DO ORTHOTIC WALKERS AFFECT KNEE AND HIP FUNCTION DURING GAIT?

ABSTRACT

Background: Much previous research on orthotic walkers has focussed on their ability to offload structures in the foot and ankle, however little is known about their effects on lower limb mechanics. This study aimed to determine effects of two orthotic walkers on the biomechanics of the knee and hip joints compared to standardised footwear. **Technique**: Ten healthy participants walked under three conditions; Walker A (Össur,IS), Walker B (DJO Global,CA) and Standardised footwear (Hotter,UK). Kinematic and kinetic data were collected using a Qualisys motion analysis system and force plates. Significant differences were seen in hip kinematics and knee moments between walkers and standardised footwear and in knee kinematics between Walker A and standardised footwear. **Discussion:** Both walkers show significant kinematic and kinetic differences compared with standardised footwear; however Walker A appeared to produce greater deviation, including potentially damaging greater hyperextension moments at the knee.

Word Count: 143 words

Clinical Relevance:

Further research is needed into the effects of orthotic walkers on knee and hip joint mechanics, which should help to inform future designs of walker, with greater focus on obtaining a more normal gait pattern. **Word Count: 35 words**

BACKGROUND AND AIMS

Orthotic walkers are frequently used in clinical practice in the management of various pathologies; though the predominant use of these orthoses is in the management of diabetes related foot health (1). Orthotic walkers and Total Contact Casts (TCC's) work by redistributing the plantar pressure more evenly over the midfoot and TCC techniques are increasingly being replaced by the removable orthotic walker (2). Orthotic walkers allow early weight bearing while providing protection; they are adjustable and removable for examination, facilitating exercise and early intervention in the event of a problem and reducing the need for orthopaedic technicians (2). Reduced hospital stay, less rehabilitation sessions and early intervention together with ease of application and adjustment mean orthotic walkers are becoming the cost effective solution (3) to conservative management of a range of acute and chronic conditions.

Walkers have been shown to be more effective than traditional fibreglass casts in reducing lower leg muscle activity (4) as well as promoting a faster return to baseline activity (3). Early mobilisation with the use of orthotic walkers affords a better clinical outcome in terms of ankle function, bone strength and faster bone healing (2,5), with individuals showing improved quality of life through a shorter hospital stay and faster return to activities of daily living and sport (2,5,6). In contrast the use of the TCC, to immobilise the lower limb is decreasing, due to the requirements of an experienced technician and its associated joint, muscle and skin related undesirable outcomes (7). Several studies have explored use of orthotic walkers and their effect on plantar pressure distributions (8), however limited attention has been given to the study of kinematics and kinetics when wearing such orthoses (2,9). Whilst these studies imply that orthotic walkers elicit less adverse effects (2) than TCC's, the true impact of these walkers during longer term use requires further investigation (10). The aim of this study is to explore the short-term effect of two designs of orthotic walkers on hip and knee kinematics.

TECHNIQUE

Participants

Ten healthy participants (6 Males, 4 Females; 37.1±12.1 years) were recruited from university staff and student populations. All participants reported to be free from any pain or pathology of the lower limbs or spine at the point of testing. All data collection conformed to the Declaration of Helsinki and volunteers gave written informed consent prior to participation. The study was approved by the Built, Sport and Health Ethics Committee (XXXXXXXXXX XX XXXXXXX XXXXXXXXXX, XX).

Procedure

Passive retro-reflective markers were placed on the lower limbs and pelvis using the Calibrated Anatomical System Technique (CAST) to allow for segmental kinematics to be tracked in 6-degrees of freedom. Markers were positioned on the anterior superior iliac spine, posterior superior iliac spine, greater trochanter, medial and lateral femoral epicondyle, medial and lateral malleoli, the head of the 1st metatarsal, the head of the 5th metatarsal, the dorsum of the foot and the calcaneus or equivalent placement over these landmarks on the walker. Additionally clusters of four non-colinear markers were attached to the body segments of the shank and thigh and on the anterior plate of the walker. Kinetic data were collected at 200Hz using four AMTI force plates. Kinematic data were collected using a ten camera infra-red Oqus motion analysis system (Qualisys medical AB, Gothenberg, SE) at 100 Hz. All participants were asked to walk along a 10 metre walkway under three conditions; (a) Standardised footwear {with No Orthosis} (Hotter, UK) (b) Walker A (Rebound™ Air Walker, Ossur, IS) and (c) Walker B (Aircast® FP Walker, DJO Global, USA) [Figure 1]. Five repetitions for each condition were performed in a randomised order. All walkers were applied in accordance with the manufacturer's instructions on the left foot.

Anatomical frames were defined by landmarks positioned at the medial and lateral borders of the joint, from these right handed segment co-ordinate systems were defined. The kinematics were calculated based on the cardan sequence of XYZ. Raw kinematic and kinetic data were exported to Visual3D (C-Motion Inc., USA). Kinematic and kinetic data were filtered using fourth order Butterworth filters with cut off frequencies of 6 and 25 Hz, respectively. Knee and hip angles and moments and centre of pressure were exported and repeated measured ANOVAs were performed on maximum, minimum and range values using SPSS v20 (IBM,NY, USA).

Results

The two walkers showed a slight increase in the amount of knee flexion during stance phase. Significant differences were also seen between walking with standardised footwear and Walker A, and between the two walkers with Walker A showing a greater transverse plane range of motion during stance phase, (Table 1A). A trend towards a significant difference was seen between walking in standardised footwear and Walker A, for peak hip extension during stance phase (Table 1A). Though the average walking speed for both Walkers was notably smaller than when walking with standardised footwear, the differences were not significant (P=0.099).

Significant differences in peak knee extension moments were seen between all conditions with Walker A showing the highest knee extension moment followed by Walker B, and in the peak knee flexion moments between the two walkers. Significant reductions in peak knee adduction moments were seen when walking with both walkers compared with standardised footwear (Table 1B). Hip extension moments also showed significant differences between Walker A and both Walker B and standardised footwear (Table 1B).

No significant differences between walking with standardised footwear and the two walkers for Centre of Pressure Velocity during stance phase (Table 2).

DISCUSSION

A slight increase in the amount of knee flexion was seen during stance phase when wearing the both walkers, however there was a significantly greater flexion moment when walking with the Walker A compared with Walker B. The increased knee flexion moment during loading response may be attributed to the difference in the rocker profile under the heel during the loading response phase (Figure 1).

A trend towards a significant difference was seen between walking with standardised footwear and Walker A for peak hip extension angle and significant differences in peak knee and hip extension moments were also seen between all conditions with the Walker A showing the highest knee extension moment and the lowest hip extension moment. Despite there being no significant difference in walking speed, an increased knee flexion moment during loading response suggests that either the angle of tibial inclination or the movement of the centre of pressure under the rocker sole could be responsible. This increase in the moments being exerted at the knee could have damaging complications to the internal structures of the knee.

Significant differences were also seen between walking with standardised footwear and the two walkers for peak knee adduction during stance phase, however no differences were seen between the two walkers. Differences were also seen between walking with standardised footwear and Walker A and between the two walkers in the transverse plane range of motion with Walker A showing a greatest amount of rotation. As these orthotic walkers can be prescribed over an extended period of time, for instance, over a period of four weeks in conservative treatment of Achilles tendon rupture (11,12),further investigation is warranted on the long term effects of these results.

No significant differences were seen between any of the conditions for centre of pressure velocity during stance phase indicating that both walkers were able to produce a smooth forwards progression of the ground reaction forces. The differences seen may be related to the rocker sole profile and/or the tibial inclination angle of the walkers as this is the only major technical difference between the walkers (Figure 1).

Summary

- Both walkers showed significant differences compared with standardised footwear, in a sample of ten healthy individuals however Walker A appears to produce the greatest deviation. This is particularly noteworthy in knee flexion, knee extension moments and hip extension moments which could be damaging over long term usage.
- The differences between walkers may be attributed to the subtle differences in rocker profile and tibial angles.
- It is clear from this study that further research is required with a greater number of individuals, in order to explore the effects of orthotic walkers on the knee and hip joint mechanics. This should in turn help to inform future designs of walker, with a greater focus on obtaining a more normal gait pattern.

DECLARATION OF CONFLICTING INTERESTS

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Figure 1: Showing the tibial inclination and rocker profile of (left) Walker A {Tibial Inclincation angle: 4.3°, Heel Rocker Profile: 25°, Forefoot Rocker Profile: 12°} (Rebound™ Air Walker, Ossur, IS), (right) Walker B {Tibial Inclincation angle: 2°, Heel Rocker Profile: 22°, Forefoot Rocker Profile: 6°} (Aircast® FP Walker, DJO Global, USA).

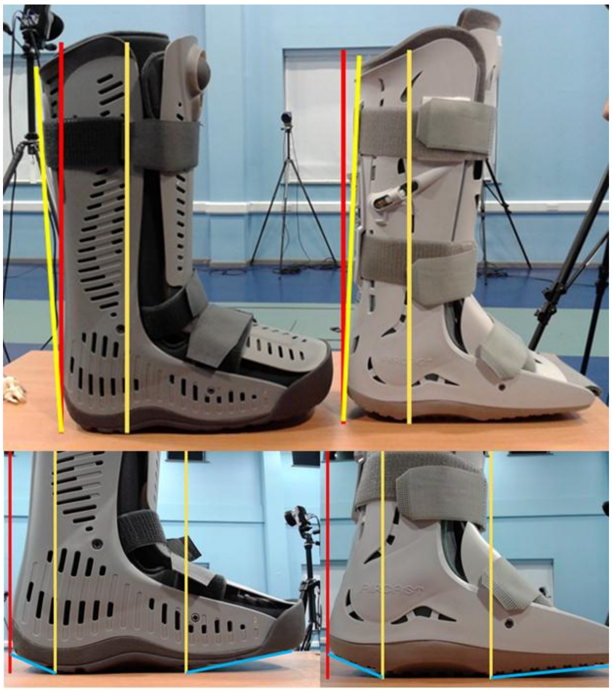

Table 1A

Knee and hip joint angles for Standardised footwear (SF), Walker A (WA) and Walker B (WB).

			Mean Difference	Significance	95% Confidence Intervals	
Knee Angles	Knee flexion angle during stance phase					
	WB	SF	3.007	0.034*	0.284	5.729
	WB	WA	0.614	0.631	-2.147	3.375
	WA	SF	3.621	0.065	-0.270	7.511
	Knee extension angle during stance phase					
	WB	SF	0.681	0.556	-1.811	3.172
	WB	WA	1.602	0.298	-1.6511	4.856
	WA	SF	0.922	0.441	-1.640	3.484
	Knee flexion Angle during swing phase					
	WB	SF	1.662	0.364	-2.232	5.556
	WB	WA	-1.016	0.485	-4.136	2.104
	WA	SF	-2.678	0.220	-7.239	1.883
	Knee adduction angle					
	WB	SF	0.155	0.815	-1.301	1.612
	WB	WA	-0.156	0.834	-1.790	1.478
	WA	SF	-0.312	0.603	-1.618	0.995
	Knee transverse plane range of motion					
	WB	SF	1.554	0.179	-0.859	3.967
	WB	WA	-1.822	0.044*	-3.585	-0.059
	WA	SF	-3.376	0.007*	-5.594	-1.158
Hip Angles	Hip flexion angle					
	WB	SF	1.611	0.137	-0.610	3.833
	WB	WA	-0.129	0.863	-1.749	1.491
	WA	SF	-1.740	0.279	-5.126	1.645
	Hip extension angle					
	WB	SF	-0.625	0.353	-2.055	0.806
	WB	WA	0.952	0.351	-1.218	3.123
	WA	SF	1.577	0.053**	-0.028	3.182

***Significant difference, **trend towards significance**

Table 1B

Knee and hip joint moments Standardised footwear (SF), Walker A (WA) and Walker B (WB).

			Mean Difference	Significance	95% Confidence Intervals	
Knee Moments	Peak Knee flexion moment					
	WB	SF	0.070	0.413	-0.112	0.252
	WB	WA	-0.091	0.005*	-0.147	-0.035
	WA	SF	-0.161	0.097	-0.356	0.035
	Peak Knee extension moment					
	WB	SF	-0.211	0.001*	-0.307	-0.115
	WB	WA	0.130	0.005*	0.048	0.212
	WA	SF	0.341	0.000*	0.210	0.471
	Peak Knee adduction moment					
	WB	SF	0.116	0.002*	0.054	0.179
	WB	WA	-0.033	0.121	-0.077	0.011
	WA	SF	-0.150	0.002*	-0.231	-0.068
Hip Moments	Peak Hip flexion moment					
	WB	SF	-0.019	0.723	-0.135	0.098
	WB	WA	-0.021	0.647	-0.120	0.078
	WA	SF	-0.002	0.979	-0.167	0.164
	Peak Hip extension moment					
	WB	SF	0.071	0.079	-0.010	0.153
	WB	WA	-0.050	0.016*	-0.088	-0.012
	WA	SF	-0.121	0.006*	-0.198	-0.045

***Significant difference**

Table 2

Centre of pressure velocity

		Mean Difference	Significance	95% Confidence Intervals	
WB	SF	0.076	0.260	-0.071	0.224
WB	WA	-0.003	0.963	-0.146	0.141
WA	SF	0.079	0.313	-0.093	0.252