Does Flexible Flatfoot Require Treatment?

Plantar Pressure Effects of Wearing Over-the-Counter Insoles when Walking on a Level Surface and Up and Down Stairs in Adults with Flexible Flatfoot

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Background: Orthotic insole is a popular physiotherapy for flatfoot. However, the effects and whether flexible flatfoot needs orthotic insole treatment are not clear, and how the plantar pressure changes while walking up and down stairs has not been studied. Therefore, this study observed the plantar pressures of different walking conditions to find the answers.

Methods: Fifteen adults with flexible flatfoot and 15 adults with normal foot were examined while walking on a level surface and while walking up and down 10- and 20-cm stairs before treatment. The maximum force and the arch index were acquired with a force plate system. Participants with flexible flatfoot were instructed to wear the orthotic insoles for 3 months, and plantar pressures were measured again after treatment. The repeated measure was performed to analyze the data.

Results: The maximum force and the arch index of flatfoot after treatment were significantly decreased under different walking conditions ($P < .01$). When walking down 10- and 20-cm stairs, the plantar data of normal foot and flatfoot were significantly increased ($P < .05$).

Conclusions: Orthotic insoles could effectively improve the plantar pressure of flatfoot under different walking conditions. In addition, the arches of normal foot and flatfoot were obviously influenced when walking down stairs. It is, therefore, necessary to wear orthotic insoles for flexible flatfoot to prevent further deformation. (J Am Podiatr Med Assoc 109(4): 299-304, 2019)

Flexible flatfoot is a common lower-limb deformity[1] characterized by a low medial longitudinal arch.[2] Owing to incorrect alignment of the foot bones,[3] it causes calcaneal eversion, talar adduction with plantarflexion, and dorsolateral forefoot subluxation. The deformity will change the plantar pressure distribution and the gait over time,[4] producing a substantial effect on the quality of life of the patient.[5]

Flatfoot can be divided into rigid flatfoot and flexible flatfoot.[6] Regarding the former, the arch of the foot is always missing in either the weightbearing or nonweightbearing position,[7] and surgery is needed to restore the missing arch.[8] Regarding the latter, the arch is missing only in the weightbearing position; in nonweightbearing, the arch is the same as that of a normal foot.[9] Owing to the arch's flexibility, the treatment methods and whether the flexible flatfoot requires treatment have always been controversial.[10,11]

Orthotic insole is a kind of popular physiotherapy. Previous studies have focused only on the effects of wearing orthotic insoles when walking on a level surface.[12,13] However, the effects were mixed, and how the plantar pressure changes while walking up or down stairs has not been studied.

In this study, we examined the plantar pressure of flexible flatfoot before and after wearing orthotic insoles while walking on a level surface and while walking up and down 10- and 20-cm stairs to determine whether plantar pressure improves and

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further to find out whether flexible flatfoot needs orthotic insole treatment.

Materials and Methods

Participants

The study protocol was approved by the institutional review board of The First Affiliated Hospital of Xi'an Jiaotong University (Xi'an, China). All of the participants signed the written informed consent form before study participation.

Fifteen college students with flexible flatfoot and 15 college students with normal foot were subjected to footprint collection with a force plate by two researchers. For participants with flatfoot, the arch was missing in a load-bearing position, the proportion of the midfoot print between the hollow and solid areas was 1/2, or the hollow area was missing. For participants with normal foot, the arch was always present, and the proportion was 2/1. All of the participants were female students, and there was no significant difference between flatfoot and normal foot in participant age, height, weight, and foot length. None of the participants had experienced any lower-limb diseases in the past 6 months.

Procedure

Before the measurement, participants needed to take off their shoes, wear the unified socks, and perform the walking exercises at a speed of 1 step per second. Then the participants were asked to walk on the level force plate and then up or down 10- or 20-cm stairs on the instrument. The maximum force and the arch index of the foot were recorded by the force plate system under those walking conditions. To ensure accuracy, the data were measured three times and an average was obtained. After all of the data were collected, participants with flexible flatfoot were asked to wear the unified shoes with orthotic insoles 8 hours a day for 3 months. After the treatment, the maximum force and the arch index were measured again. Finally, the repeated measure of the general linear model with significance of $P < .05$ was performed using SPSS for Windows, Version 13.0 (SPSS Inc, Chicago, Illinois).

Equipment

A force plate (footscan 7 USB2 gait; RSscan International, Paal, Belgium) with an area of 40 × 50 cm, including four sensors in each square centimeter, was used to measure the dynamic data of maximum force and arch index under different walking conditions. When the participant was walking on the force plate, the foot was divided into ten parts automatically: toe 1, toes 2 through 5, first metatarsal, second metatarsal, third metatarsal, forth metatarsal, fifth metatarsal, midfoot, medial heel, and lateral heel.

In addition, there is a main difference of plantar pressure in the midfoot region between normal foot and flatfoot. For normal foot, the main load-bearing regions include the metatarsal area and the heel area, but for flatfoot it includes not only the metatarsal and heel areas but also the midfoot.[14] In other words, it is the pressure of the midfoot that differs in flatfoot versus normal foot. Therefore, we focused only on the midfoot data.

Orthotic Insoles

In this study, the orthotic insoles were over-the-counter insoles made of ethylene vinyl acetate resin material. The thickness of the foot arch is 2.6 cm, and the thickness of the forefoot and heel is 0.4 cm.

Data Analysis

This study measured two kinds of dynamic data: maximum force and arch index. With progression of the disease, the arch will become flat and the structure of the foot bones will be deformed, which results in increased pressure of the midfoot, further increasing the maximum force[15] and the arch index.[16] Maximum force, is defined as the maximum plantar pressure of one part of the foot.[17] Arch index, a proportion of the midfoot area and the whole foot area, is useful in determining the prevalence of flatfoot and possibly in predicting pathologic foot conditions.[18] We focused on the maximum force of the midfoot and the arch index.

Before data analysis, all of the data were divided into three groups: flatfoot before treatment, flatfoot after treatment, and normal foot. Each group was further divided into five conditions: walking on a level surface, walking up 10- and 20-cm stairs, and walking down 10- and 20-cm stairs.

In the SPSS 13.0 system, we first created six columns (group, level surface, up 10- and 20-cm stairs, and down 10- and 20-cm stairs) and 45 rows (15 rows for each group) and input the corresponding data. Then, the repeated measure of the general linear model with significance of $P < .05$ was performed using SPSS 13.0. The 95% confidence interval (CI) ($P < .05$) were considered statistically

significant. Finally, we used the five walking conditions as within-subject variables and the three groups as between-subject factors to analyze the data.

Results

Significant differences were found in the maximum force and the arch index before and after treatment ($P < .01$), and there was still a significant difference between the posttreatment foot and the normal foot in both measures ($P < .01$) (Tables 1 and 2).

In addition, there was no intersection of the 95% CIs of both measures before and after treatment in five different walking conditions. However, there was an intersection between the posttreatment foot and the normal foot in both measures when walking down 10- and 20-cm stairs (Tables 3 and 4).

Furthermore, the 95% CIs of the maximum force and the arch index for walking down stairs did not intersect with those of any other walking conditions not only in flatfoot but also in normal foot (Tables 3 and 4).

These results imply that although there was still a difference between the posttreatment foot and the normal foot, the plantar pressures of flatfoot were effectively decreased after treatment, especially when walking down stairs. In addition, the arches of both normal foot and flatfoot were obviously deformed when walking down 10- and 20-cm stairs.

Table 1. Maximum Force Before and After Treatment

Group	Group	Mean Difference[a]	Significance[b]	95% CI for Difference
		Left Foot		
Before	Before			
	After	61.032[c]	0.000	42.131 to 79.933
	Normal	98.129[c]	0.000	79.228 to 117.031
After	Before	–61.032[c]	0.000	–79.933 to –42.131
	After			
	Normal	37.097[c]	0.000	18.196 to 55.999
Normal	Before	–98.129[c]	0.000	–117.031 to –79.228
	After	–37.097[c]	0.000	–55.999 to –18.196
	Normal			
		Right Foot		
Before	Before			
	After	71.776[c]	0.000	55.122 to 88.430
	Normal	107.556[c]	0.000	90.902 to 124.210
After	Before	–71.776[c]	0.000	–88.430 to –55.122
	After			
	Normal	35.780	0.000	19.126 to 52.434
Normal	Before	–107.556[c]	0.000	–124.210 to –90.902
	After	–35.780[c]	0.000	–52.434 to –19.126
	Normal			

Abbreviations: After, flatfoot after treatment; Before, flatfoot before treatment; CI, confidence interval; Normal, normal foot.

[a]Based on estimated marginal means.

[b]Adjustment for multiple comparisons: least significant difference (equivalent to no adjustments).

[c]The mean difference is significant at $P < .05$.

Table 2. Arch Index Before and After Treatment

Group	Group	Mean Difference[a]	Significance[b]	95% CI for Difference
		Left Foot		
Before	Before			
	After	3.019[c]	0.000	2.206 to 3.831
	Normal	4.727[c]	0.000	3.914 to 5.539
After	Before	–3.019[c]	0.000	–3.831 to –2.206
	After			
	Normal	1.708[c]	0.000	0.896 to 2.520
Normal	Before	–4.727[c]	0.000	–5.539 to –3.914
	After	–1.708[c]	0.000	–2.520 to –0.896
	Normal			
		Right Foot		
Before	Before			
	After	3.237[c]	0.000	2.789 to 3.686
	Normal	4.852[c]	0.000	4.404 to 5.300
After	Before	–3.237[c]	0.000	–3.686 to –2.789
	After			
	Normal	1.615[c]	0.000	1.166 to 2.063
Normal	Before	–4.852[c]	0.000	–5.300 to –4.404
	After	–1.615[c]	0.000	–2.063 to –1.166
	Normal			

Abbreviations: After, flatfoot after treatment; Before, flatfoot before treatment; CI, confidence interval; Normal, normal foot.

[a]Based on estimated marginal means.

[b]Adjustment for multiple comparisons: least significant difference (equivalent to no adjustments).

[c]The mean difference is significant at $P < .05$.

Discussion

Orthotic Effects of Maximum Force and Arch Index

The results showed that the maximum force and the arch index of flatfoot were effectively decreased after wearing orthotic insoles, which is in accordance with previous studies.[19-22]

Orthotic insoles can support the form of the foot arch,[23,24] which reduces the load-bearing of the midfoot and further decreases the maximum force of the midfoot and the arch index. However, although the plantar pressures of flatfoot were effectively improved, there was still a difference between the posttreatment foot and the normal foot. This may have happened because the treatment duration was not long enough.

Table 3. Maximum Force of Different Walking Conditions

Group	Walking Condition	Mean Difference	SE	95% CI for Difference
		Left Foot		
Before	Level surface	285.240	5.086	274.977 to 295.503
	Up stairs, 10 cm	274.013	5.492	262.930 to 285.097
	Up stairs, 20 cm	268.700	5.636	257.326 to 280.074
	Down stairs, 10 cm	330.013	8.341	313.181 to 346.846
	Down stairs, 20 cm	373.180	11.129	350.721 to 395.639
After	Level surface	232.167	5.086	221.903 to 242.430
	Up stairs, 10 cm	227.673	5.492	216.590 to 238.757
	Up stairs, 20 cm	226.127	5.636	214.753 to 237.501
	Down stairs, 10 cm	259.680	8.341	242.847 to 276.513
	Down stairs, 20 cm	280.340	11.129	257.881 to 302.799
Normal	Level surface	188.653	5.086	178.390 to 198.917
	Up stairs, 10 cm	176.773	5.492	165.690 to 187.857
	Up stairs, 20 cm	178.387	5.636	167.013 to 189.761
	Down stairs, 10 cm	230.780	8.341	213.947 to 247.613
	Down stairs, 20 cm	265.907	11.129	243.448 to 288.366
		Right Foot		
Before	Level surface	291.740	5.050	281.548 to 301.932
	Up stairs, 10 cm	282.827	5.234	272.265 to 293.389
	Up stairs, 20 cm	280.333	5.085	270.072 to 290.594
	Down stairs, 10 cm	337.053	6.769	323.394 to 350.713
	Down stairs, 20 cm	389.713	9.293	370.959 to 408.467
After	Level surface	228.847	5.050	218.655 to 239.038
	Up stairs, 10 cm	227.500	5.234	216.938 to 238.062
	Up stairs, 20 cm	226.933	5.085	216.672 to 237.194
	Down stairs, 10 cm	254.907	6.769	241.247 to 268.566
	Down stairs, 20 cm	284.600	9.293	265.846 to 303.354
Normal	Level surface	187.667	5.050	177.475 to 197.858
	Up stairs, 10 cm	177.933	5.234	167.371 to 188.495
	Up stairs, 20 cm	179.480	5.085	169.219 to 189.741
	Down stairs, 10 cm	232.740	6.769	219.080 to 246.400
	Down stairs, 20 cm	266.067	9.293	247.313 to 284.821

Abbreviations: After, flatfoot after treatment; Before, flatfoot before treatment; CI, confidence interval; Normal, normal foot.

Orthotic Effects on Different Walking Conditions

Previous studies have estimated that orthotic insoles could improve the plantar pressure of flatfoot when walking on a level surface.[19-22] However, it has not been examined how the plantar pressure changes when walking up and down stairs. In this study, the maximum force and the arch index were effectively decreased not only when walking on a level surface but also when walking up and down stairs after treatment. This result indicates that orthotic insoles could improve the plantar pressure of flatfoot,[25] and the function could be explained by that because the insoles have always been maintaining the proper form of the foot and finally reducing the load-bearing of the midfoot.[26]

On the one hand, the largest maximum force and arch index values were in walking down 20-cm stairs, and the second largest were in walking down 10-cm stairs, which may be due to the fact that the plantar pressure is influenced not only by the body weight but also by the acceleration of gravity when a person walks down stairs.[27] Therefore, with the increase in gravity, the plantar pressure increases as well.

On the other hand, according to this study, the maximum force and the arch index of both normal foot and flexible flatfoot were obviously larger when walking down stairs, illustrating that the arches of both normal foot and flatfoot were apparently deformed whenever walking down 10- or 20-cm stairs. Because the arch of the normal foot needs certain elasticity to protect plantar vessels and nerves from compression,[28] the arch could be influenced by the impact of walking down stairs. The arch of flatfoot was more easily influenced owing to the weak stability.[29] In other words, it is harmful to the foot arch when walking down stairs.

Table 4. Arch Index of Different Walking Conditions

Group	Walking Condition	Mean Difference	SE	95% CI for Difference
		Left Foot		
Before	Level surface	31.520	0.256	31.003 to 32.037
	Up stairs, 10 cm	31.180	0.298	30.579 to 31.781
	Up stairs, 20 cm	31.180	0.316	30.541 to 31.819
	Down stairs, 10 cm	33.313	0.331	32.646 to 33.980
	Down stairs, 20 cm	35.760	0.436	34.881 to 36.639
After	Level surface	28.873	0.256	28.357 to 29.390
	Up stairs, 10 cm	28.647	0.298	28.046 to 29.248
	Up stairs, 20 cm	28.320	0.316	27.681 to 28.959
	Down stairs, 10 cm	30.347	0.331	29.680 to 31.014
	Down stairs, 20 cm	31.673	0.436	30.794 to 32.553
Normal	Level surface	26.780	0.256	26.263 to 27.297
	Up stairs, 10 cm	26.460	0.298	25.859 to 27.061
	Up stairs, 20 cm	26.440	0.316	25.801 to 27.079
	Down stairs, 10 cm	29.167	0.331	28.500 to 29.834
	Down stairs, 20 cm	30.473	0.436	29.594 to 31.353
		Right Foot		
Before	Level surface	31.940	0.191	31.554 to 32.326
	Up stairs, 10 cm	31.267	0.191	30.880 to 31.653
	Up stairs, 20 cm	31.187	0.195	30.792 to 31.581
	Down stairs, 10 cm	34.507	0.175	34.153 to 34.860
	Down stairs, 20 cm	36.167	0.177	35.809 to 36.524
After	Level surface	29.140	0.191	28.754 to 29.526
	Up stairs, 10 cm	28.947	0.191	28.560 to 29.333
	Up stairs 20 cm	28.793	0.195	28.399 to 29.188
	Down stairs, 10 cm	30.387	0.175	30.033 to 30.740
	Down stairs, 20 cm	31.613	0.177	31.256 to 31.971
Normal	Level surface	26.700	0.191	26.314 to 27.086
	Up stairs, 10 cm	26.433	0.191	26.047 to 26.820
	Up stairs, 20 cm	26.393	0.195	25.999 to 26.788
	Down stairs, 10 cm	29.940	0.175	29.586 to 30.294
	Down stairs, 20 cm	31.340	0.177	30.983 to 31.697

Abbreviations: After, flatfoot after treatment; Before, flatfoot before treatment; CI, confidence interval; Normal, normal foot.

Ironically, people prefer to take an elevator when walking up stairs but, as long as the floor is not too high, would rather walk down stairs than wait for the elevator.

Furthermore, none of the participants reported discomfort throughout the treatment, and the therapeutic effects were apparent. In addition, even the arch of the normal foot will be influenced when walking down stairs; therefore, it could be treated for flexible flatfoot to avoid further development.

Conclusions

Wearing orthotic insoles could effectively decrease the plantar pressure of flexible flatfoot not only when walking on a level surface but also when walking up and down stairs. In addition, the data from both normal foot and flexible flatfoot were influenced whenever walking down 10- or 20-cm stairs. Therefore, adults with flexible flatfoot may need to wear orthotic insoles to prevent further deformation. However, further studies are necessary to analyze the plantar pressure of adults with flatfoot in other areas in the future.

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