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Orthotic Intervention and Postural Stability in Participants With Functional Ankle Instability After an Accommodation Period

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Context: Most protocols established to treat patients with functional ankle instability (FAI) have focused on taping the ankle. Orthotic intervention is a different treatment protocol that may have a positive effect on these patients, especially after an accommodation period.

Objective: To determine whether the use of a prefabricated orthotic affects postural stability in patients with FAI and a control group.

Design: Randomized controlled clinical trial.

Setting: Research laboratory.

Patients or Other Participants: Forty patients with unilateral FAI.

Intervention(s): Postural stability was measured on both limbs using a force plate on 3 occasions. Participants were instructed to balance on 1 limb with their eyes closed for 20 seconds. In session 1, postural stability was measured with the patient wearing his or her own athletic shoes. The control group repeated this procedure in sessions 2 and 3. When those in the orthotic group returned for session 2, they received prefabricated, full-length Quick Comfort Insoles for both feet, immediately placed the orthotics in their shoes, and were tested for postural stability. Patients in the orthotic group were instructed to wear the inserts daily and return 2 weeks later for session 3 and repeat postural stability testing.

Main Outcome Measure(s): Center of pressure.

Results: In the orthotic group, postural stability improved between sessions 1 and 2 and sessions 1 and 3. In session 3, postural stability was different for the orthotic and control groups. We also identified a difference between the limbs such that the FAI ankle displayed worse postural stability than did the healthy ankle.

Conclusions: Prefabricated orthotics improved postural stability in participants with FAI. Similar to the findings of previous researchers, we found that postural stability was worse in FAI ankles than in healthy ankles.

Key Words: balance, center of pressure, postural control

Key Points

- Postural stability was worse in functionally unstable ankles than in healthy ankles.
- Prefabricated orthotics improved postural stability in patients with functional ankle instability.
- Prefabricated orthotics may be an early intervention option for patients with functional ankle instability, allowing them to remain physically active and improving their overall stability and proprioception.

Functional ankle instability (FAI) was originally defined as a feeling of the ankle giving way after an acute ankle sprain.[1] Because lateral ankle sprains are common injuries,[2,3] the recurrent instability that often follows[3] is a major concern for health care providers. Researchers[4–6] have shown that 55% to 72% of patients have residual symptoms for weeks, if not years, after an initial ankle injury. Residual symptoms can include pain, swelling, giving way, and weakness.[6] The presence of these symptoms may lead to decreased quality of life and reductions in functional capacities.[6]

The presence of FAI also affects an array of activities, from basic balance tasks[7–12] to more advanced functional performance tests. Based on these reported deficits, clinicians have developed a variety of rehabilitation protocols, including basic strengthening[13–15] and proprioception[16–19] to more advanced plyometric training.[20,21] Outcomes from these protocols include improved joint reposition sense[14,15] and postural control[21] and increased muscle activity[22]; however, the residual symptoms of FAI continue to affect a large number of people.

One treatment protocol that has the potential to increase stability at the ankle joint in people with FAI is orthotics. Orthotics have been used to control foot motion, reduce biomechanical stresses, support arches, improve shock absorption, increase proprioceptive capabilities, and position the subtalar joint in a more mechanically stable position.[23–26] In patients with a variety of conditions from plantar fasciitis to low back pain, previous authors[27–29] have shown that after orthotic treatment, patients report resolution of symptoms and reduced pain. More specifically, a number of investigators[30–33] found that orthotic intervention improved postural stability in healthy and injured people. However, little research has been conducted on how orthotics may reduce the signs and symptoms of FAI, such as deficits in postural stability.[7,12]

To date, only one group[30] has studied custom-fit orthotics

and postural stability in patients with chronic ankle instability and found that dynamic postural stability improved after 4 weeks of orthotic use.[30] We plan to continue this line of inquiry using a prefabricated orthotic. We believe that orthotics have the potential to improve postural stability because (1) a neutral orthotic can control the subtalar joint, subsequently providing a more stable foundation of support, and (2) by supporting the medial longitudinal arch, the orthotic stimulates afferent cutaneous receptors, subsequently stimulating the somatosensory system.[33] Therefore, the purpose of our study was to determine whether using a prefabricated orthotic affects postural stability in participants with FAI; 1 group received the orthotic and the other was the control group.

METHODS

Participants

Forty volunteers from a large midwestern university participated in this study. All had unilateral *FAI*, which was defined as a history of at least 1 lateral ankle sprain, followed by multiple occurrences of the feeling of the ankle giving way. Each person completed the Cumberland Ankle Instability Tool (CAIT)[34] so that we could determine eligibility. We chose the CAIT because it allowed each ankle to be evaluated individually. Hiller et al[34] determined that the threshold score on the CAIT, which indicated a person had FAI, was 27.5. Therefore, we stipulated that participants must have a score of 27 or less on the CAIT for inclusion. In addition, each participant's contralateral limb was required to be healthy, with a CAIT score between 28 and 30. Volunteers were excluded if they had any history of ankle or lower leg fractures or surgeries or any ankle injury within 2 months of testing. Other exclusion criteria were any type of ear or sinus infection and pregnancy. Demographic data for all participants are provided in Table 1. Before the study began, all participants read and signed an informed consent form approved by the university's Institutional Review Board for the Protection of Human Subjects, which also approved this study.

Procedures

Testing occurred in 3 sessions. In session 1, postural stability was evaluated on both the FAI and healthy limbs using the AccuGait force plate (model ACG; Advanced Mechanical Technology, Inc, Watertown, MA). Participants wore their own low-top athletic shoes and were instructed to stand centered on the force plate while maintaining a single-limb stance with their eyes closed. We evaluated postural stability in the eyes-closed condition to focus the testing on the somatosensory system.[33] The nonstance limb was held in slight hip and knee flexion, and the hands were placed on the hips. Before testing began, all participants were allowed a maximum of 2 practice trials to familiarize themselves with the procedures. Three 20-second trials were then completed on each limb. If the person lost balance during a trial and the nonstance limb touched the force plate, he or she was instructed to return to the test position as quickly as possible. However, if the nonstance limb touched down on the floor around the force plate, the trial was excluded and repeated. These procedures are consistent with those of previous authors[35] who evaluated reliable force-platform testing procedures.

After session 1 was completed, we rank ordered the baseline postural stability data on the FAI limb. Then participants were alternately placed into the control group and orthotic group based on their ordinal position on this list. Using this matched-group technique enabled us to ensure approximately equal average postural sway in both groups before any intervention.

For session 2 (which was scheduled within 7 to 14 days of session 1), the control group wore the same low-top athletic shoes used in session 1 and repeated the same postural stability testing. Those in the orthotic group received the Quick Comfort Insole (Foot Management, Inc, Pittsville, MD), a prefabricated, full-length semirigid orthotic manufactured with a urethane base and an ethylene vinyl acetate top cover (Figure 1). It was designed to support the medial longitudinal arch and stabilize the rearfoot. Per the manufacturer's guidelines, the orthotic size was based on the shoe size of the participant. To properly fit into the shoe, some orthotics had to be trimmed. The orthotic group replaced the insoles of both shoes with the orthotics, and postural stability testing was repeated as in session 1. After testing, the orthotic group was instructed to wear the orthotics for 1 hour on the first day and then to increase use by approximately 1 hour per day. Therefore, after 2 weeks, each participant was wearing the orthotics for 12 hours daily and had had sufficient time to accommodate to the orthotics before the final test. For session 3, all participants repeated postural stability testing as in session 2.

Postural stability was measured using center-of-pressure (COP) area (in square centimeters). This dependent variable is commonly used in postural stability studies[19,36–38] to investigate ankle instability. This measure allowed us to evaluate the overall stability of the limb and quantify how it changed with the use of orthotics. Given the wide array of conflicting evidence related to the use of orthotics in people with lower limb

Table 1. Demographic Data (N = 40)

Characteristic	Side	Group	
		Orthotic (n = 20)	Control (n = 20)
Sex, men/women		11/9	10/10
Age, y		20.0 ± 2.3	20.5 ± 2.1
Height, cm		175.8 ± 8.3	175.0 ± 12.3
Weight, kg		73.3 ± 12.6	76.0 ± 21.6
Cumberland Ankle Instability Tool score (range, 0–30)			
	Functional ankle instability	15.0 ± 4.6	16.6 ± 4.0
	Healthy	29.8 ± 0.6	29.2 ± 0.9

Figure 1. The prefabricated, full-length Quick Comfort Insole (Foot Management, Inc, Pittsville, MD).

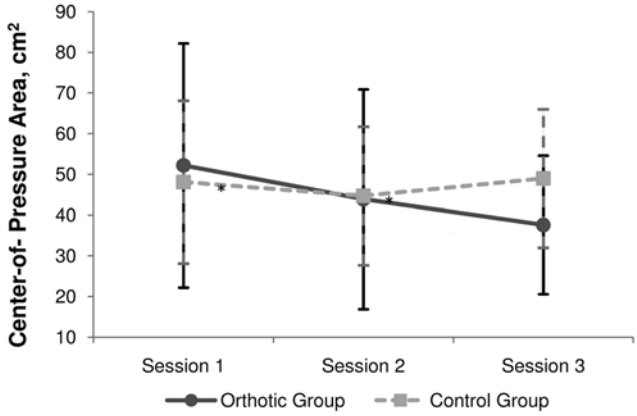

Figure 2. Center-of-pressure area by group and session. Data are pooled from functional ankle instability and healthy limbs. [a] Postural stability improved in the orthotic group between sessions 1 and 2 and sessions 1 and 3. [b] Postural stability was better in the orthotic group than the control group in session 3.

conditions, we chose a general measure of postural stability to provide clinicians with an easily interpreted measure to guide clinical practice.

Data Processing

Using NetForce software (version 2.4.0; Advanced Mechanical Technology, Inc), we collected data for the 20-second trial at a rate of 200 data points per second with a fixed, 100-Hz 3rd-order analog filter. Data were then analyzed using BioAnalysis software (version 2.4.0; Advanced Mechanical Technology, Inc). For each trial, COP area was calculated as the value that encircled 95% of the COP data. The average of 3 trials was used for statistical analysis.

Statistical Analysis

A repeated-measures analysis of variance was calculated with 2 within-subjects factors, side (FAI and healthy) and session (1, 2, 3), and 1 between-subjects factor, group (orthotic, control). Tukey post hoc testing was conducted on any significant findings. The α level was set at .05. Data analysis was performed using SPSS (version 16.0; SPSS Inc, Chicago, IL)

RESULTS

We identified a session-by-group interaction ($F_{2,76}=4.18$, $P=.02$, Figure 2). Specifically, in the orthotic group, postural stability improved between sessions 1 and 2 ($P=.04$) and sessions 1 and 3 ($P=.02$); however, there were no differences across sessions in the control group. Additionally, the orthotic and control groups showed a difference in session 3 ($P=.03$). We also identified a main effect for side ($F_{1,38}=6.98$, $P=.01$), such that the FAI ankle had worse postural stability than did the healthy ankle. We did not find a side by session-by-group interaction ($F_{2,76}=1.26$, $P=.29$) or a main effect for group ($F_{1,38}=0.21$, $P=.65$). Means, standard deviations, and 95% confidence intervals are shown in Tables 2 and 3.

DISCUSSION

Our primary finding was that orthotics improved postural stability in people with FAI. Immediately after receiving the orthotics, participants displayed improved stability, and these values continued to progress after the 2-week accommodation period. Following the guidelines typically used in the clinical setting, we instructed participants to wear the orthotics every day, beginning with 1 hour per day and increasing by 1 hour each subsequent day. By the end of the accommodation period, they should have been wearing the orthotics all day. The type of orthotic used in this study is an important point of distinction. We used a prefabricated orthotic that did not need any customization. The neutral shell and deep heel cup of the orthotic allow it to be used in patients with a variety of foot types.

As did previous authors,[30,33,39] we believe that several factors might have contributed to the improved postural stability. A theorized function of an orthotic intervention is to support

Table 2. Center-of-Pressure Area by Session and Side (Mean ± SD)

		Center-of-Pressure Area, cm²	
Session	Side	Orthotic Group (n = 20)	Control Group (n = 20)
1	Functional ankle instability	54.7 ± 29.2	54.2 ± 25.6
	Healthy	49.7 ± 36.9	42.0 ± 16.6
2	Functional ankle instability	45.4 ± 26.6	47.0 ± 21.8
	Healthy	42.4 ± 28.5	42.4 ± 15.4
3	Functional ankle instability	42.6 ± 19.6	51.9 ± 24.1
	Healthy	32.7 ± 13.7	46.2 ± 13.1

Table 3. Session and Orthotic and Control Group Differences in Center-of-Pressure Area, cm² (Mean [95% Confidence Interval])[a]

Session(s)	Orthotic Group (n = 20)	Control Group (n = 20)	Orthotic Group–Control Group
1 to 2	–8.3[b] (–16.2, –0.5)	–3.4 (–9.6, 2.8)	NA
1 to 3	–14.5[b] (–26.9, –2.1)	0.9 (–5.51, 7.34)	NA
2 to 3	–6.2 (–14.6, 2.3)	4.3 (–0.6, 9.3)	NA
1	NA	NA	4.0 (–11.8, 19.9)
2	NA	NA	–0.9 (–14.9, 13.2)
3	NA	NA	–11.4[b] (–21.6, –1.2)

Abbreviation: NA, not applicable.

[a] Pooled data from both functional ankle instability and healthy limbs.

[b] Significant difference ($P < .05$).

the 3 major arches of the foot.[39] Supporting the arches also increases contact area between the plantar surface of the foot and the orthotic. Therefore, the orthotic can systematically disperse pressure throughout the foot[33] and increase tactile stimulation to the skin of the foot.[40,41] Together, these mechanisms might improve proprioceptive feedback on the foot's position and subsequently create a more stable base of support. We agree with previous authors[24,33] who reported that the use of orthotics increases somatosensory stimulation. However, because we measured postural stability alone in this study, we can only speculate on the exact cause of the improved stability.

Our results are in agreement with those of the only other group[30] that looked specifically at an orthotic intervention in participants with ankle instability. Interestingly, they used 2 dynamic tasks to measure postural stability: the Star Excursion Balance Test and limits-of-stability test (conducted on the Balance Master, NeuroCom, Clackamas, OR). These authors[30] reported that the orthotic intervention improved performance on the Star Excursion Balance Test but not on the limits-of-stability test. They concluded that because the limits-of-stability test was a double-limb stance test, it did not sufficiently challenge the participants' balance abilities. Even though we used a static test of postural stability, our results were similar to those they obtained on the Star Excursion Balance Test.

Earlier authors[31,42,43] in the area of foot orthotics and postural stability reported conflicting evidence for orthotics as a viable option for improving balance performance. We believe the major reason for the conflicting findings is either the population tested or the type of orthotic used. In the following paragraphs, we discuss these factors.

Study Sample

Our study focused on participants with FAI but excluded those with any type of acute injury to the lower extremity in the past 2 months. We recruited people with significant FAI identified on the CAIT. Hiller et al[34] found that the threshold score on the CAIT indicating FAI was 27.5. Therefore, participants had to receive a score of 27 or less on the CAIT for inclusion. The CAIT score of the FAI ankle in the orthotic group ranged from 5 to 22, and in the control group, it ranged from 10 to 24. We specifically sought participants with severe FAI because we expected that more severe FAI would result in greater postural stability deficits. In contrast, authors[43,44] of previous work studied a variety of populations, including healthy participants. Inherently, healthy, uninjured participants probably have little or no postural sway deficit, and therefore a change in postural sway is difficult to detect. This theory is supported by the results of 2 studies.[31,43] Orteza et al[31] concluded that molded orthotics improved postural sway in the injured group but not in the healthy group. Percy et al,[43] who investigated only healthy people, stated that orthotics may not have affected the uninjured participants because they were already performing at near-optimal levels of stability. Other authors[31,42] concentrated on people who had sustained a lateral ankle sprain within the previous 6 weeks. This population may have included a wide variety of participants with many confounding symptoms. Such variations make their results difficult to compare with ours.

Type of Orthotics

An assortment of different orthotics was used in previously published works. Orthotics are typically classified as prefabricated (unmolded) or custom (molded) orthotics. The literature on these broad classifications is still very mixed. Most investigators[30,31,33,40] who used molded orthotics found that postural stability improved. However, studies of unmolded orthotics had conflicting results. As we did, one group[45] found that postural stability improved with unmolded orthotics, but others[42,44] found no improvement with this intervention.

Hertel et al[42,44] evaluated a variety of orthotics, some molded and some unmolded, but with an array of rearfoot postings. The results varied with the population. Interestingly, for participants with acute ankle sprains, none of the orthotics affected postural stability.[42] In healthy people, however, some of the unmolded orthotics improved postural control.[44] Therefore, in the absence of a consensus, we chose the prefabricated, full-length Quick Comfort Insole because it was inexpensive, required no visit to a health care professional, and was readily available to numerous populations. Given the results, this rationale is even more important because we concluded that a prefabricated orthotic improved postural stability. This particular orthotic supported the medial longitudinal arch and also provided a deep heel cup. However, the orthotic was not customized to each participant and simply provided a neutral shell. Placing the foot in a neutral position could have alleviated stress that was normally placed on the static and dynamic structures of the lower leg. The orthotic could have also increased tactile stimulation to the skin of the foot, enabled more afferent information to reach the central nervous system, and subsequently improved balance.

Clinical Implications

To provide patients with FAI with the best care possible, clinicians must always explore new options to protect them from further harm while still allowing them to remain active. We have

demonstrated that prefabricated orthotics can be considered as a treatment method to improve postural stability in participants with FAI. Not only did we identify a statistical difference, but we believe this difference is clinically meaningful, especially after the 2-week accommodation period. Postural stability improved as soon as participants used the prefabricated orthotic, and this improvement increased after participants wore the orthotic for 2 weeks. We hypothesize that the orthotic improved stability by placing the rearfoot in a more stable position, and over the accommodation period, the participants were able to adjust to this new foot position and further improve their postural stability. This concept is in agreement with previous findings[45] of improved stability after orthotic use for several weeks.

Limitations

The accommodation phase permitted uncontrolled periods of time between testing sessions. Participants were instructed orally and in writing on the protocol for orthotic use between sessions. However, we could not determine whether each person followed the protocol properly. In addition, even though pilot testing showed no difference between participants wearing their own shoes for testing and those wearing standardized shoes, the condition (ie, wear and tear) of the shoes worn for testing sessions could have been different.

An additional limitation might have been the procedures used to obtain the COP data. Although single-limb balance tasks are commonly accepted measures of static stability, some procedures exclude trials in which deviations in balance cause participants to touch down on the force plate. We followed previously published guidelines[35] and included these trials. This allowed us to capture all trials, including those in which participants exhibited the greatest deviations in balance. Yet this procedure made our COP area measurements larger than those commonly found in the literature, a factor that should be considered when comparing these values with those of other studies.

Future Research

We believe that more research is needed on the effects of orthotics on the ankle and other lower extremity structures proximal to the ankle. Conducting these studies over time will demonstrate how orthotics affect injury rates and identify any long-term effects of orthotic intervention on self-reported function. Investigators should continue to focus on the differences between prefabricated and custom orthotics. Additionally, research on textured insoles and textured orthotics will be useful in learning about tactile stimulation of the foot.[41] Future authors should also consider a wider variety of postural control measures. Finally, these studies should be conducted in athletes with various foot and ankle conditions, including those with minor, moderate, and severe postural deficits.

CONCLUSIONS

Our purpose was to determine whether orthotics can be used as a treatment option to improve the postural stability of participants with FAI. We found that a prefabricated orthotic improved postural stability in patients with FAI. Therefore, prefabricated orthotics may be an early intervention option for patients with FAI while allowing them to continue to participate in physical activity. Ideally, orthotics would be used in conjunction with traditional rehabilitation exercises to improve the overall stability and proprioception of patients with FAI.

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