Effect of Orthoses on Postural Stability in Asymptomatic Subjects With Rearfoot Malalignment During a 6-Week Acclimation Period

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Objective: To determine the effect of custom-fitted orthoses on postural sway over a 6-week acclimation period.

Design: Repeated-measures analysis of variance on postural sway measures with factors being group (control, malaligned), time (initial, 2wk, 4wk, 6wk postintervention), and condition (with orthoses, without orthoses). For single-limb stance, side (right, left) was analyzed to determine bilateral differences.

Setting: Biodynamics laboratory.

Participants: Twenty-one subjects, 11 asymptomatic with rearfoot malalignment and 10 asymptomatic with normal rearfoot alignment.

Interventions: Orthoses were prescribed and worn for 6 weeks. Balance testing was performed on 4 different dates with each subject tested in both orthotic conditions. Postural control was measured with three 10-second eyes-closed trials for single-limb stance, one 20-second eyes-closed bilateral stance with the platform moving, and one 20-second eyes-open bilateral stance with the platform and surroundings moving.

Main Outcome Measures: Sway velocity (in deg/s) for single-limb stance and equilibrium score for bilateral stance.

Results: Postural sway measures were significantly decreased during single-limb testing with orthoses versus without orthoses, regardless of group. The orthotic intervention significantly improved bilateral stance equilibrium score in the malaligned group at weeks 2, 4, and 6 when compared with measures at the initial week. Equilibrium score of the malaligned group with orthoses at initial week was significantly lower (worse) than the control group; however, these results were not repeated during measurements taken at weeks 2, 4, or 6.

Conclusions: The application of orthoses decreased sway velocity for single-limb stance, improving postural stability regardless of group when visual feedback was removed. During bilateral stance, postural stability was initially worse for the malaligned group with and without orthoses when compared with the control group; however, improvements were seen by week 2 and continued throughout the remainder of testing. Clinically, the application of orthoses appears to improve postural control in people with rearfoot malalignment, particularly when vision is removed.

Key Words: Adaptation, physiological; Balance; Equilibrium; Musculoskeletal system; Orthotic devices; Posture; Rehabilitation.

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I T HAS BEEN SUGGESTED that "structural and positional imbalances of the foot" may contribute to overuse injuries throughout the kinetic chain.1 Orthoses are designed to assist a malaligned foot in adapting to the external environment and, in theory, reduce the frequency of injury. Thus, orthoses are built to place the foot into a position of stability.1 This position is often termed the neutral position and is defined as the position of the foot in which the angle formed between the bisection of the distal one third of the lower leg and the bisection of the calcaneus is 0°.1,2 For the majority of the population, however, subtalar joint neutral is generally a position of 2° to 3° of inversion, or rearfoot varus.3 Walker and Fan4 defined subtalar joint neutral position as a navicular angle between 130° and 150°, a normal medial longitudinal arch, and a calcaneal position of perpendicular to the ground.

The exact mechanism of effectiveness for an orthosis is unclear. Freeman et al5 have proposed that there are proprioceptive deficits after ankle injury due to pain, weakness, or limitation of movement. It has been suggested that orthoses provide support to the injured5,6 and fatigued7 foot. In turn, this may decrease the stress on the injured ligaments and allow the joint mechanoreceptors to provide appropriate feedback to the balance system.6,8

The efficacy of orthotic intervention has been limited to the immediate feedback from the initial application of orthoses to the foot. Nigg et al9 have suggested that orthoses act as a filter to the forces acting on the sole of the foot. These “filtered” forces are then transmitted to the central nervous system (CNS) to initiate an appropriate dynamic response. Nigg’s theory is based on research that has tested the initial reaction to orthoses; however, so it is possible that the “filter” is only an initial response to tactile stimulation of the foot. Without long-term study, it is difficult to clearly state the mechanism by which orthoses work, especially when much of that work has been done with nonpathologic subjects.10,11

Although traditional research has focused on the use of orthoses to alter the gait cycle, recent literature has begun to focus on the use of orthoses as an aid for proprioception and postural stability. Numerous researchers have examined the effects of orthoses on people who have suffered an acute ankle sprain. Orteza et al12 and Guskiewicz and Perrin13 reported, respectively, positive effects on both pain and postural sway.
measurements after orthotic intervention. Conversely, Hertel et al.\textsuperscript{12} reported orthotic intervention, regardless of type, to have no effect on improving postural sway measures after lateral ankle sprains. Hertel et al.\textsuperscript{10} also studied the effects of orthoses on postural control in healthy subjects. Their results showed an improvement in sway velocity measures in the frontal plane. Alternatively, Percy and Menz\textsuperscript{13} reported no significant effect of orthoses on postural stability in a group of healthy professional soccer players. Thus, although the evidence is conflicting, orthoses have been shown to have proprioceptive benefits after inversion ankle sprains\textsuperscript{6,8,12} and reducing mediolateral (ML) sway in nonimpaired subjects.\textsuperscript{10,13}

Few studies have actually evaluated the use of orthoses over a sustained time period. Stude and Brink\textsuperscript{1} reported an improvement in balance and a reduction in fatigue in a group of experienced golfers over a 6-week period. The subjects were tested only without orthoses initially, however, and then only with orthoses after the intervention, thereby raising some doubt as to the exact efficacy of the orthoses themselves. In another study following orthotic intervention over a course of 4 weeks, Rome and Brown\textsuperscript{14} reported significant improvement in ML sway measures in a group of subjects with rearfoot malalignment who wore orthoses compared with a group of subjects with rearfoot malalignment who did not wear orthoses. The device used to measure postural sway values did so only in a bilateral static condition, however.

The aforementioned studies have shown an immediate effect for the use of orthoses in both an injured\textsuperscript{6,8,12} and nonimpaired population.\textsuperscript{10,13} Although studies that examine the effects of orthoses over a sustained time period do exist, they either incorporate subjects without rearfoot malalignment\textsuperscript{11} or use a measurement tool that only assesses static balance parameters.\textsuperscript{14} A study of effectiveness of orthoses over a sustained time period using subjects with structural abnormalities warranting orthotic intervention is needed. Therefore, the purpose of our study was to determine the effect of orthoses on postural sway over a 6-week acclimation period on subjects with a rearfoot malalignment. We hypothesize that the application of orthoses will significantly reduce postural sway measures over the 6-week time frame.

**METHODS**

**Participants**

Twenty-one subjects (10 men, 11 women) volunteered for this study. We recruited volunteers through a sample of convenience. Subjects were divided into 2 groups: malaligned (n=11) and control (n=10). Criteria for inclusion in the malaligned group included: bilateral calcaneal valgus or calcaneal varus of 5° or greater as measured with a standard goniometer, and an observational amount of standing pronation or supination.\textsuperscript{15} Subjects in the malaligned group were asymptomatic at the time of the study. Subjects not meeting these criteria were placed into the control group. Exclusion criteria for all subjects included: previous use of orthoses, history of severe ankle injury in the last 6 weeks, stress fracture within 1 year, use of any medications that affect the CNS, or the ability to balance, vestibular or neurologic disorders, history of severe head injury within the last 6 months, or history of unexplained falls. The institutional review board at the University of Kentucky, Lexington, KY, approved testing procedures and all subjects signed an informed consent prior to participation.

**Materials and Instrumentation**

Materials used to form foot impressions were provided by Foot Management Inc.\textsuperscript{4} After receipt of the foot impressions, Foot Management fabricated a pair of custom fitted semi-rigid orthoses (Ortho Arc sport model). A standard goniometer\textsuperscript{6} was used to measure calcaneal valgus and varus to the nearest degree.

We used the long forceplate of the NeuroCom Smart Balance Master\textsuperscript{6} to measure postural sway during single-limb stance. Unilateral postural sway was measured as sway velocity. Sway velocity is a ratio of distance to time (d/t). The center of gravity (COG) sway velocity is the ratio of the distance traveled by the COG (in degrees) to the time of the trial (in seconds).\textsuperscript{16}

We used the Smart Balance Master to measure postural stability. The Smart Balance Master is a balance-testing device that is composed of a dual forceplate, a visual surround around the forceplate, and a safety harness. It is integrated with a personal computer. The Sensory Organization Test (SOT) of the Smart Balance Master was used for evaluation. The main outcome measure for the SOT is equilibrium score. Equilibrium score is a nondimensional percentage that compares the patient's peak amplitude of anteroposterior (AP) sway to the theoretical AP limits of stability. The subject's theoretical limit of stability is the maximum forward and backward COG sway angles (θ) that can be achieved by a normal subject of similar height and weight, and is measured as the angular distance from vertical. It is based on the following formula:

\[
\text{Equilibrium score} = \left( \frac{12.5 - (\theta_{\text{max}} - \theta_{\text{min}})}{12.5} \right) \times 100
\]

12.5° is the maximum AP sway angle range. Subjects that exhibit little sway will achieve an equilibrium score close to 100. Subjects that approach a fall will exhibit a score close to zero.

**Procedures**

During a familiarization session, we explained the testing protocol and the data collection procedures to the subjects and each subject was asked to sign an informed consent document. In this session, subjects completed a health and injury questionnaire that we developed. The questionnaire was used to determine the subject's medical history and to determine in which group the subjects would be placed. If the subject met inclusion criteria, calcaneal alignment was then measured according to procedures outlined by Hunter et al.\textsuperscript{1}

We measured calcaneal varus by placing the subject in a prone position on a plinth. The leg to be measured was positioned with knee extended and ankle approximately 15.2cm (6in) over the plinth. The opposite leg was placed in a position of flexion, abduction, and external rotation. A line was drawn along the midpoint of the posterior aspect of the calcaneus bisecting it into equal right and left portions. Similarly, a second line was drawn down the distal one third of the lower leg. The examiner then determined subtalar neutral by using the thumb and index finger to palpate the medial and lateral aspects of the talus.\textsuperscript{1} Next, the examiner inverted and everted the calcaneus until there was no pressure of the talus felt on either the thumb or index finger. The angle formed by the intersection of these 2 lines was measured using a standard goniometer.\textsuperscript{1}

Calcaneal alignment was also measured in a standing position. The subject stood in bilateral stance on a wooden box (38×46×21cm). Using the lines of bisection described above, the examiner used thumb and index finger to palpate the medial and lateral aspects of the talus. With the weight of the body on 1 limb, the subject was then asked to pronate and supinate the
foot while the examiner determined subtalar neutral. The angle formed by the intersection of the bisected lines was defined as standing neutral rearfoot motion (see fig 1A). These steps were then repeated on the opposite side. Next, the examiner measured resting standing foot posture (see fig 1B), as described by McPoil et al.17-19 Resting standing foot posture was defined as “the position of the subtalar and talocrural joints when the subject was standing relaxed with knees fully extended, the arms at the side, feet 6 inches apart, and a comfortable amount of toeing-out.”20(p368) If this angle was 5° or greater (varus or valgus) for both the left and right limbs for all 3 measurements, the subject was included in the malaligned group. If these measurements were less than 5° for either limb, they were placed in the control group. All rearfoot measurements were performed by the principal investigator.

Prior to testing, intratester reliability was established. Seven subjects were assessed in a single occasion. Intratester reliability measurements were separated by 1 hour. Rear foot motion was assessed by a single examiner, all marks were removed and after 1 hour, rear foot motion was reassessed. Pearson product-moment correlations were determined for prone neutral rearfoot motion and standing neutral rearfoot motion. Reliability for the left prone measurements was determined to be \( r = 0.79 \). Reliability for the right prone measurements was determined to be \( r = 0.93 \). Standing neutral subtalar motion for the left foot was calculated at \( r = 0.90 \); and standing subtalar joint motion for the right foot was calculated at \( r = 0.94 \). Resting standing foot posture for the left foot was calculated at \( r = 0.91 \); and resting standing foot posture for the right foot was calculated at \( r = 0.86 \).

**Orthotic Construction**

After determination of inclusion and exclusion criteria, we fitted subjects for orthoses. Subjects were seated with the ankles, hips, and knees each in a 90° position. Subtalar joint neutral position was found and maintained while the examiner guided the foot into the foam impression and pressed the heel approximately 5cm into the foam impression. The impressions were then sent to Foot Management for semi-rigid orthoses to be posted according to manufacturer recommendations (fig 2). The manufacturer was also instructed to correct for any malalignments or abnormalities revealed by the impression.

**Testing**

Subjects reported for testing on 4 separate occasions after orthosis construction (initial test and at 2-, 4-, and 6-wk intervals after receipt of the orthoses). The long forceplate of the Smart Balance Master was used to test the 2 single-limb stance conditions (eyes closed on the left and right foot) (fig 3A). Two test conditions of the SOT of the Smart Balance Master21 were used to test the 2 double-limb stance conditions (fig 3B). The SOT protocol assesses abnormalities in a subject’s somatosensory, visual, and vestibular systems, which help contribute to postural control.21 During the test, information from the various systems is altered through sway referencing. Sway referencing involves the tilting of the support surface and/or visual surround to directly follow the subject’s COG sway, such that the orientation of the surface remains constant in relation to the COG angle.22 The 2 conditions of the SOT that were used in our study were condition 5 (double-limb stance with eyes closed and the force platform moving in a sway-referenced position relative to the subject) and condition 6 (double-limb stance with eyes open and the visual surround and force platform moving with the subject’s AP sway). We chose to test conditions 5 and 6 because these conditions were found to exhibit the highest reliability between all testing sessions in our lab, and they challenged the 3 sensory systems to the greatest extent.
Each subject participated in an introductory and practice session on both the long force plate and the Smart Balance Master to minimize any type of learning effect. After this session, initial measurements of postural stability were obtained. Each subject completed each of the 4 different conditions on the appropriate instrument with and without orthoses. Subjects were instructed to stand in a comfortable stance with their arms down at their sides. The single-limb stance conditions were performed 2 times for 10 seconds each. Each bilateral stance condition was performed 2 times for 20 seconds each. There was a 10-second rest between each trial. All subjects performed the postural stability tests with and without orthoses in a counterbalanced fashion to prevent order biasing.

**Design and Data Analysis**

The research design consisted of a 1 between (group) and 2 within (time, condition) mixed-design analysis of variance (ANOVA). The independent variables were group (control vs malaligned), time (initial evaluation, 2-wk, 4-wk, and 6-wk interval), and condition (orthosis, no orthosis). Separate ANOVAs were used for each limb. The dependent variable for bilateral stance was calculated as equilibrium score, and the dependent variable for single-limb stance was calculated as sway velocity (in degrees per second). An α level of P equal to or less than .05 was determined to be statistically significant. Any significant findings were further analyzed using Tukey post hoc testing with a Bonferroni adjustment. A statistical package for Windows was used to perform all statistical analyses.

**RESULTS**

There were no significant differences between the 2 groups for any of the subject demographic characteristics (P > .05). A total of 11 subjects met the criteria for inclusion into the malaligned group (age, 24.5 ± 6.5y; mass, 75.5 ± 4.6kg; height, 177.80 ± 37.7cm), with 9 subjects classified as having rearfoot varus and 2 as having rearfoot valgus. Mean rearfoot measures in the prone position were 6.48° ± 1.2° (left foot) and 6.81° ± 2.1° (right foot) for the varus subjects and 5.25° ± 0.6° (left foot) and 6.00° ± 0.5° (right foot) for the valgus subjects. Mean rearfoot measures in the standing neutral position were 5.93° ± 1.1° (left foot) and 6.33° ± 1.8° (right foot) for the varus subjects and 5.33° ± 0.5° (left foot) and 5.17° ± 0.7° (right foot) for the valgus subjects. Mean rearfoot measures for the resting standing position were 8.17° ± 2.6° (left foot) and 9.04° ± 1.8° (right foot) for the varus subjects and 5.67° ± 3.3° (left foot) and 5.5° ± 0.2° (right foot) for the valgus subjects. Ten subjects did not exceed 5° for the rearfoot measures in any measurement and were placed in the control group (age, 22.3 ± 2.2y; mass, 77.13 ± 3.5kg; height, 169.9 ± 25.9cm).

The means and standard deviations (SDs) for bilateral limb postural sway condition 6 (eyes open with forceplate and surround moving in a sway-referenced position) are presented in table 1.

**Single-Limb Postural Stability**

Analysis of the single-limb stance values revealed a significant main effect for orthoses regardless of group (P < .05). Left leg sway velocity was significantly lower for the orthotic condition versus the nonorthotic condition (1.79°/s vs 1.92°/s, P = .019). Right leg sway velocity was also found to be significantly lower for the orthotic condition than for the nonorthotic condition (1.74°/s vs 1.86°/s, P = .043). There were no significant differences between weeks for the single-limb conditions.

**Bilateral Postural Stability**

There were no significant differences for condition 6. There was a significant 3-way interaction (week by condition by group) for bilateral stance condition 5 (fig 4). Post hoc analysis revealed that equilibrium score for the malaligned group with orthoses at the initial week (mean, 60.27% ± 13.35%) was significantly lower than equilibrium score for the malaligned group with orthoses during week 2 (mean, 70.73% ± 10.54%), week 4 (mean, 71.23% ± 6.46%), and week 6 (mean, 70% ± 7.63%) (P < .01). Therefore, balance measures in the malaligned group improved over time with orthoses. At the initial week, equilibrium scores for the malaligned group with orthoses were significantly lower than the control group with orthoses (60.27% ± 13.35% vs 72.15% ± 9.73%, P < .01). Finally, when comparing the control group without orthoses, initial week measures were significantly lower than week 4 measures (69.15% ± 8.13% vs 76.81% ± 7.37%, P < .01).

**DISCUSSION**

The results of our study show a positive effect of orthotic intervention on certain measures of postural stability for individuals with rearfoot malalignment over time.

**Single-Limb Postural Sway**

During the initial test, we found that postural sway measures were reduced for single-limb stance with orthoses relative to without orthoses for both the right and left conditions. These results were similar to the results found by Ochsendorf et al, who reported that prior to a lower-extremity fatigue protocol, single-leg stance postural sway measurements for the orthotic condition were significantly less than the nonorthotic condition. Similarly, Hertel et al determined that rigid full foot orthoses posted at the medial side of the rearfoot provided a reduction in single-limb center of pressure (COP) length and velocity in healthy subjects. Hertel also reported that a Sprained Ankle Orthotic increased the movement of postural COP length and velocity, however. The Sprained Ankle Orthotic is a noncustom orthosis that is rigid and is equipped with a laterally posted heel wedge. Therefore, although these results differed from ours, the difference may have been because of the different materials used to construct the orthoses in the Hertel et al study and ours as well as the change in position of the foot due to the lateral wedge of the orthosis used by Hertel.

Although there are results to support the use of orthoses for improving single-limb postural sway, there are several studies...
that provide conflicting results.\(^6,^8\) Gusiewicz and Perrin\(^6\) found no effects on postural sway measures for 12 unimpaired subjects in an orthotic and nonorthotic condition using the Chattecx Balance System. Likewise, Orteza et al\(^8\) showed that molded orthoses did not improve balance measures for 10 subjects with no history of ankle sprains. Hertel et al\(^12\) reported initial increases in single-limb postural sway measures after acute ankle sprain; however, an orthotic intervention did not

![Figure 3](image)

**Fig 3.** (A) Testing position for single-limb stance condition on the long forceplate. (B) Testing position for double-limb stance conditions on the Smart Balance Master.

<table>
<thead>
<tr>
<th>Week</th>
<th>Malaligned (orthotic)</th>
<th>Control (orthotic)</th>
<th>Malaligned (no orthotic)</th>
<th>Control (no orthotic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>67.77 ± 15.89</td>
<td>73.30 ± 11.72</td>
<td>67.00 ± 19.16</td>
<td>74.90 ± 10.20</td>
</tr>
<tr>
<td>2</td>
<td>69.14 ± 17.41</td>
<td>75.30 ± 11.37</td>
<td>71.36 ± 15.71</td>
<td>73.55 ± 13.56</td>
</tr>
<tr>
<td>4</td>
<td>73.95 ± 14.59</td>
<td>75.15 ± 13.85</td>
<td>72.18 ± 12.39</td>
<td>75.11 ± 16.88</td>
</tr>
<tr>
<td>6</td>
<td>75.86 ± 11.70</td>
<td>76.55 ± 16.56</td>
<td>76.41 ± 10.27</td>
<td>75.00 ± 12.55</td>
</tr>
</tbody>
</table>

**Table 1: Bilateral Postural Sway Values for Condition 6 (eyes open with the platform and surround moving)**

NOTE. Values are mean ± SD and expressed as equilibrium score (%).
improve these measures. Conversely, our results suggest that balance was improved for both the unimpaired and malaligned groups.

Differences in our results may be attributed to methodology in testing, subject size, or subject inclusion criteria. One rationale for orthosis use is that it increases somatosensory afferent input. Therefore, we chose to test subjects with eyes closed during single-limb stance to minimize visual feedback so that subjects relied more on somatosensory feedback. Guskiewicz and Perrin, Hertel, and Orteza tested subjects with their eyes open. One possible difference in our results was the removal of visual feedback. Although athletes do not compete with their eyes closed, blind landings and changes in visual horizons during dynamic conditions result in theoretically more reliance on somatosensory feedback than visual feedback. Our study supports the rationale of Nigg et al that the orthosis increases somatosensory stimulus.

The Smart Balance Master allows for measurement of reaction forces with 4 transducers. Methodologically, Orteza tested subjects on a digital balance evaluator that only tests time out of balance. Because the Smart Balance Master may be a more sensitive measuring device, the difference in instrumentation sensitivity might explain variability of the results. Also, Orteza allowed for a recovery of 1 to 2 minutes between testing and subjects were tested with their eyes closed, whereas we allowed a resting period between trials of only 10 seconds. Therefore, subjects had less chance to adapt to the testing procedures.

Guskiewicz and Perrin and Orteza compared subjects with acute ankle sprains to noninjured subjects. Acute was defined as occurring within 21 days of testing and within 6 weeks of training. Therefore, the severity of injury and extent of dysfunction at the time of testing is unclear. Current literature suggests that injury to the ankle changes the joint mechanoreceptors and alters balance. Although their results showed that postural sway with orthotic intervention was reduced more in injured subjects than uninjured subjects, they also established that the injured group swayed more without orthoses.

**Bilateral Postural Sway**

For condition 5 at the initial week, the malaligned group with orthoses had lower equilibrium scores, indicating worse balance than the control group with and without orthoses. Therefore, the control group performed better initially with and without orthoses than the malaligned group with orthoses.

In 1999, Nurse and Nigg established that there was a relationship between tactile stimulation and vibration sensitivity of the human foot with plantar pressure distributions during gait. Thus, the higher the pressure at various areas of the foot (hallux, heel, lateral arch, first metatarsal head), the lower was the vibration threshold at these particular areas. Because of this, Nurse and Nigg suggested that the body is able to determine small biomechanical changes in the external environment. In comparison with the control group, the malaligned group had a greater biomechanical deficit. Similarly, McPoil et al determined that during the stance phase of gait, the COP migration was lower with orthoses for a population of women with forefoot varus. Therefore, the orthoses for the malaligned group were posted more than for the control group in order to place the foot into a neutral position. It is possible that, initially, it was harder for the malaligned group to adjust to the biomechanical change than for the control group; postural stability values improved from week 0 to week 2 for the malaligned group with orthoses (60.27 ± 13.35 vs 70.73 ± 10.54, P < .01). When bilateral postural stability scores between week 0 and week 2 were compared, there was no difference between the malaligned group without orthoses. Consequently, it is possible that by week 2, the malaligned group was able to adjust to the biomechanical change and the equilibrium scores increased, reflecting better balance. Interestingly, there was no difference between week 0 and week 2 when the control group was compared with and without orthoses. A possible theory for this lack of change was that the control group had already adjusted to the small biomechanic change during the initial test.

At week 4, the control group without orthoses was significantly better than week 2 and week 0 without orthoses. We are
not certain why this occurred, and, because there were no significant differences between week 4 and week 6, it is possible that at week 4 subjects experienced a learning effect. It is also possible that this instance may be explained through some of the basic principles of neuromuscular education. First, all beings have potentials that are not fully developed. Although the control group did not have a pathologic deficit in postural sway, it is possible that the orthoses provided a tactile stimulation to improve learning. Furthermore, motor learning is enhanced through the use of multisensory inputs. Tactile cues also provide direction, encouragement, and optimize learning opportunities. Consequently, when the individuals were tested without orthoses in the shoe, some sort of altered sensitivity may have occurred to improve balance scores.

There were no significant differences from week 0 to week 6 for the control group. These results differ from previous studies on the effectiveness of orthoses over time. Stude and Brink found that orthoses improved balance for 12 unimpaired subjects over a 6-week time period; however, they only tested the individuals on 2 separate occasions: at the initial visit without orthoses and after 6 weeks of orthotic intervention with the orthoses. Consequently, one may question whether their results can be compared with ours, because evaluation at the 6-week intervention time frame is the only time that balance was assessed with orthoses. Rome and Brown reported improvements in ML sway measurements after orthotic intervention over a 4-week time period in a group of subjects with excessively pronated feet. Differences in results could be attributed to methodologic differences. Rome and Brown used a balance measurement tool that only measured static balance in a bipedal stance, whereas ours measured dynamic balance in a single-limb stance. It is difficult to make direct comparisons between studies when there are distinctly different measurement strategies.

We observed that subjects with rearfoot deformities tend to place pressure at a more focal point when standing. Conversely, individuals with a more neutral rearfoot alignment, however, place a more distributed pressure on the foot. One may theorize that it is possible that orthoses promote a more diffuse pressure under the foot and promote postural stability. According to our data, there was significant difference in the malaligned group between the orthotic and nonorthotic condition for bilateral stance on the first test occasion. Yet there were no significant differences in postural stability values in this same group when weeks 2 to 6 were compared. Therefore, we recommend a 1-week acclimation period when evaluating the effectiveness of orthoses, especially in people with rearfoot malalignment.

Study Limitations

A limitation of our study was that the subjects with rearfoot malalignment were asymptomatic at the time of the study. In a clinical setting, orthoses are often prescribed to those people who have symptoms as a result of their foot malalignment; therefore, the results of this study do not imply relief of symptoms. Another limitation of our study was that our inclusion criterion for the malaligned group of 5° or greater of rearfoot motion may be a relatively small number according to some of the literature. Our choice of this definition of abnormal pronation of 5° or greater was based on the work of Tomaro and Burdett, however. Consequently, we might have seen different results with a less restrictive criterion for the malaligned group. Also, it was difficult to control the amount of time that subjects wore the orthoses each day. Although they were told to wear them a minimum of 6 to 8 hours a day, some subjects may have worn them the minimum amount of time, whereas other subjects may have worn them more. It might have been beneficial to have each subject record daily wearing using a calendar and report this usage to us at the end of the study to determine compliance.

CONCLUSIONS

The application of orthoses improved eyes-closed single-limb postural sway, and bilateral postural stability measures regardless of the rearfoot measure. The application of orthoses resulted in improved postural control after acclimation in a group of malaligned subjects. Further research focusing on the use of muscle activation patterns may better describe the neuromuscular role of orthoses. If the anterior musculature is shown to work more efficiently, this may explain the improvement of postural stability.

Acknowledgment: We thank Foot Management Inc for providing the orthoses.

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Suppliers
a. Foot Management Inc, 7201 Friendship Rd, Pittsville, MD 21850.
c. NeuroCom International Inc, 9570 SE Lawnfield Rd, Clackamas, OR 97015.
d. Version 13.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.