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Original research

Effect of soft and semirigid ankle orthoses on Star Excursion Balance Test performance in patients with functional ankle instability

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ABSTRACT

Objectives: To evaluate the effect of soft and semirigid ankle orthoses on dynamic balance assessed using Star Excursion Balance Test in patients with functional ankle instability compared with healthy individuals.
Design: Non-experimental, observational study with multiple-factor design, including group (functional ankle instability and healthy) as the between-subjects factor and orthotics condition (no orthosis, soft orthosis and semirigid orthosis) as the within-subjects factor.
Methods: Sixteen unilateral functional ankle instability patients and a group of 16 healthy control individuals, matched for age, height and weight, participated in the study. Dynamic balance was tested with and without wearing ankle orthosis. Reach distance of participants in 3 bracing conditions were measured in anteromedial, medial and posteromedial directions of Star Excursion Balance Test. Average of 3 trials in 3 measured directions, normalized to leg length of each participant, was used for statistical analysis.
Results: There were no differences among orthotics conditions in healthy people. However, normalized reach distance increased from no-orthosis to semirigid to soft orthoses in FAI patients. Differences were significant between soft and no-orthosis (13% in anteromedial, 14% in medial and 15% in posteromedial direction $p = 0.01$) and between semirigid and no-orthosis (10% in anteromedial, 8.5% in medial and 8.5% in posteromedial direction, $p = 0.01$) conditions in all 3 measured directions. The difference between soft and semirigid orthoses was significant (6% difference, $p < 0.05$) only in PM direction.
Conclusions: Ankle orthoses improve reach distance in functional ankle instability patients in various reach directions. Soft orthosis has a more pronounced effect on dynamic balance, especially in posteromedial direction, compared with semirigid orthosis.

1. Introduction

Ankle sprains are amongst the most common musculoskeletal injuries that affect both physically active and sedentary people.[1] The most frequent problem associated with this injury is the recurrence of sprain.[2] Recurrent ankle sprain can occur in combination with or independently of mechanical instability and functional instability of the ankle joint.[3] Functional ankle instability (FAI) is characterized by experiencing frequent episodes of "giving way" of the ankle and feelings of ankle joint instability.[4] Neuromuscular deficits such as proprioceptive impairment and poor postural control predispose a person to development of FAI.[5]

The prophylactic and therapeutic effects of ankle orthoses in patients with FAI have been the topic of investigation in recent years. The effect of foot and ankle orthoses on postural sway measured by center of pressure excursion using force platform has been studied in both healthy[6,7] and FAI[7,8] populations. The results confirm that ankle orthoses can decrease body sway in FAI[7,8] patients during standing in static situations but with no effect on healthy group.[6,7] It is, however, important to consider that impairment of postural control in FAI patients can be seen in both static and dynamic conditions.[1] Furthermore, testing of balance under static conditions may not reflect the real situations of activities of daily living.[9] Due to this limitation, more attention has been devoted to assessment of postural control under dynamic balance conditions in recent years.

The Star Excursion Balance Test (SEBT) is a simple and reliable measure that is frequently used for evaluation of dynamic postural control in patients with ankle sprain.[10–12] Since its inception

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in 1995,[13] the SEBT was used in many studies to assess balance in patients with ankle sprain.[14–16] In addition, many investigators have employed this measure in their study to evaluate the effectiveness of different treatment approaches on postural control in such patients.[17,18] However, few studies have examined effect of the external ankle supports on dynamic balance. One of these studies[19] showed that prophylactic ankle braces have no effect on SEBT reach distance in healthy people and another study[9] found that foot orthoses improved dynamic balance in patients with ankle instability. However, based on authors' knowledge, to date no study has investigated the effect of ankle orthoses on dynamic balance as assessed by SEBT in patients with FAI.

Therefore, the purpose of the present study is to evaluate the effect of soft and semirigid ankle orthoses on dynamic balance in patients with FAI compared with healthy people. A recent study has found that external ankle supports, especially soft orthosis, could decrease postural sway during quiet stance in patients with FAI.[8] Based on these results, we hypothesized that dynamic balance would improve when wearing either soft or semirigid orthoses, with the former – soft orthosis – having more pronounced effect.

2. Methods

The volunteers were 16 patients with unilateral FAI (10 male, 6 female, mean ± standard deviation (SD) of age, height and weight: 22.9 ± 2.2 years, 169.3 ± 8.6 cm and 61.8 ± 10.1 kg, respectively) and 16 healthy people (10 male, 6 female, mean ± SD of age, height and weight: 22.2 ± 2.4 years, 170.3 ± 8.4 cm and 60.2 ± 9.3 kg, respectively).

Patients were included in the study if they had at least one unilateral inversion sprain of each ankle but not during the last year. They should have at least 1 episode of recurrent sprain or feeling of ankle instability or giving way in the past 6 months. Based on this criterion, the participants in this study reported multiple episodes ranging from 3 to 10. The FAI patients were excluded if they had mechanical instability of the ankle. Mechanical instability was confirmed by anterior drawer and talar tilt tests. Healthy individuals had no history of ankle sprain or sensation of giving way. Other exclusion criteria for both groups were fracture or surgery of lower limb, uncorrected visual impairment, neurological dysfunction, vestibular or respiratory disorder and using any mediation that influences their balance. All participants signed an informed consent, approved by Ethics Committee of University of Social Welfare and Rehabilitation Sciences.

In this study Arizona Ankle orthosis (PRO Orthopedic Devices Inc., Tucson) and Active Ankle Brace (Active Ankle System Inc., Louisville, KY) were used as soft and semirigid orthosis, respectively. The soft orthosis is a low profile brace with two figure of eight lift straps supporting ankle medially and laterally. To improve comfort and eliminate irritation a cushioned neoprene tongue is added to anterior part of brace. This brace locks and consequently stabilizes the ankle. The semirigid orthosis contains two polypropylene shells that support medial and lateral border of the ankle. These shells hinge with a solid U-shaped plastic stirrup bilaterally. Its design provides superior protection by relieving pressure from the ankle joint. The inner surfaces of shells are padded to improve comfort. The shells are secured around ankle with two straps.

In the current study, the SEBT was used as a measure to quantify dynamic postural control. The SEBT is a lower extremity functional test that assesses the ability to reach one leg as far as possible in one of 8 prescribed directions while maintaining equilibrium on the opposite (stance) leg. The reach directions form a grid placed on the floor, with 8 radials projecting from the center into the periphery. The radials are equally spaced 45° from each other. The maximum reach distance represents the SEBT performance. Previous studies have concluded that the SEBT has enough sensitivity to detect balance deficits associated with musculoskeletal injuries like ankle instability.[14–16] Also investigations report high test–retest reliability of SEBT with intraclass correlation coefficients ranging from 0.84 to 0.92.[10–12]

Participants were assessed in 3 orthotics conditions; no orthosis, soft orthosis and semirigid orthosis. To make participants comfortable with standing while wearing the orthosis, individuals first practiced walking with each orthosis for duration of 5 min before testing. Subsequently, participants were prepared for practicing SEBT by performing 5 trials of reaching in each direction. Participants were tested barefoot with no footwear in all experimental conditions.

At the beginning of each test condition, individuals were asked to place their target foot at the center of grid, while with the most distal part of their free foot lightly touch the furthest point along the Medial (M), Anteromedial (AM) and Posteromedial (PM) directions. Hertel et al. suggest that these directions are most affected among different reach directions in patients with chronic ankle instability.[20] After each touch the participants returned to the start position and stood bipedal. The same investigator measured reach distance from center of the grid to the touch point in cm with a tape measure. According to the results of a previous study, external ankle supports had no significant effect on control of posture in the non-injured leg.[8] Hence, measurements were performed only for the injured leg of the FAI group and the matched leg of healthy group. Corresponding dominant/non-dominant leg of the healthy group was used for the matched leg. The maximum reach distance normalized to leg length was considered as the response variable. The distance between anterior superior iliac spine and distal margin of the medial malleolus was considered as the leg length.

In all directions, 3 successful trials were recorded. Trials were repeated if individuals could not maintain their balance or changed the initial position of the stance leg during the trial. Participants rested 30 s between trials and 2 min between orthotics conditions to minimize fatigue effect. To control order effects, the sequence of orthotics conditions and reach directions were randomized for each individual. None of the participants had previous experience of orthotics wear. The whole session lasted approximately 50 min and each participant completed a total of 27 attempts of SEBT.

Independent *t*-test was used to compare demographic variables between the two groups. The alpha level was set at 0.05 for all analyses. The data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

The mean of three trials of normalized reach distance for each direction was used for statistical analysis. To determine the main effects and interactions of group (with two levels: FAI and healthy) and orthotics condition (with three levels: no orthosis, soft orthosis and semirigid orthosis), a 2×3 mixed model analysis of variance (ANOVA) was used for each direction. Bonferroni adjustment method was used to assess multiple comparisons.

3. Results

Comparison of demographic factors between the 2 groups showed no statistically significant difference for age ($p = 0.59$), height ($p = 0.61$) and weight ($p = 0.65$).

Mean and SD values of normalized reach distance in M, AM and PM directions for both healthy and FAI groups are displayed in Table 1. Significant group-by-orthosis interaction was found for all reach directions ($p < 0.01$) (Table 2). Post hoc analysis revealed no differences between orthotics conditions in healthy group for all reach directions. However, statistically significant differences were found between orthotics conditions in the FAI group. Pairwise comparisons in FAI group for AM and M directions showed that