

Research Paper: Immediate Effect of Textured Insole on Static Balance in Individuals With Flexible Flatfoot



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ABSTRACT

Introduction: Flatfoot is a common orthopedic disorder in the world. Some investigations have demonstrated flatfoot as the cause of many problems such as balance impairment by affecting the proprioception of the soles. Balance reduction can lead to injuries too. In this regard, textured surfaces can be used for stimulating somatosensory system as well as improving proprioception. Therefore, this study aimed to examine the role of textured insole on somatosensory system stimulation and consequently its effect on the balance improvement in individuals with flatfooted.

Material and Methods: This study is a kind of interventional quasi-experimental research. Twenty male students of Iran University of Medical Sciences (Mean [SD] age 22.1 [1.3] years with bilateral flexible flatfoot) were recruited in this study by convenience sampling method. The study variables were as follows: anteroposterior and mediolateral displacements and total velocity of the center of pressure that were measured using a Kistler force plate instrument. Repeated measures ANOVA test was used to compare the test values.

Results: Textured insole reduced the average of all measured parameters in eyes closed condition. This reduction was significant in both anteroposterior displacement and total velocity parameters ($P < 0.05$). Surprisingly, the common arched medical insole leads to balance reduction when used in shoe.

Conclusion: Data analysis demonstrated that using textured insoles can be effective in balance improvement in individuals with flexible flatfooted. This can be the result of extroception and proprioception improvement. On the other hand, we found that common traditional insoles can disturb balance in this group of patients.

1. Introduction

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alance is the ability to maintain body's center of gravity within the base of support

[1]. Maintaining balance depends on receiving accurate information from visual, vestibular, and somatosensory systems [2-7]. Somatosensory system consists of a series of superficial and deep mechanoreceptors [2]. While

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standing or walking, the data of superficial and deep receptors of the foot combine with each other to improve balance [8]. Recent studies have shown that flatfoot can affect this balance [9-18].

Some studies noted that flatfoot can be considered a factor in reducing balance by disturbing the neuromechanical link of kinetic chain [15]. In a study by Harrison performed on participants with the average age of 18 years, it was found that the flatfoot has a direct relationship with reduced postural stability [12]. In Cobb study, 32 subjects with the mean age of 29 years were examined. The results indicated that subtalar joint pronation was effective in reducing balance in the subjects. This reduction may happen as a result of the foot structure loosening [11]. Akbari et al. reported that this reduced balance in these patients is due to the change in foot orientation that ultimately leads to dysfunction of mechanical receptors [9].

Nowadays, several surgical and conservative methods are used to treat or reduce symptoms of foot disorders. Foot orthoses is widely applied as a non-invasive treatment [19]. Medical insole is an example of such orthoses. Recently, the textured insoles have also been considered in improvement of sensation status of plantar surface [20] or ankle injuries [21]. The use of textured insoles is based on the assumption that it changes the discharge rate of the mechanical receptors [19, 22, 23]. In addition, based on the theory of sensory reweighting, enhancement of sending data via mechanoreceptors may somewhat offset the inadequacy of other sources of balance [21, 24, 25]. Aruin and colleagues found that textured insoles could be used to improve the symmetry of gait in healthy young subjects [26]. Another study by Palluel, performed on 19 elderly people and 19 healthy young people, assumed that spike insole had the ability to stimulate the proprioceptors. The results of his study indicated that the use of these insoles would be useful in improving balance parameters, especially in younger people [27]. Waddington found that putting textured in-

sole inside shoes could enhance perception of the ankle position in athletes and improve balance [28].

However, proper research is not available about the effect of orthoses on somatosensory system and their role in improving the balance of people with flexible flatfoot. Therefore, this study aimed to determine whether textured insole was a convenient and efficient intervention for improving balance ability in this people.

2. Materials and Methods

This is a quasi-experimental study with intervention. A total of 20 males with a mean (SD) age of 22.1(1.3) years and the average height of 178(9.6) cm with bilateral flexible flatfoot were recruited in this study using simple non-random sampling. Demographic characteristics of participants are presented in Table 1. The participants who had flatfoot were enrolled in the study based on the foot posture index. Validity and reliability of this index has already been approved [29]. Based on this criteria that evaluates foot on all three planes with scoring range from -12 to +12, subjects who scored $\geq +6$ were initially entered into the study. This scoring system consists of six items that each of them can be scored from -2 to +2. Finally, sum of these items will be the total score. Then each participant was asked to stand on his toes. Forming the arch at the plantar surface was an indicator of flexible flatfoot. Exclusion criteria were as follows: history of any orthopedic or neurological injury, history of damage to the vestibular system or brain, visual impairment, using drugs affecting the balance, use of orthosis within 6 months before the test, doing professional sports, inability to perform the tests due to any physical problems and unwillingness to cooperate until the end of the test for any reason.

After completing the consent form by participants, insoles and proper footwear for each of them were prepared. This research was approved by the Ethics Committee of Iran University of Medical Sciences. Two types of in-

Table 1. Demographic characteristics of the participants

	Mean \pm SD	Range
Age (y)	22.1 \pm 1.3	20–26
Weight (kg)	72.7 \pm 8.5	59–94
Height (cm)	178.0 \pm 9.6	171–190
Body mass index score (kg/m ²)	22.6 \pm 2.1	18–29
Foot posture index score	8.5 \pm 1.4	6–10

soles used in this study were common insoles available in the market and the technical orthopedic dep. of the Iran University of Medical Sciences (these insoles is made of Ethylene-Vinyl Acetate [EVA] and consists of a medial-longitudinal arch support and a heel cup), and textured insole (these insoles were prepared in the aforementioned department, based on the foot size of the participants). Specifications of textured insoles were as follows: overall thickness of the insole was 5 mm; small nubs with the diameter of 5 mm, nubs height as 3 mm and the distance between nubs was 4 mm. In addition, the density of EVA insole was 320 mg/cm³ and its shore was 45 (Figure 1).

A Kistler force plate with dimensions of 50×60 cm was used in this study. Device filtering frequency for passing the data was set on 10 Hz and sampling frequency was set on 100 Hz. The study was performed in the aforesaid department. All participants were asked to use shoes and insoles and walk for 5 minutes. Then they were asked to stand with eyes closed on the force plate. It results in elimination of the visual impact to obtain more refined effect from mechanoreceptors stimulation. The distance between ankles while standing, was determined as two third of the distance between subject's anterior superior iliac spines. External rotation of lower extremity depends on the comfort level of the participant [30]. Required time for each test was 30 seconds [15]. Performing tests included standing on the force plate 1) with shoes alone, 2) with shoes and common insole, and 3) shoes and textured insole. Each trial was repeated 3 times. Data were analyzed using Excel (2013) and SPSS (version 21) software.

As the normal distribution of data was confirmed by Shapiro-Wilk test, the parametric repeated measures ANOVA was conducted. Then, the least significant difference (LSD) was used to determine the difference between tests. The P value less than 0.05 was considered statistically significant. The average value of the measured indices and the results of post hoc test are present-



Figure 1. Textured insole (right) and common insole (left) used in this study

ed in Tables 2 and 3, respectively. To calculate the force plate data, the following formulae were used:

$$\text{First: Displacement}_{(\text{anteroposterior})} = \sum_{i=1}^{(n-1)} \sqrt{(X_i - X_{i-1})^2}$$

$$\text{Second: Displacement}_{(\text{mediolateral})} = \sum_{i=1}^{(n-1)} \sqrt{(Y_i - Y_{i-1})^2}$$

$$\text{Third: Velocity}_{(\text{total})} = \frac{\sqrt{(\sum_{i=1}^{(n-1)} \sqrt{(X_i - X_{i-1})^2})^2 + (\sum_{i=1}^{(n-1)} \sqrt{(Y_i - Y_{i-1})^2})^2}}{t}$$

X: anteroposterior displacement of CoP; *Y*: mediolateral displacement of CoP; and *T*: time of standing on the force plate.

3. Results

The anteroposterior (AP) displacement of the center of pressure (CoP) showed a significant difference between the common insole and textured insole (Sig.=0.017, P<0.05). Mediolateral (ML) displacement of the CoP for textured insole was lower than other intervention but the difference was not statistically significant (P>0.05). The total velocity also indicated a significant difference between common insole and textured insole (Sig.=0.01, P<0.05) as well as the common insole versus shoes alone (Sig.=0.024, P<0.05) (Figure 2). Although differences in balance indices value among aforementioned states were considerable, the difference between the textured insole and shoes was not statistically significant. The results are presented in Tables 2 and 3.

4. Discussion

According to the previous studies, flatfoot affects static stability. Unfortunately, there is no research on the impact of foot orthoses on the somatosensory system performance in people with flexible flatfoot. Therefore, this study aimed to evaluate whether the stimulation of mechanoreceptors of plantar surface would have a significant impact on patients' balance. The results of this study showed that use of textured insole can be effective in increasing the stability of individuals with flexible flatfoot. Moreover, the results indicated that the embedding common arch support in the shoes decreases the stability of participants. This might demonstrate some facts. First, it is possible that the damaging effects of the change in foot's natural orientation, and subsequently unbalanced and abnormal weight distribution in plantar surface results in exerting inappropriate pressure and tensions to soft tissue. As a result, the optimal performance of the somatosensory system in this area is likely to be affected. These changes may undermine perception of nerve signals transmitted from the plantar surface

Table 2. Values of balance parameters in different condition

	Textured Insole	Common Insole	Shoe
Anteroposterior displacement (mm)	230.3±841.9	307.2±1064.4	217.6±958.4
Mediolateral displacement (mm)	68.1±470.6	179.8±535.5	137.1±477.9
Total velocity (mm/min)	522.4±1929.1	526.3±2383.0	468.5±2141.8

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Table 3. LSD post hoc results (*means significant difference)

	Tests Comparisons	Means Differences	Significance
Anteroposterior displacement (mm)	Shoe–common insole	-105.98	0.073
	Shoe–textured insole	116.54	0.113
	Textured insole–common insole	222.53	0.017*
Mediolateral displacement (mm)	Shoe–common insole	-56.51	0.072
	Shoe–textured insole	5.26	0.755
	Textured insole–common insole	61.71	0.112
Total velocity (mm/min)	Shoe–common insole	-242.00	0.024*
	Shoe–textured insole	212.07	0.067
	Textured insole–common insole	454.07	0.010*

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to the central nervous system. Second, the stimulation of somatosensory system by textured insoles can reduce this distortions and create better perception about the foot posture on the underside [20].

In this respect, the present study is in line with the results of Steinberg [31] and Palluel [27] studies. These researchers believe that textured insole is effective in better perception of the foot posture in young people. It should also be noted that based on our study, the restora-

tion of natural foot orientation does not necessarily improve balance. Because according to our findings, using conventional arch support impairs the balance. This poor balance may result from the change in foot posture that a person got used to it over the years. These findings are inconsistent with the results of Satvati [16] and Takada [17] studies. Finally, this study was about the immediate effect of aforementioned insoles. The long-term use of such insoles might lead to different results. Hence, this could provide the basis for future research. These insoles

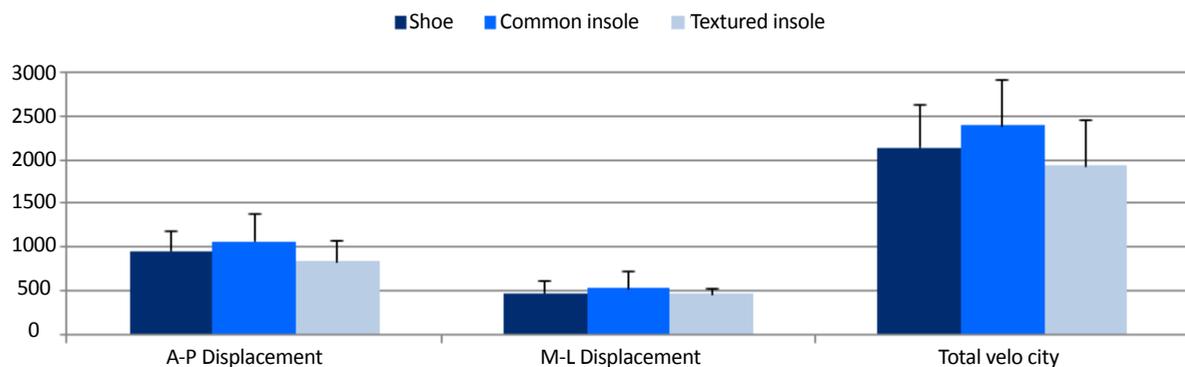


Figure 2. Comparing the tests between conditions

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can also be tested in people with weak eyesight and even blind people who rely more on other sources of balance.

In conclusion, the results of this study suggest that textured insole has the ability to significantly increase the balance. Thus, as a low-cost, accessible and non-invasive intervention, use of such insoles is recommended to people with flexible flatfoot.

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Conflict of Interest

The authors declared no conflicts of interest.

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