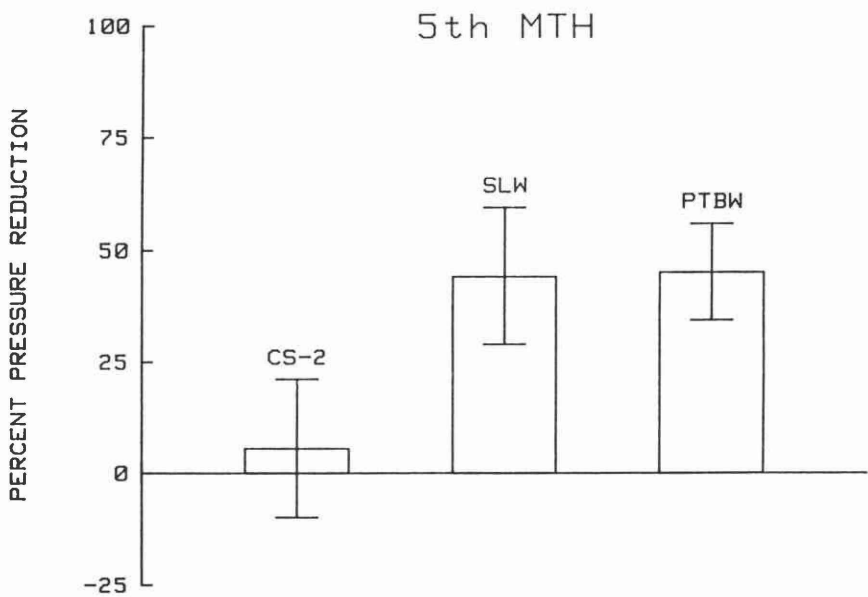


Figure 7. Percent pressure reduction at the fifth metatarsal head (5 MTH) walking in cast shoe-2 (CS-2), short leg walker (SLW) and patellar tendon bearing walker (PTBW) compared to walking in cast shoe-1.

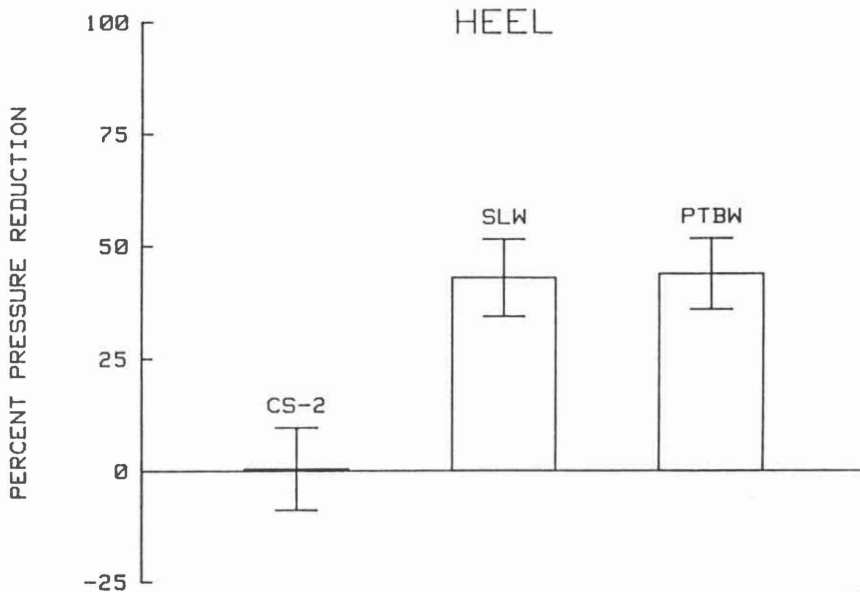


Figure 8. Percent pressure reduction at the heel walking in cast shoe-2 (CS-2), short leg walker (SLW) and patellar tendon bearing walker (PTBW) compared to walking in cast shoe-1.

ylene, non-custom molded patellar tendon cuff. Since no treatment difference was seen between these devices, the PTBW cuff design must not have been effective. However, in follow-up, single subject trials, we were not able to change walking pressures by redesigning the PTBW cuff using polyethylene or plaster custom molded PTB cuffs. An alternative conclusion is that the SLW design alone optimally reduced plantar pressure by the fixed ankle joint and uprights snugly supporting the lower leg and calf.

In this study, orthopedic walkers were equally effective in reducing pressure at all sites tested on the foot. In previous studies, casts were shown to reduce pressure more effectively in the forefoot than the heel, and PTB orthotics reduced pressure more effectively in the heel than the forefoot.^{2,11,15}

Based on the results of this study, orthopedic walkers may be effective devices in the reduction of plantar foot pressure in patients with neuropathic conditions of the foot. There is no evidence to show that the PTBW will be more effective than the SLW. Further study utilizing a patient population is recommended.

Conclusions

Within the scope of this study, it is possible to conclude the following: (1) SLW and PTBW orthopaedic walkers are effective in reducing pressure at the first MTH, third MTH, fifth MTH and heel in normal subjects during walking, and (2) there is no difference in pressure distribution between the SLW and PTBW during walking.

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Authors

James A. Birke, P.T., M.S., is Chief of the Physical Therapy Department at G.W. Long Hansen's Disease Center, Carville, Louisiana 70721.

Deborah A. Nawoczenski, P.T., M.Ed., is Assistant Professor at the Department of Physical Therapy for the College of Allied Health Professions at Temple University, Philadelphia, Pennsylvania 19140.