Pharmacophore

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

Pharmacophore
an International Journal
ISSN 2229-5402

IMMEDIATE EFFECTS OF SEMI-RIGID FOOT INSOLES ON POSTURAL STABILITY IN INDIVIDUALS WITH FLAT FOOT

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ARTICLE INFO

Received:
03th Jun 2017
Accepted:
29th Nov 2017
Available online:
14th Dec 2017

Keywords: *Flat foot, postural stability, insole, cognition, dual-task*

ABSTRACT

One of the standard treatment protocol for Flat foot is the use of therapeutic insoles. Far too little attention has been paid on the effect of insoles on postural stability. Therefore, the aim of this study is to examine postural stability regarding pre and post use of therapeutic insole in individuals with flat foot deformity. Twenty subjects (5 men, 15 women) with flexible flat foot deformity and 20 matched control participated in this study. Center of pressure (COP) data was assessed under 2 measurement conditions with and without insoles. Mean velocity and standard deviation of amplitude and velocity of the center of pressure sway. The results of this study showed that flat foot subjects had greater postural sway compared with control group. Center of pressure parameters in flat foot subjects were significantly different when they wear an insole and this effect was more obvious in the eyes closed conditions. The effect of cognition loading was not significantly different between the 2 groups. The results of this study showed greater postural sway in flat foot subjects. Use of insoles improved postural stability especially in closed eye conditions. Therefore, the use of insoles may be a beneficial modality to improve stability in these patients, particularly in conditions that sensory information is limited.
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To Cite This Article: Sara Habibian, Maryam Saadat, Reza Salehi, Mohammad Mehravar, Payam Ahmadi, Seifolah Jahantabinejad, (2017), "immediate effects of semi-rigid foot insoles on postural stability in individuals with flat foot" ***Pharmacophore, 8(6S),*** *e-1173602.*

Introduction

Flat foot (FF) is one of the most common lower limb conditions that might be characterized partially or totally collapse in the medial arch height and valgus deformity of the heel, increased tibial internal rotation and forefoot abduction [1-3]. The presence of flat foot may be associated with pain under stress, fatigue of controlling muscles, tenderness of the plantar fascia, and achilles tendonitis [4, 5]. It also causes passive instability of the medial side foot structure and hypermobility of foot joints [6]. This instability during weight bearing leads to impairment in postural control [7]. Change in the height of the foot arch was reported to induce alter center of pressure (COP) progression during walking and postural actions for control of postural stability in standing and walking [8]. Postural control is defined as an individual's ability to maintain the center of gravity in the base of support, and it is necessary for performing motor tasks in daily activities. Some studies have reported that the postural stability of subjects with flat foot is different from the normal subjects [9].
One of the standard conservative treatment for symptomatic FF deformity is insoles orthotic therapy or exercise therapy [10]. It assumed that insoles supports the medial arch, improve shock absorption, enhancement of sensory feedback, and stabilizes foot joints [11, 12]. A number of pervious research investigated the use of foot insoles for postural stability in different individuals [13-15]. Cuskiewicz et al. reported the benefits of orthotics for pain and postural sway in subjects with ankle sprain [16]. Also, several studies indicated effectiveness of application of insoles in the treatment of postural instability in older adults. Hamlyn at el. investigated the effect of orthotics on postural stability of patients with chronic ankle instability and found that orthotics improved their postural stability [12]. However, far too little attention has been paid to postural stability of people with flat foot deformity after the use of therapeutic insoles. Few research in this area has examined the effect of insoles on postural stability in quiet standing [9, 17]. In many daily activities, people often require performing an additional

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cognitive-demanding task while standing or walking (i.e., dual-task performance). Dual-task can lead to deterioration in postural stability or decrement in cognitive task and this is termed as dual-task interference [18]. To the best of our knowledge, no research has examined the effect of insoles on postural stability in more challenging postural tasks such as concurrent execution of cognitive task with postural task (dual-task condition) and when the visual information is limited. We hypothesize that increase in the sensory input and joint congruency due to insoles, especially under visual depression circumstances, can improve postural stability. It is deemed that the use of insoles is likely to have a positive effect on postural stability in more challenging postural tasks.

Therefore, the aim of this paper was firstly, examine the postural stability of the individuals with flat foot deformity regarding pre and post use of therapeutic insoles; second, to determine the effect of cognitive task on postural performance of flat foot subjects and third, to compare the interference of postural difficulty and insole between the healthy and flat foot groups.

Material and Method

Twenty subjects with flexible flat foot deformity (5 men, 15 women), and twenty control subjects with normal foot type participated (5 men, 15 women) in this study. They were matched according to age, body mass index, height, and lower-limb dominance. Participants were included if they aged between 18 and 35 years, rear foot eversion angle greater than 9° measured by goniometry, medial longitudinal arch angle lesser than 134° [6, 19]. Also, they excluded if they had severe ankle injuries in the past 6 weeks before the beginning of the test, history of foot surgery, fracture of lower extremity one year before the testing, leg length discrepancy, history of vestibular, diabetic or neurological disorders, and use of any drug which affected on the central nervous system [2, 3, 5 – 7, 9, 10, 12]. All participants signed written informed consent before the test. This research was approved by the Ethics Committee of Ahvaz Jundishapur of Medical Science.

All postural stability data were collected by using a strain gauge Bertec 4060-10 force platform and Bertec AM-6701 amplifier (Bertec Corporation, Columbus, OH, USA). For postural stability measurements, the participants were asked to stand on a dominant limb. Dominant limb was defined as the leg to kick the ball from a standing position. They were instructed to stand on the central region of the force platform while hands on the iliac crest, Non-weight bearing limb applied the knee flexed about 30°, and hip flexed about 20°. The postural stability was assessed under 2 measurement conditions; with and without insoles. These conditions were then evaluated in 4 situations: (1) eyes open, no dual-task (2) eyes closed, no dual-task (3) eyes open, dual-task (4) eyes closed, dual-task.

For dual-task conditions, individuals performed the postural and cognitive tasks simultaneously. Silent backward digit span was used as a cognitive task. In this conditions, each participant listened to a list of random numbers by headphone, and then he or she was expected to repeat them in reverse order. Maximum digit span was determined by the Wechsler Adult Intelligence Test. If non-weight bearing limb touched force platform, the test was repeated again. Before testing, the examiner first fitted insoles (composite insole, Ethyl Vinyl Acetate with Poron layer) for each participant and then he/she was expected to perform each test three trials and keep a stable position for thirty seconds. Three minutes rest period was provided between the trials to avoid fatigue.

To examine postural performance, Anterior/posterior (AP), medial/lateral (ML) amplitude, mean velocity, standard deviation (SD) of velocity in AP and ML directions of the COP that extracted from force platform were calculated. The rationale for choosing of these parameters was based on their reported acceptable reliability in previous studies and assessment of different aspect of the postural performance [20-22]. Also, displacement in the AP and ML directions has been used in effect of insole on postural control studies so, we reported these parameters for expanding of comparability of our study.

Statistical analysis

All data were analyzed using SPSS software version 21. Normal distribution of all variables was confirmed by Shapiro-Wilk test. Average of dependent variables of three trials of each condition was used for statistical analysis. Two groups (flat foot, healthy) × 2 postural difficulty (eye open, eye closed) × 2 cognitive difficulty (single task, dual task) × 2 condition (insole, no insole) mixed model analysis of variance (ANOVA) was performed for the postural sway data. A level of *P* equal to or less than 0.05 was considered to be statistically significant. For multiple comparison, the Fisher's least significant difference (LSD) method was used.

Results

Demographic characteristics for the all participants are demonstrated in Table 1._None of the baseline variables were significantly different in the two groups ($P > 0.05$). The mean and standard deviation of postural stability measures are demonstrated in Table 2. A summary of ANOVA results of the postural performance is also shown in Table 3. The results of this study showed that individuals with flat foot had greater postural sway compared to those in the control group. All the center-of-pressure measurements except the standard deviation of velocity in the ML direction in flat foot patients were significantly different when they wear insoles. This effect was more obvious in the eyes closed because the interaction between groups by postural difficulty by insole was significant, indicating that the effects of closed eyes on the postural sway measures was larger for FF participants compared to the participants in the control group. Both groups when performing dual-task had decrement in the postural sway measures.

Discussion

The results of this study showed greater postural sway in the flat foot individuals than those with neutral foot. This finding can be explained by the increased mobility of the subtalar and the midtarsal joints in the flat foot group that causes loss of a stable base of support [7]. This finding is in agreement with Tsai et al. [6], Tahmasebi et al. [9], Ali et al. [19] that reported that flat foot subjects had different postural stability from individuals with a neutral foot.

In contrast to the findings of this study, Hertel et al. did not find any postural sway difference between subject with flat foot and those in the control group [23]. This may be due to the short time data collection (10 seconds) in their study. Also, Cote et al. reported that postural stability is not different between pronated foot and those with a neutral foot [24]. A possible explanation for this finding, is the assessment of postural control in that study was in quiet stance that needed low demand. Thus it could not to detect differences in postural stability of two groups.

In addition, this study indicated that the postural sway measures except the standard deviation velocity in the ML direction decreased significantly during standing by insole. Improvement of postural stability when flat foot subjects wear insoles can be related to several factors such as realigning foot joints, increase somatosensory feedback, supporting foot arcs and controlling excessive motion that can provide a more stable base of support [9, 25]. This result is agreement with Nazari et al.[17] and Tahmasebi et al.[9] that found using insoles is effective in improving balance in flexible flatfoot subjects.

An interesting result of this research was that postural stability improved, especially when visual information was limited. It is, therefore, likely that insoles increase somatosensory inputs from foot in FF patients in circumstances with visual depression, hence, it could be hypothesized that the use of orthotics is a useful modality in closed eye condition for FF subjects or those with weak eyesight.

In dual-task condition, both FF and control groups had less postural sway. It means that the effects of a concurrent cognitive task on postural stability were similar between the groups. We suggest that further studies be done under more challenging dynamic postural conditions for discriminating the dual-tasking effects. A limitation of the present study is the assessment of effect of long-term of insole that in future research should be considered.

Conclusion

The results of this study showed that the flat foot individuals had more postural sway than the normal subjects. Use of insoles improved postural stability, especially under limited visual information. Therefore, use of insoles in addition to reducing pain and correcting alignment, may be a beneficial modality to improve stability in these patients, particularly in conditions that sensory information is limited and subjects with weak eyesight. Therefore it is recommended to prescribe insoles for them.

Acknowledgements

This study is part of MSc thesis of Mrs. Habibian (grant no: pht-9310). Special thanks to Ahvaz Jundishapur University of Medical Sciences for the financial support.

Competing interests

The authors declare that they have no competing interests.

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Table 1: Demographic characteristics of flat foot and healthy control subjects.

Demographic data	**Flat foot group (N= 20) Mean (SD)**	**Control group (N= 20) Mean (SD)**	**P-value**
Age (year)	24.9 (9.3)	25.4 (3.7)	0.64
Height (m)	164.1 (8.4)	161.8 (9.57)	0.96
Weight (kg)	60.8 (8.2)	61.2 (8.8)	0.56
Body mass index (kg / m^2)	22.74 (3.74)	25.43 (3.70)	0.80

Table 2: The mean values of stability parameters of healthy control group and Flat footed individuals standing with and without insole.

Parameter	**Control group**		**Flat foot group**			
			without insole		with insole	
	single task	Dual-task	single task	Dual-task	single task	Dual-task
Eye open						
Mean velocity (m/s)	0.0002	0.0002	0.0003	0.0002	0.0003	0.0002
SD Velocity (AP)	0.04	0.03	0.05	0.04	0.04	0.03
SD Velocity (ML)	0.04	0.03	0.04	0.04	0.04	0.04
SD Amplitude (AP)	0.005	0.004	0.006	0.005	0.006	0.005
SD Amplitude (ML)	0.004	0.003	0.005	0.005	0.005	0.005
Eye close						
Mean velocity (m/s)	0.0004	0.0004	0.0007	0.0006	0.0005	0.0005
SD Velocity (AP)	0.08	0.07	0.17	0.14	0.09	0.08
SD Velocity (ML)	0.07	0.06	0.1	0.09	0.08	0.08
SD Amplitude (AP)	0.008	0.007	0.01	0.01	0.009	0.008
SD Amplitude (ML)	0.008	0.006	0.01	0.01	0.008	0.008

Table 3*:* Summary of Analysis of Variance for Outcome Measures of Postural Performance: F Ratios and *P* Values.

Independent variable	SD Amplitude (AP)		SD Amplitude (ML)		Mean velocity		SD velocity (AP)		SD velocity (ML)	
	F-Ratio	P-Value	F-Ratio	P-Value	F-Ratio	P-Value	F-Ratio	P-Value	F-Ratio	P-Value
Main effect										
Group	7.46	**0.01**	7.79	**< 0.01**	5.9	**0.02**	4.47	**0.03**	6.57	**0.01**
Insole	6.31	**0.01**	12.19	**< 0.01**	8.84	**< 0.01**	20.44	**< 0.01**	2.33	0.13
Postural difficulty	96.28	**< 0.01**	45.67	**< 0.01**	103.59	**< 0.01**	58.99	**< 0.01**	144.02	**< 0.01**
Cognitive difficulty	37.11	**< 0.01**	5.19	**0.02**	16.55	**< 0.01**	10.21	**< 0.01**	11.32	**< 0.01**
Interaction										
Group × postural difficulty	7.32	**0.01**	4.96	**0.03**	7.04	**0.01**	5.43	**0.01**	10.27	**< 0.01**
Group × cognitive difficulty	0.31	0.57	0.11	0.73	0.16	0.66	0.29	0.58	0.058	0.29
Insole× postural difficulty	16.77	**< 0.01**	13.86	**< 0.01**	14.19	**< 0.01**	21.81	**< 0.01**	7.94	**< 0.01**

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Insole× cognitive difficulty	1.16	0.28	2.81	0.1	8.54	**0.01**	4.72	**0.03**	0.73	0.3
Postural × cognitive difficulty	1.69	0.2	1.21	0.27	3.69	0.06	1.40	0.24	0.56	0.45
Group × postural × cognitive difficulty	0.22	0.64	0.05	0.81	0.00	0.99	0.03	0.85	0.006	0.93
Insole × postural × cognitive difficulty	1.89	0.17	5.21	**0.02**	4.67	**0.03**	3.88	**0.05**	0.25	0.61

Significant P-values are presented in bold.