

The Effect of Two Types of Silicone Insole on Selected Kinetic Variables on the Skill landing-Jumping-Landing Active Young Women with Flat foot

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Submitted: 2018-03-19; Accepted: 2018-06-22

Abstract

Introduction: Since the use of medical insole is recommended as one of the strategies to deal with the potential for joint injuries, Flatfoot is one of the most common abnormalities in body structure that Due to the decrease in the height of the medial longitudinal arch of the foot and its functional defect, the increases risk of joint damage due to changes in the transfer of ground reaction forces. One of the treatment options that is suggested is the use of a medical insole. The purpose of this study was to investigate the effect of two different forms of silicone insoles on the peak of the ground reaction force, loading rate and time to stability in the landing-jumping-landing skill of active young women with flat foot. **Materials and methods:** 28 women with a history of regular activity exercise were divided into two groups of 14 (flat foot and normal foot). The subjects landed two legs on a level with a height of 0.5 m on the forwards of the first force plate, jumped without stopping and landed on second force plate. In this study, two types of silicone insoles were used that support the entire sole of the foot (type I), and only the inner portion of the foot and the medial longitudinal arch (Type II). The flat foot subjects performed without using the insole and using two types of insoles. The Data Analysis of data Evaluation of Variables were done by MATLAB software. Also its statistical analysis was done by using spss ($P \leq 0.05$). **Results:** The results of statistical analysis of variance analysis showed a significant difference in the amount of ground reaction forces in all three axes between normal and flat foot subjects, while the use of medical insoles only in outer medial- lateral & anterior- posterior directions has been significant. The rate of loading at the first landing showed a significant difference between the subjects with flat foot and normal foot. But there was no significant effect after using the medical insole. However, there was no significant difference between the time to stability in the two groups of flat foot and normal foot. **Conclusion:** According to the results of the study, it can be said that flat foot abnormality in high intensity plometric skill has effect on the ground reaction forces in all three directions, and the use of a Type I insole can reduce the amount of force in all three directions. On the other hand, the decrease in the height of the longitudinal arch of the foot is associated with the rate of loading during the landing, which is identified as a risk factor for joint and muscular damage. But the use of silicone insoles cannot effect on the rate of loading. The results of this study indicate that the time to stability in active subject does not correlate with the height of the medial longitudinal arch, or the time to stability is corrected in the active subjects with flat feet with the help of compensatory mechanisms.

Keywords: Flat Foot, Kinetic, Insole

Please cite this paper as: Naghi Nezhad F, Sadegi H, Tabatabaei Ghomshe F, Barati A, Khaleghi M. The Effect of Two Types of Silicone Insole on Selected Kinetic Variables on the Skill landing-Jumping-Landing Active Young Women with Flat foot. J Clin Physio Res. 2018; 3(2): 82-88.

Introduction

Sole is the first organ which gets into contact with the ground, which is responsible for transferring the ground reaction forces to the upper organs with the help of medial-longitudinal arc

structure. Investigating these reaction forces provides researchers with suitable information about the movement and pressures exerted to the organs during movement (1). Any functional defect in the medial longitudinal arc structure can affect the functional duty of force transference (1), though these

effects are unknown. Among the abnormalities of sole, flatfoot is very common, such that it affects 74% of the population, whose prevalence is age-dependent. In this disorder, the height of the medial longitudinal arc declines, and the medial part of the feet is in contact with the ground (2). Irrespective of the reasons of incidence of flatfoot and considering the functional task of sole arcs, it is conceived that this disorder results in impaired transference of the ground reaction forces, causing incidence of joint problems and pain (3). Howard *et al.* considered the abnormalities of the medial longitudinal arc structure of the sole as a potential factor of sport injuries (4). Clodiadus *et al.* also observed a significant correlation between the pains in the back region plus lordosis and diminished height of the medial longitudinal arc (5). Higidus *et al.* stated that possibly following the diminished height of the medial longitudinal arch, pain and movement disorders develop which may be correlated with each other. However, one cannot predict pain or movement disorder after incidence of the diminished height of medial longitudinal arch (6). Since the flatfoot emerges across different age groups and for different reasons, use of medical insoles, performing corrective exercises, and surgical operation are the methods proposed for resolving the disorder or mitigating the effects resulting from it (7-8). Moli *et al.* stated that surgical treatments are unnecessary for flatfoot (9). If a person has flatfoot and complains about pain, the cause of pain should be sought after apart from this abnormality (9). Meanwhile, use of medical insoles is one of the simplest and most available therapeutic ways for flatfoot, which are offered with different forms and materials, though the effect of its usage is still unknown (10-11).

Among sports skills, jumping-landing is considered as one of the most practical techniques, whose most correct implementation can contribute to the superiority of the person in sports activities. However, if it is done incorrectly or not optimally, not only it is not effective, but also it is damaging, where evidence has shown that most pains in the back region, instability during walking, and deformity of the ankle and knee joints are associated with it (12-14). Cilic *et al.* indicated that diminished height of the medial longitudinal arc affects the height of vertical jumping, causing reduction of height (15). On the other hand, some researchers have concluded that flatfoot cannot be a reason of poor physical preparation and sports activities of athletes (16). Shojaedin *et al.* observed no significant change in kinetic factors of landing and jumping among different types of feet with low, high, and normal navicular height. They claimed that other reasons apart from the feet structure determine genetic variables of jumping and landing

skill (16). Nevertheless, in the research by Arioalomora malo *et al.* in 2016 on 108 children with different medial longitudinal arc structures, they found no negative effect on movement skill to be attributed to diminished medial longitudinal arc. They investigated nine skill tests including different types of walking, jumping, as well as single-leg and double-leg balance. They claimed that the subjects with abnormal feet structure showed better performance when doing the tests (17). Nakhaei *et al.* (2008) claimed that the complexity of the anatomical structure of the feet and in turn the feet ability for incidence of rapid compensatory mechanisms of the feet for relating to new situations is a reason for justifying the lack of difference in mechanical variables among people with normal and flatfoot (18). Williams *et al.* claimed that the changes in the medial longitudinal arc height of the feet bring about different mechanics of the lower limbs, which is considered as a risk factor for injury (2).

Furthermore, the results obtained from studies on the effect of flatfoot on movement function are contradictory. Accordingly, the present study was conducted with the aim of investigating the effect of two different types of silicon medical insole on the maximum ground reaction forces, loading rate and the time of achieving stability in jumping-landing-jumping skill of active young women suffering from flatfoot.

Materials and Methods

Fourteen active young women with flatfoot anatomical structure (whose mean and standard deviation of their age was 24.75 ± 1.5 years old, height was 160.85 ± 6.18 cm, and weight was 51.82 ± 3.2 kg) along with 14 active young women with a normal sole anatomical structure (mean and standard deviation of age: 25.33 ± 2.71 years old, height: 161.13 ± 1.76 cm, and weight: 53.23 ± 4.76 kg). After assessing flatfoot, they participated in this research voluntarily. The inclusion criteria for the subjects included an age range of 20-30 years old, being willing to participate in the research, not having acute and progressive neuromuscular, orthopedic, neurological, rheumatological, psychological diseases, diabetes, fracture of limbs, cardiovascular diseases, and structural defects preventing from doing vertical jumping and landing skill, history of sports activity for more than six months, such that they had at least three regular sessions of exercise per week. Furthermore, if one of the characteristics mentioned in the approval criteria section was not met or if the subject did not wish to continue cooperation in the research, they were excluded from the study. After assessing flatfoot by pedoscope (19), the subjects were

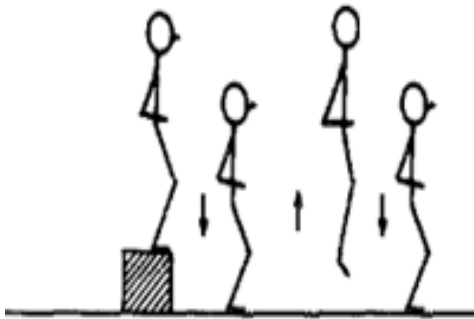


Figure 1. Landing- Jumping- Landing



Figure 2. Insole Type II



Figure 3. Insole Type I



Figure 4. Shoes used in research

chosen from the students of Khayam University, Mashhad, and from the eligible individuals, those who were willing to participate in the research were employed as subject. The present research was implemented after one educational and briefing session and after receiving consent form in the biomechanics laboratory at Mashhad Azad University. Since the analyzed skill has been a plyometric skill, all subjects were chosen from people who had done enough exercise with a regular and advanced exercise program, who lacked any disease or limitation preventing implementation of the skill. The dominant limb of all subjects was the right side, and in order to remove the effect of limb dominance and for similarity of analysis for all subjects, all assessments and analyses of movement were done on the right side. The kinetic information was collected by two KISTLER force plates (Kistler 9260AA6, Switzerland) with a frequency of 1200 Hz (20). The subjects performed a double leg landing from one 50-cm step (21) on the first force plate. Then they jumped upwards and eventually landed on the second force plate (Figure 1).

The time range between the first landing until the second landing has been analyzed. The subjects with normal sole repeated this movement pattern three times, and between every two repetitions, they had 5-10 min for rest. During the rest, they walked several times on the laboratory walkway without any shoes and insole so that the effect of confounding variables as well as insoles on each other would be eliminated. The subjects with flatfoot performed the movement pattern without using medical insole with and with the help of two types of common medical insole in medical supply both of which were made of silicon. The silicon insoles belong to soft insole groups. The first silicon insole covered the entire sole (Figure 2), while the second silicon insole covered only part of the medial section of the sole, which is the site where the medial longitudinal arch declines (Figure 3). All subjects used the same model of standard sport shoes to remove the effects resulting from the material of shoes for sliced marker localization (Figure 4). The size of the variables of ground reaction forces, loading rate, and the time for achieving stability were obtained from the force plate data and through programming in MATLAB software. The noise of the force plate data was filtered using low-pass Butterworth filter with cutting frequency of 50 Hz, which were then normalized using the weight of the subjects. The descriptive statistics of mean and standard deviation were used to describe the demographic information of the subjects, while inferential statistics of repeated measures analysis of variance was utilized to investigate the differences between the two groups at the significance level of 0.05 using SPSS 24 software.

Table 1. The results of the statistical analysis of the ground reaction forces across three directions (unit: N/Kg)

	Ground reaction forces					
	Vertical (GRF/z)		Anteroposterior (GRF/x)		Mediolateral (GRF/y)	
	Mean (SD)	Sig	Mean (SD)	Sig	Mean (SD)	Sig
Normal sole	64.363 (10.553)		10.09 (2.27)		1.961 (0.725)	
Flatfoot	81.66 (13.435)	0.00*	33.008 (15.44)	0.00*	22.065 (21.43)	0.00*
Flatfoot using the insole Type I	75.971 (18.056)	0.04*	28.06 (17.66)	0.00*	18.429 (21.86)	0.00*
Flatfoot using the insole Type II	81.953 (21.705)	0.936	35.82 (21.96)	0.564	28.686 (23.11)	0.00*
*P-value≤0.05						

Table 2. The results of statistical analysis of loading rate and the time for achieving stability

	Loading rate in the first landing (kN/s)		Loading rate in the second landing (kN/s)		Time of achieving stability (second)	
	Mean (SD)	Sig	Mean (SD)	Sig	Mean (SD)	Sig
Normal sole	67.245 (24.637)		84.815 (2.488)		0.668 (0.172)	
Flatfoot	174.581 (60.006)	0.00*	74.049 (24.765)	0.261	0.795 (0.335)	0.141
Flatfoot using the insole Type I	162.733 (107.688)	0.654	77.428 (25.647)	0.761	0.766 (0.409)	0.851
Flatfoot using the insole Type II	211.872 (24.144)	0.283	90.095 (24.212)	0.272	1.03 (0.569)	0.06
*P-value≤0.05						

Results

The results of the statistical tests for the ground reaction forces, which can be observed in Table 1, indicate a significant difference in the mean value of ground reaction forces across all of the three directions of vertical, anteroposterior and mediolateral in active individuals with normal and flatfoot. The value of ground reaction forces was higher in those with flatfoot as compared with normal sole. After using the medical insoles, although the level of the ground reaction vertical force declines, this reduction of force was not statistically significant, which can come from the fact that the type of medical insole to absorb vertical shock is useless. On the other hand, considering the ground anteroposterior force, after using the medical insole Type I, the mean force exerted diminished significantly, but for the second type of medical insole, it did not reduce the force, and even increased the mean force exerted to the body to some extent. These changes also apply to the mediolateral reaction force. In other words, use of the medical sole Type I which supports the entire sole has caused diminished ground reaction forces.

Table 2 provides the mean loading rate on the first force plate and the time for achieving stability on the second force plate in normal sole and flatfoot individuals when using and not using the two types of insole. The results suggest that the loading rate on the first force plate, which is a result of landing from a 50-cm platform has a significant difference between normal and

flatfoot individuals. However, this rate of loading has been different significantly only using the medical insole Type I. Considering the second loading rate, which has been calculated after jumping on the second force plate, no significant difference was observed between normal sole and flatfoot.

The average time of achieving stability on the second force plate has not been significantly different between normal sole and flatfoot individuals, or after employing the medical insole either (Table 2).

Discussion

The aim of this research was to investigate the effect of two different types of silicon medical insole on the maximum ground reaction forces, loading rate, and time of achieving stability in landing jumping landing skill among active young women with flatfoot. The present research which has been done on active young women with flatfoot and normal sole indicated that in the landing jumping landing skill, the anatomical structure of the sole arc is an important factor in the extent of shock absorption of the ground reaction forces, which becomes more evident at the second landing which is more intensive. The results of this research have been in line with the findings of Subra *et al.* (22). They (2015) showed that jumping on trampoline at the moment of collision forces the person to bear a force of 5000 N or 500 Kg. If this force is not transferred properly, it will damage the upper

limbs of the person (22). Absence of medial longitudinal arc and its shock absorptivity is a justification for these results. Nevertheless, the results of this research are incongruent with the findings obtained by Shojaedin *et al.* (16). They observed no significant difference among the kinetic factors of jumping and landing between different types of feet with low, high, and normal medial longitudinal arc. They claim that other factors apart from the feet structure can determine the kinetic variables of the jumping and landing movement skill (16). Since the medial longitudinal arc structure is assisted by the four dimensional system of the sole fasciae, intrinsic muscles in the sole, extrinsic muscles of the plantar arc, and plantar ligament, this difference in the results of the research with the findings obtained by Shojaedin can be attributed to different levels of physical preparation and the force of the intrinsic muscles of the sole as well as the extrinsic muscles and its compensatory mechanisms. Aidag *et al.* stated that the muscular power of the feet dorsiflexion is lower among flatfoot individuals when compared with normal people, causing diminished stability after landing skills. Accordingly, achieving optimal parameters of jumping becomes more difficult for flatfoot individuals (31), which is in line with the results of this research. Yivi Chang *et al.* investigated the extent of vertical jumping in individuals with flatfoot. They found that flatfoot deviates the vertical jumping from its mechanical target, and predisposes the person to damage (32). In their research, they compared walking, vertical jumping, and Sprint start as well as static movement (standing when the weight has been equally divided on both feet) on 17 men and 6 women with the mean age of 20.3 years old. The dynamic information of the arc height, bark angle, and arch index across the walking and the two sports skills of vertical jumping and Sprint start indicate that sole arch plays a modifying role in the power of strong muscles of the lower limbs in the two skills of vertical jumping and Sprint start. The range of changes in the arc height in walking and other support activities plays a preventive role in orthopedic injuries. In addition to confirming the importance of the medial longitudinal arc height as an important structure for forced transfer and shock absorption in the sport, Chang *et al.* suggested that the design of suitable sports shoes for runners and other sport fields should be informed by the results of the research findings in the area of sole arc structure, due to the importance of the function of sole arcs (32).

Today, one of the treatments recommended for flatfoot is use of suitable medical insoles, which has a supportive role on ankle, sole, and preserves the natural anatomical shape of the feet and diminish pain (23). The insoles are designed to mitigate the complications resulting from flatfoot (24-25). One of the reasons of use of medical insoles is stated to be absorbing shock (23). In this research, it was shown that medical insole Type I which covers

the entire sole structure can be effective as a shock absorbent for anteroposterior and mediolateral forces. Nevertheless, considering the vertical ground reaction force, it was not effective. Factors are investigated regarding shock absorption by objects including the diameter and extent of stiffness of the object. Since the silicon insole Type I has had no effect on the vertical force of the reaction, it can be inferred that the diameter of the utilized insole as well as its stiffness and softness are not large enough to be effective for absorbing shock. These results have been in line with previous findings stating that the material and stiffness of the insole affect the extent of the ground reaction forces (26-27). The ground reaction force in the mediolateral direction is directly associated with the force transfer function by the medial longitudinal arc structure. Using a medical insole which supports the entire sole and the force transfer path, this force can decrease. On the other hand, the results of this research highlight that the medical insole that lies beneath the sole arc cannot be effective in transferring force, and the feet cannot match it and use it for optimal force transfer. These results confirmed the findings obtained by Young *et al.* (28). They showed that out of two types of medical insole used for 40 children with flatfoot, the children who had used medical insole with Talus bone support indicated better outcome in the extent of supporting the medial longitudinal arc, though the other medical insole was also effective (28). They employed radiography technique for the research. Book *et al.* found that inverse angle in the insole structure can help children with flatfoot to perform walking by minimizing sole pressures. In their research, they used two different angles for the insoles. They considered the combination of its structure and angle as crucial (29). Therefore, it can be concluded that the shape and material of the medical insole are other important factors in loading rate. Loading rate and force absorption are more important than the forces exerted to the body. Indeed, abnormal loading of forces in the lower limbs maximizes the negative effects of diminished medial longitudinal arc (22). For this reason, in this research it has been examined as a separate variable. In a basic skill like walking (21), it has been shown that flatfoot individuals have a faster loading rate of force in the soft-tissue part of sole in walking stance phase, though no significant difference was observed in other phases (3). Research has stated increased loading rate as the pathologic cause of soft and hard tissue of lower limbs (3, 21). Accordingly, sportsmen or sportswomen are constantly seeking after compensatory mechanisms to decrease the loading rate. Meanwhile, one of the assumptions of this research is use of medical insole to decrease the loading rate. The results of this research indicate that the loading rate of the first landing which is more intense has a larger mean in flatfoot individuals compared

to normal sole people. However, in the second landing, which is less intense, no difference is observed. Indeed, the intensity of the skill can play a significant role in the loading rate in flatfoot individuals, though use of medical insole has had absolutely no effect on this variable. Nevertheless, medical insoles with the aim of improving the medial longitudinal arc direction of the feet and placement of the feet in normal anatomical state and in turn improving movement skills are recommended (24-25). Also, some research has shown a considerable effectiveness for usage of different types of medical insole in biomechanical variables of movement skills (33-40). The results of this research suggest that coordinated strategies occur during movement between the ankle and shin, which is not very related to the shoe sole and insole. The time of achieving stability is another influential factor in optimal implementation of movement for athletes. It has been shown that in flatfoot individuals and those with normal sole, this factor does not have any significant difference. This result also highlights that active flatfoot individuals who have a regular sport background benefit from compensatory strategies to compensate for the absence of optimal function of the medial longitudinal arc, where getting support from the shin might be one of these strategies, which is in line with the results of previous studies (21).

Conclusion

In addition to emphasizing the effect of medial longitudinal arc defects on some biomechanical variables of movement, this research has given insights into the structures of insole and standard shoes, so that they would be effective in explosive activities for individuals with medial longitudinal arc functional defects, thereby minimizing the extent of damaging factors of sports skills. These results also underscore that the medical insole should first cover the entire sole and secondly should be made of a material capable of absorbing the shock of ground reaction forces and the force loading rate to some extent.

Acknowledgement

Hereby all professors and scholars who assisted us in performing and writing this paper are highly appreciated

Conflict of interest:

None

Funding support:

None

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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