Review Article

Efficacy of Different Types of Foot Orthoses on Postural Control in Subjects With Lateral Ankle Sprain: A Systematic Review

Mahmood Bahramizadeh[1*], **Hanieh Khaliliyan**[1]

1. Department of Orthotics and Prosthetics, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

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ABSTRACT

Objectives: Lateral ankle sprain is one of the most common injuries to the musculoskeletal system, especially among active people. This injury causes complex complications, such as recurrent sprain because of reduced postural control. Foot orthoses are among the interventions used to improve postural control in this population. This review aims to investigate foot orthoses to improve postural control among patients with an acute or chronic lateral ankle sprain.

Methods: Four electronic databases (Scopus, PubMed, Web of Sciences, and Google scholar) were searched for experimental studies. Articles were selected using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) method. The articles were reviewed for their quality based on the standards for reporting diagnostic accuracy statements and then entered into this review.

Results: The search results in all databases provided a total of 48 articles. After reviewing the documents, we excluded 38 articles that did not pass the inclusion criteria, resulting in 10 remaining articles. Data extraction from population, interventions, and outcome measures was done for these 10 articles.

Discussion: Foot orthoses are effective in improving the postural control of individuals with an acute or chronic lateral ankle sprain. Considering the existence of mechanical and functional instability, foot orthosis which is made to affect the proprioception and follow the biomechanics of the body seems to be the most effective in this field; however, more studies are required to confirm this

*** Corresponding Author:**
Mahmood Bahramizadeh, Associate Professor.
Address: *Department of Orthotics and Prosthetics, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.*
Tel: *+98 (21) 22180010*
E-mail: *ma.bahramizadeh@uswr.ac.ir*

Highlights

• Foot orthoses improve postural control in subjects with an acute or chronic lateral ankle sprain.

• Both types of foot orthoses aimed at affecting the sensorimotor system and reducing improper torques around the ankle joint are effective in improving postural control in subjects with lateral ankle sprain; however, the foot orthoses which is made with both purposes seem to provide the best results.

Plain Language Summary

Foot orthoses are small and inexpensive interventions to improve postural control in subjects with a lateral ankle sprain. We reviewed studies that used foot orthoses as an intervention for improving postural control in this population. It is important to investigate this because of the growing interest in professional sports, many people worldwide suffer from ankle sprains and subsequent chronic instability. This systematic review has found that custom-molded foot orthoses are made by impression, according to body-specific biomechanics and with a deep heel cup is more effective than prefabricated types in improving postural control in this population. A recent study developed a custom molded with textured surface foot orthosis to improve mechanical and functional instability and introduced it as the most effective foot orthosis in the field; however, further studies are required to substantiate this claim.

1. Introduction

The ankle joint is one of the most common sites of damage to the musculoskeletal system of the human body [1] and sprains account for 25% of injuries in this area [2]. Ankle sprains are often caused by repeated movements of jumping on the ground and running at high speed [3]. This happens especially if the movements are accompanied by a change of direction. This can be considered one of the most common injuries during sports and recreational activities. Among the types of ankle sprains, lateral (inversion) sprains account for 85%, medial (eversion) sprains for 5%, and syndesmosis sprains for 10% of the injuries [4].

The ankle joint is surrounded by different ligaments that connect the bones. This fibrous connective tissue stabilizes the joint and limits its range of motion. If additional stress is applied to the joint, it causes the ligaments to stretch and if the stress is beyond the tolerance of the ligaments, the joint will be damaged or sprained [5]. At the time of the lateral ankle sprain, the ankle is in plantar flexion. Supine torque is applied to the foot and external rotational force is applied to the leg [6, 7]. After a lateral ankle sprain, there is usually pain and disability because of the possible damage to the ligament structures, nerves, and muscle-tendon parts [8]. It is estimated that in 36% to 85% of cases, complete recovery from these complications takes up to 3 years [9]. Residual signs of instability and recurrent ankle sprains that last for more than one year are defined as a chronic ankle sprains or instability [10, 11]. More than 70% of people suffer from an acute sprain. These patients show signs of chronic ankle instability over time [9]. Common symptoms of this complication include a feeling of giving away, ligament laxity, edema, weakness, pain, and decreased proprioception in the ankle joint during activity. These complications can cause significant biomechanical changes in the gait. Long-term complications include osteoarthritis and osteochondral in the talus dome [12, 13].

Chronic ankle instability is a complex phenomenon associated with various disorders. The two main disorders are mechanical and functional instability. Mechanical instability occurs because of the structural changes in the ligaments shortly after the initial injury. This type of instability increases the range of motion in both the talocrural and subtalar joints [14]. In this case, the foot contacts with the ground in an inverted position during rapid movements. A large amount of inversion torque is created in the subtalar joint and the probability of recurrence of sprain increases [15, 16]; however, functional instability is associated with impairment in sensorimotor control and proprioception [17]. In other words, lateral ankle sprain destroys the integrity of the ligament structure, and the mechanical receptors in the joint capsule, tendons, and ligaments around the joint that are a part of the somatosensory system suffer. Nerve fibers combine the information from the receptors with information received from the visual and vestibular sensory systems and after being transmitted to the central nervous system, this information is used for postural control [18]. Postural control is a method in which the central nervous

system uses the sensory information of other systems to produce the motor output needed to maintain proper posture. The visual, vestibular, and somatosensory systems are the main systems involved in controlling posture [19]. Postural control is the basis of all daily activities [20]. Decreased ability to maintain balance and postural control is a major risk factor for the recurrence of lateral ankle sprain and it is the focus of most researchers to evaluate the effects of orthoses for patients with a lateral ankle sprain. Accordingly, balance and postural control restoration are the basis of acute or chronic lateral ankle sprain rehabilitation programs [12].

Given the high incidence of lateral ankle sprains and subsequent chronic instability, various conservative treatments have been proposed for this complication. Acute sprains can be managed with rest, ice, compression, elevation (RICE) and nonsteroidal anti-inflammatory drugs, followed by functional rehabilitation exercises, taping, and orthoses. As the use of orthoses reduces the time and effort required for treatment, it can provide better results [6].

Common orthoses prescribed to these patients are ankle supports and foot orthoses (FOs). Over the years, FOs have been used by specialists to treat acute and chronic ankle injuries in athletes. Satisfaction with these devices is reported to be 70% to 80% [21]. Compared to ankle orthoses, FOs are used because of their adjustability, reasonable price, ease of use, and comfort.

In this review study, we searched for different types of FOs whose effect is on postural control in people with a lateral ankle sprain. We also sought to determine the most effective FO in this field.

2. Materials and Methods

Articles were selected using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) method.

Eligibility criteria

In this study, the inclusion criteria were level 2 or higher studies (the level of evidence was estimated based on the center of evidence-based medicine definition, which is related to the study design) that evaluated the effects of FOs on postural control in adults (18 years old or older) with acute or chronic lateral ankle sprain (Table 1). The exclusion criteria were studies that did not show postural control as an outcome measure; participants who had sprains because of an underlying disease, such as Charcot; and participants who used tapping, ankle support, or a combination of ankle and foot orthoses as an intervention.

Information sources

Articles were searched in PubMed, Scopus, Web of Sciences, and Google Scholar databases in all languages. The search period was from 1990 to 2022.

Search strategy

The search strategy was based on the population intervention comparison outcome (PICO) method by selecting the keywords and constructing the search terms with the help of "OR", "AND", and "NOT" operators (Figure 1). Synonyms for the keywords were also obtained from the MEDLINE database.

Study selection

The review strategy was to review the title and abstracts to check the existence of inclusion and exclusion criteria. Studies with the following items in the title or abstract were eligible: (1) participants were adults with an acute or chronic lateral ankle sprain, (2) the intervention included FOs, (3) the outcome measures were all the variables that according to the documents could be attributed to the concept of postural control, (4) statistical analyses were reported, and (5) the full text of the article was available. First, the title and introduction of the articles were reviewed and then the full text of the articles was reviewed separately by two reviewers more than once in terms of the existence of inclusion criteria. In case of disagreement between the two reviewers, the final decision was made after discussion and then the articles were assessed in terms of quality.

Quality assessment

Non-full-text, non-peer-reviewed and non-experimental studies did not enter the study. The selected papers were checked following the standards for reporting diagnostic accuracy statements and then entered into review. This checklist consists of 30 sections (scores 0 to 30) and was developed to contribute to the completeness of reporting of diagnostic accuracy studies. The guiding principle of standards for reporting diagnostic accuracy development was to select items that, when reported, would help readers judge the likelihood of study bias, evaluate the application of the study findings, and validate the conclusions and recommendations.

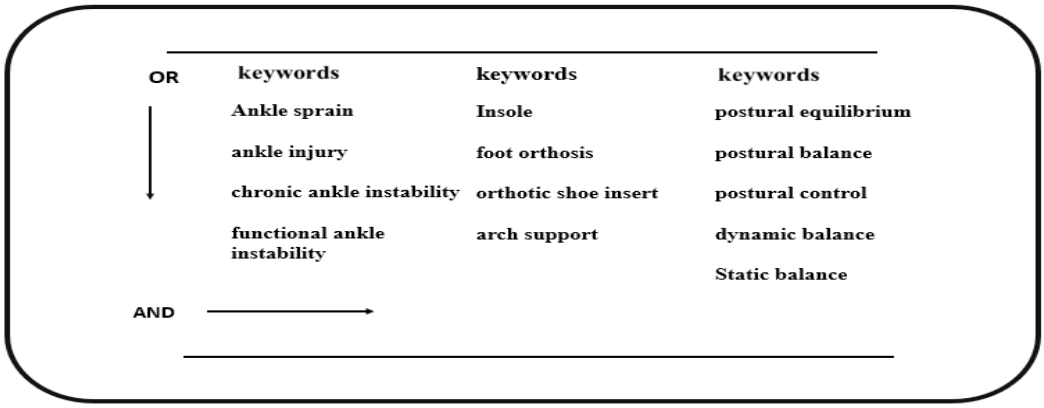

Figure 1. Search terms used to select the studies

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3. Results

In the initial search, 48 articles were found, 20 of which were deleted after eliminating duplicates and reviewing the keywords, titles, and abstracts. After further evaluation of the articles by reviewing the full text, 8 articles were identified as irrelevant and 10 articles fully met the inclusion criteria (Figure 2). Study designs included randomized controlled trials and repeated-measure studies that included within- and or between-group comparisons.

Characteristics of participants

The number of participants in each study ranged from 15 to 49. A total of 284 people participated in these studies, of which 51 were healthy (control group), 37 patients (3 studies) were in the acute phase, and 196 patients were in the chronic phase (7 studies). The mean age of all participants was 21.6.

Types of interventions

The types of FOs used in these studies included custom molded FOs that are made with impression and keep the

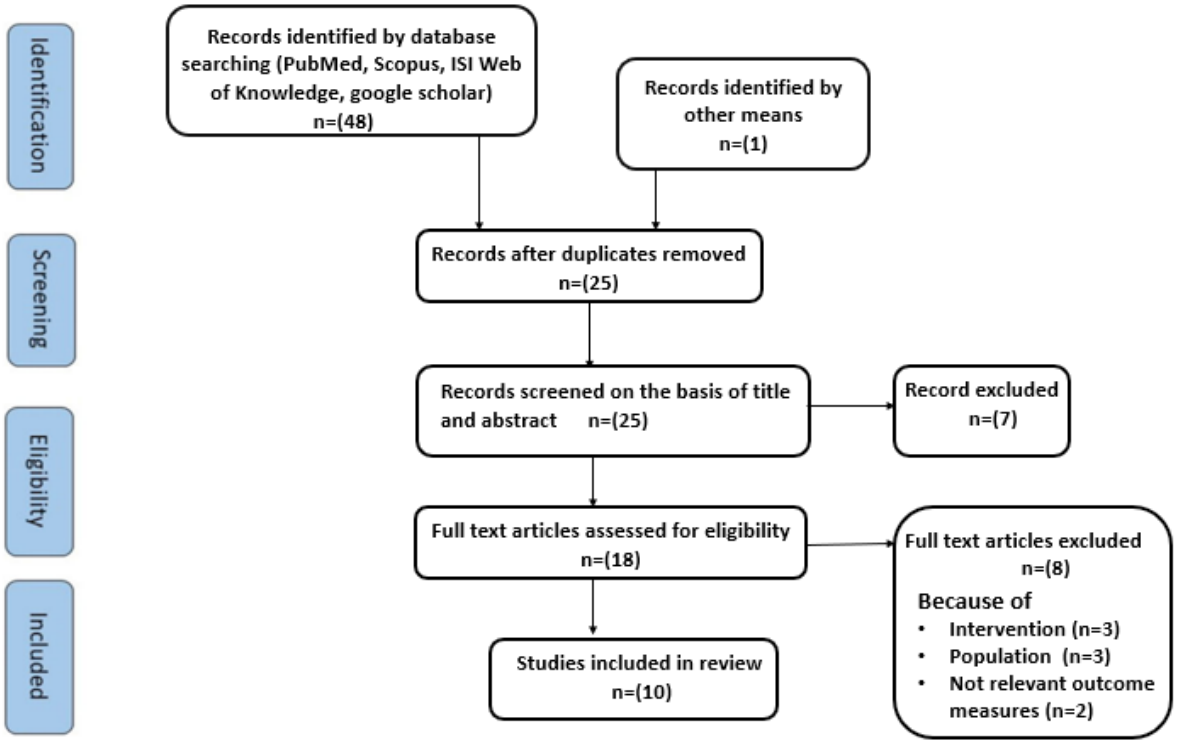

Figure 2. PRISMA study selection flow diagram

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Table 1. Participants, methods, outcomes, results, and conclusions

Authors	Study Design	Sample Size	Participant Characteristics	Intervention	Procedure	Outcome Measures	Results and Conclusions
Orteza et al., 1992 [23]	Repeated measures within and between groups	9 Injured 15 Uninjured	An acute ankle sprain in the previous 6 weeks; 6 males and 9 females; age=22.0±2.3 years	Molded, Unmolded foot orthoses	Participants stay on a single-axis board of digital scanning. The amount of time that the loss of balance is maintained is recorded in seconds.	Time out of balance	Improvements were seen in the injured group with the molded orthotic devices.
Guskiewicz et al., 1996 [6]	Repeated measures within and between group	13 Injured 12 Uninjured	Acute inversion ankle sprains within 21 days of testing; 7 males and 6 females; age= 18.1±5.8 years	Molded foot orthoses	The balance system measured the length and velocity of postural sway using 4 force transducers placed under the medial and lateral aspects of the heel and forefoot.	Center of pressure displacement	Foot orthoses are a useful strategy for reducing increased postural sway.
Hertel et al., 2001 [27]	Repeated measures within group	15 Injured	Unilateral lateral ankle sprain; 8 men and 7 women; age=21.9±6.2 year; height=176.5±7.4 cm; weight=74.3±11.2 kg	Custom molded, medially and laterally posted; neutral texture; laterally posted with heel wedge; a shoe-only condition	To maintain a single-leg stance while standing on the force plate under the 6 conditions.	Center of pressure length and velocity in the frontal and sagittal planes	Rearfoot orthotics, irrespective of design or posting were ineffective at improving postural sway after a lateral ankle sprain.
Sesma et al., 2008 [24]	Repeated measures within the group	20 Injured	Age=24.15±7.73 years with self-reported unilateral chronic ankle instability; defined as a history of more than one ankle sprain; a recurrent feeling of giving away; and a score of 24 or less on the Cumberland ankle instability tool	Custom molded foot orthoses	Participants performed the star excursion balance test.	Reach a distance of star excursion balance test	Foot orthoses are effective in improving reach distances during the star excursion balance test in patients with chronic ankle instability over time.
Hamlyn et al., 2012 [26]	Randomized clinical trial	40 Injured	Unilateral functional ankle instability and a Cumberland ankle instability tool score of 27 or less. Control group=10 males and 10 females, age=20.5±2.1 year; orthotic group=11 males and 9 females, age=20.0±2.3 year.	Quick comfort and prefabricated, full-length, semirigid orthotics	Participants performed three, single limb stance, eyes-closed trials on both limbs wearing their low-top athletic shoes on the force plate.	Center of pressure displacement	Prefabricated orthotics improve static postural stability in people with functional ankle instability.

Authors	Study Design	Sample Size	Participant Characteristics	Intervention	Procedure	Outcome Measures	Results and Conclusions
McKeon et al., 2012 [30]	Repeated measures within the group	20 Injured	Physically active individuals; 12 men and 8 women; age=18 to 45 years (21.5±5.51) with self-reported chronic ankle instability.	Textured and sham foot orthoses with no texture	The foot was positioned in the center of the force plate surface grid for each testing condition. Subjects were instructed to maintain their position.	Center of pressure displacement	Stimulating the plantar surface of the foot, via a textured foot orthoses, affects the broad spectrum of postural control maintenance in individuals with chronic ankle instability.
Lee et al., 2013 [29]	Repeated measures within and between group	41 Injured	Suffering from a repeated ankle injury, had chronic pain; age=21.7±3.2 years, 177.6±5.6.	Rehabilitation exercise; prefabricated foot orthoses with lateral wedge	Participants were assessed in situations with sensory limitation, motor limitation, and with functional limitation using a force plate.	Center of pressure displacement	Improvement of postural control was observed in both groups but the effect of both interventions was reported to be the same.
Jamali et al., 2014 [28]	Repeated measures within and between group	20 Injured	Age=19.2±4.82 years; a history of unilateral sprain with pain and swelling before the study; a history of at least two emptyings or sprain in 12 recent months.	Flat ethyl vinyl acetate (EVA) base foot orthoses; textured flat EVA foot orthoses	Participants stood on two limbs on the force plate and Standing balance variables were recorded.	Center of pressure displacement	The use of texture on a flat insole in femoroacetabular impingement may have some positive impact on standing balance.
Abassi et al., 2018 [22]	Repeated measures within the group	30 Injured	Age=22.3±2.7 years; one major ankle sprain (at least 12 months before the study); last ankle sprain at least 3 months before the study; Cumberland ankle instability tool score of less than 24.	Without foot orthoses; Prefabricated foot orthoses; Custom mold foot orthoses; Custom mold with texture	Participants performed the star excursion balance test.	Reach a distance of the star excursion balance test	The custom-molded with textured foot orthoses is the better choice for patients with chronic ankle instability.
Chang et al., 2019 [25]	Randomized control trial	25 Injured 24 Uninjured	History of at least 1 lateral ankle sprain, ankle pain, instability, and bucking in the 12 months; Cumberland ankle instability tool score of 27 or lower.	Four degrees medial wedge	The Zebris FDM system was used to evaluate static balance and a multiple single-leg hop stabilization test was adopted to evaluate dynamic balance.	Center of pressure displacement	Wearing a 4 medial heel wedge improved static and dynamic balance immediately in athletes with chronic ankle instability.

subtalar joints in neutral (semirigid or rigid with deep heel cup) [6, 22-24] and prefabricated (semirigid, deep

heel cup, medially posted, laterally posted, neutral textured, and laterally posted with heel wedge) [21-23, 25-30]. Also, in one study a custom molded with textured surface FO was used [22]. Semirigid custom-molded FOs were made of Aquaplast T and rigid types were made of polypropylene. In some of these studies, the control group used flat FOs with different shoes.

Study outcomes

The variables that were measured in these studies and attributed to the concept of postural control included the center of pressure (COP) displacement and velocity, time out of balance, and reaching the distance of the star excursion balance test (SEBT).

seven studies measured COP displacement as the primary outcome and the force plate systems were the most common measuring device [6, 14, 25, 26, 30]. Two of these studies used the SEBT [22, 24], and one measured the number and amount of time that a person lost balance via a digital balance evaluator [18].

Some studies have examined a type of FOs on postural control in subjects with a lateral ankle sprain [6, 29, 30] and other studies compared the effects of different types of FOs in this population [22, 23, 25-27, 30]. Most measurements were performed with shoes. All shoes used in these studies were low-top to prevent the effect of high collars on postural control.

Center of pressure displacement and velocity

In this regard, 6 studies evaluated the effects of prefabricated semirigid (cm, between sessions 1 and 3; P=0.02), textured (P=0.03 in one study and P=0.04 in another study) with 4 degrees of medial wedge (path length, mm: P=0.027), lateral wedge (P=0.004), and custom molded (P=0.029) FOs on reduction of COP displacement and all reported positive results on postural control [21, 25, 26, 28-30]. One study compared the effects of 5 types of rear FOs, one of those was custom molded and the other four were prefabricated (medially posted, laterally posted, neutral textured, laterally posted with heel wedge) on the length and velocity of postural sway. They examined COP in the frontal and sagittal planes and found FOs to be ineffective in controlling posture, regardless of the types of orthoses [27].

Reaching the distance of star excursion balance test

A month-long study examined the use of custom-molded FOs on the reach distances of the SEBT and reported an increase in these distances (P=0.023) [24]. A comparative study states that among the three types of custom molded with textured, custom molded, and prefabricated FOs, the first is the most effective type in improving the reach distances (P=0.001) [22].

Time out of balance

One study compared custom and prefabricated FOs by measuring the time that participants are out of balance. The study found that only custom-molded FOs are effective in decreasing this time (P=0.013) [23]. A summary of all the studies is provided in Table 1.

4. Discussion

FOs are complex biomechanical interventions due to variances in materials, manufacturing methods, design, individual preferences, and rates of adherence [31]. Nine out of the 10 studies that examined the effects of FOs on postural control in subjects with lateral ankle sprain found FOs to be effective in improving postural control [6, 21-25, 28-30]. Hertel reported that orthoses do not affect improving balance in subjects with chronic ankle instability and the proven effects of these orthoses in the rehabilitation process of these people are because of their effects on another variable. Although Hertel used more complex systems for its experiments, the posts it used on the FOs tested were not customized, unlike previous research [27].

Prefabricated FOs seem to improve postural control in mentioned patients; however, comparative studies have found that custom-molded FOs that are adapted to specific biomechanics are more effective [22, 23]. Chang tested the prefabricated FO with 4 degrees medial wedge on postural control and found positive results. He stated this was because of the increased range of motion of the ankle joint in these individuals. This is while previous studies have shown positive results from the lateral wedge in the treatment of patients with a lateral ankle sprain and no accurate information is available as to which of these two types of wedges is more effective [25].

All subjects with acute or chronic lateral ankle sprain use compensatory strategies to maintain balance. These strategies can put more pressure on the first metatarsophalangeal joint and fingers. Placing custom orthoses in shoes allows more contact area for the foot, put the

subtalar joint in a neutral position, uniform the pressure distribution, and provides a more stable base of support. These FOs also provide mechanical support by controlling the movements of the heel to the toes. These types of orthoses, if made with a deep heel cup, can better support the subtalar joint in the single limb support, improve the integrity of the subtalar joint, provide a better biomechanical condition for the joint, and improve postural control in patients with a lateral ankle sprain [22].

It should be noted that custom molded FOs are made to affect mechanical instability in people with a lateral ankle sprain, but as mentioned, a range of posture disorders in this population are related to sensorimotor problems, and since in the absence of input data from the mechanical receptors of the lateral ankle ligaments, the sensorimotor system automatically changes the input source to the mechanical receptors on the plantar surface of the foot [32]. Therefore, it seems that adding texture tissue to the FOs increases sensory feedback by stimulating the tactile receptors of the plantar region of the foot [33]. In this regard, Patrick and Jamali have expressed positive results from the effect of texture tissue FO and considered it necessary to study various types of textural material on measures of postural control in this group [28, 30].

Abassi stated that because people with chronic ankle instability have both mechanical and functional instability, making interventions aimed at affecting both types of instability can improve the rehabilitation results of these people. In this regard, she and her colleagues made a custom FO with a textured surface for the first time, and after examining its effect on dynamic postural control and comparing it with different types of prefabricated and custom mold FOs, they introduced it as a better option [22].

5. Conclusion

FOs are effective in controlling posture in the rehabilitation process of individuals with acute sprain and chronic instability. Custom mold FOs that are made by impression, keep the subtalar joint in neutral, and have a deep heel cup to maintain proper heel position seems to have better results than prefabricated FOs. Recent studies emphasize that because these individuals have both mechanical and functional instabilities, the design of rehabilitation interventions to improve both types of instability, such as custom FO with a textured surface, has better results in improving postural control in this group; however, only three studies evaluated FOs made to alter sensory input and it seems that the design of cross-sectional studies in this area is required.

For future research, we suggest comparative studies to determine which types of medial or lateral wedges work best in improving postural control in these individuals. Also, by reviewing available studies, we found that it is not clear how many degrees of the wedge is more effective in improving postural control and no attention has been paid to the study of medial and lateral arch supports in these people. As most studies on the impact of FOs in the community of people with lateral ankle sprains have been made for mechanical purposes, we also suggest that future studies focus on FOs designed to alter sensory input.

Since this study is a review, it shows the existing data on the usage of FOs for improving postural control in people with an acute or chronic lateral ankle sprain. It is necessary to continue studies of this research segment to find out the most appropriate FO as well as standardized tests and evaluations of postural control for a better comparison.

Ethical Considerations

Compliance with ethical guidelines

This is a review article with no human or animal sample.

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Authors' contributions

All authors contributed equally to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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