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Effect of Medial Arch Support Foot Orthosis on Pressure Distribution and Peak Pressure in Women with Hallux Valgus

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Abstract

Background: Hallux Valgus (HV) entails a deformity of the hallux, resulting in heightened pressure on both the hallux and forefoot. One potential intervention involves utilizing foot orthoses with medial arch support.
Aims: This study aimed to assess the impact of medial arch support foot orthoses on pressure distribution and peak pressure among women exhibiting mild to moderate hallux valgus.
Methods: The research employed a quasi-experimental design, employing a one-group pretest-posttest methodology with 16 participants. Data collection involved recording pressure distribution and peak pressure via foot scans before and after one month of utilizing Medial Arch Support Foot Orthoses. Parametric analysis utilized a paired T-test.
Results: The findings indicated a significant reduction in peak pressure, particularly in toe 1 and the metatarsal region ($p < 0.005$). However, there were no notable alterations in pressure distribution ($p > 0.005$), although a shift in mean pressure distribution from 21.94 to 22.63 was observed in the right forefoot.
Conclusion: Medial arch support foot orthoses demonstrated efficacy in altering pressure distribution and mitigating peak pressure, thereby presenting as a viable intervention for individuals with hallux valgus. Future research should consider incorporating additional variables, such as spatiotemporal differences, both pre- and post-utilization of medial arch support foot orthoses.

Keywords: Hallux valgus, Medial arch support foot orthosis, pressure distribution, peak pressure

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Introduction

Hallux Valgus (HV) is a deformity of the foot that can be progressive and increase adduction of the first metatarsal bone against the tarsometatarsal joint (Yale et al., 2005). The main problem that commonly occurs in the foot is anatomical deformity of the foot. These anatomical deformities are generally the pathophysiologic result of chronic conditions (Nix et al., 2010a). One of the anatomical deformities of the foot is Hallux Valgus. The human foot generally functions as the main support of the body which has a complex anatomical structure (Angin & Demirbüken, 2020). By maintaining the function and anatomical structure of the feet, it can reduce health problems that may arise in the feet (Schaper et al., 2016).

A national health survey in the United States reported an estimated 0.9% prevalence of HV across all age groups (Nix et al., 2010b). While a recent survey in the UK reported an estimated 28.4% prevalence of HV in adults (Roddy et al., 2008). In a study conducted in Nigeria, it was found that the prevalence in women was greater at 11% than in men at 5% (Nguyen et al., 2010). Extrinsic factors causing HV are the use of high heels and pointed shoes in women. The use of high heels and pointed shoes can affect the pressure distribution on the sole of the foot which can then be associated with the occurrence of foot deformities such as hallux valgus (Cronin, 2014).

In a study, it was indicated that a decrease in the arch of the medial foot can lead to a change in the axis of the first metatarsal, shifting it from its original position in the transverse plane to a vertical angle in patients with hallux valgus (HV) (W. Glasoe et al., 2008). Biomechanical alterations in foot structure may result in an imbalance, causing a lateral shift in weight bearing and an increase in pressure on specific areas until pain ensues (W. M. Glasoe et al., 2010). This uneven distribution of pressure often leads to discomfort and fatigue in the soles of the feet among individuals with HV (Wen et al., 2012). Furthermore, it can induce hypermobility during the late stance phase of walking, which subsequently affects pressure distribution on the sole, particularly increasing pressure on the medial metatarsal head and hallux (Martínez-Nova et al., 2010).

Interventions for HV patients can be implemented through surgical or conservative management approaches. Among conservative interventions, foot orthosis/insole usage has been recognized as beneficial (Farzadi et al., 2014a). Foot orthosis featuring medial arch support has the mechanical capacity to realign the axis of the first metatarsal back to the transverse plane and mitigate hallux hypermobility (Farzadi et al., 2014b). Therefore, the aim of this study is to evaluate the impact of medial arch support foot orthosis on patients with mild to moderate hallux valgus. The inclusion of medial arch support in foot orthosis is anticipated to positively influence pressure distribution during walking. Based on the preceding explanation, the researcher is motivated to investigate the effects of medial arch support foot orthosis on pressure distribution and pressure points in women with mild to moderate hallux valgus.

Figure 1. Medial Arch Support Foot Orthosis

Methods

Subject

This research design is pre-experimental using the One-Group Pretest-Posttest method, this method is carried out with the aim of seeing the effects of a treatment by comparing the situation before treatment and after treatment (Sugiyono, 2013). This study analyzes the effect of Medial arch support foot orthosis on Pressure distribution and peak pressure in women with mild to moderate hallux valgus. In this study, the number of samples that fit the inclusion of researchers was 16 participants with the inclusion criteria Women with mild - moderate hallux valgus, do not have other deformities / wounds in the foot area.

16 participants received a pair of medial arch support foot orthosis. Each orthosis was equipped with the medial arch support feature. The orthosis material is made of semi-rigid material, so the arch support has a rigid material to support the medial arch (Figure 1).

Foot pressure was measured using the RSS Foot Scan. Foot scan will measure how much pressure points and pressure distribution on the soles of the feet when standing and walking. The 10 points that will be seen on the sole of the foot include Toe 1, Toe 2-5, Metatarsals 1 - 5, Midfoot, Medial and Lateral heel. Pressure will be measured using the 10MWT (10 Meter Walking Test) method. Participants will walk for 10 meters with acceleration and deceleration of 4cm.

Pre-Test is the initial condition of the participant before using Foot orthosis and will see the distribution and pressure points on the soles of the feet when standing and walking. Post-Test is a condition where participants are asked to use Foot orthosis for 1 month. Because according to research (Farzadi et al., 2014) peak pressure on the hallux, metatarsals 1,3 and 5 is reduced after using a foot orthosis after 1 month, it is seen to increase significantly in the midfoot when using a foot orthosis.

Data Analysis

Foot scan will measure how many pressure points and pressure distribution and is divided into 10 points namely, Toe 1, Toe 2-5, Metatarsals 1 - 5, Midfoot, Medial and Lateral heel. The pressure distribution is divided into 4 parts, Rearfoot right, Forefoot right, Rearfoot left, and Forefoot left. The normality test aims to test whether the plantar distribution is valid for research or not. The results of the normality test using Shapiro Wilk from this study with 16 participants and with more than one data that has a significance value of more than 0.05, so the normality test is declared successful. The researcher continued with the parametric test (paired T test) to determine the significance of changes in plantar distribution and peak pressure in participants.

Table 1. Frequency Distribution of Participants

Variable	Frequency (n)	Percentage (%)
Degree of HV Right side		
Normal	2	13%
Mild	13	81%
Moderate	1	6%
Total	16	100%
Degree of HV Left side		
Normal	2	13%
Mild	13	81%
Moderate	1	6%
Total	16	100%

Results

The data differences between the right and left leg segments for the pressure distribution are displayed in Table 2. The difference is -0.69 as FRa displays an average of 21.94 and FRb displays an average of 22.63. When the two variables are compared, the P-value is more than 0.05, and the P-value derived from FRa and FRb is 0.65. Thus, it may be concluded that there is little to no difference between FRa and FRb. With an average value of 28.94 for RLa and 25.81 for RLb, the average difference in RLa and RLb is 3.13.

Table 2. Comparison of Pressure distribution before and after using Medial arch support insole

Variable	Comparison of measurement results	Mean	P_Value
Pressure distribution	FRa	21.94	0.65
	FRb	22.63	
	RRa	29.25	0.39
	RRb	48.5	
	Fla	20.25	0.06
	FLb	23.5	
	Rla	28.94	0.15

The difference between the two variables is therefore not significant, as indicated by the P value of 0.15 where p>0.05 from the two variable comparisons. p_value of Toe 1 before and when using Medial arch support insole is 0.028 where p < 0.05 which means significant. In toe 1 there is a change in peak pressure before using the Medial arch support insole with an average T1a of 7.53 and at T1b there is an average reduction to 5.37 (Table 3).

In addition to toe 1 there are several points that show a significant difference including metatarsal 2, metatarsal 3, metatarsal 4, midfoot, medial heel, and lateral heel with p<0.05. While toe 2 - toe 5, metatarsal 1, and metatarsal 5 were considered insignificant differences because p>0.05. In metatarsal 1, the average change before using the insole was 9.06 to 7.65 when using the insole. However, because p is more than 0.05, the change is considered insignificant (Table 3).

Table 3. Comparison of Peak pressure before and when using Medial arch support insole on the right foot

Variable	Comparison of measurement results	Mean	P_Value
Pressure	T1a	8.43	0.008
	T1b	5.15	
	T25a	3.50	0.15
	T25b	4.53	
	M1a	9.15	0.006
	M1b	5.84	
	M2a	13.31	0.00
	M2b	8.87	
	M3a	13.71	0.00
	M3b	8.87	
	M4a	9.71	0.019
	M4b	7.34	
	M5a	4.96	0.13
	M5b	5.96	
	MFa	5.65	0.43
	MFb	5.18	
	Mha	10.93	0.00
	MHb	5.21	
	Lha	11.12	0.00
	LHb	5.12	

Table 4. shows the results of bivariate data processing on the peak pressure variable and the results of the effect analysis before and when participants used the Medial arch support insole on the left foot. The data shows that there are several points that have significant differences including toe 1, metatarsal 1, metatarsal 2, metatarsal 3, medial heel, and lateral heel with p<0.05. Unlike table 4.7, in table 4.8 metatarsal 1 has a significant

difference with an average difference of 3.31. Peak pressure when using Medial arch support insoles on metatarsal 1 is lower by 5.84 than before using the insole. However, at toe 2 - toe 5, metatarsal 5, and midfoot have differences but are not significant because p>0.05.

Table 4. Comparison of Peak pressure before and after using Medial arch support insole on the left foot

Variable	Comparison of measurement results	Mean	P_Value
Peak pressure	T1a	7.53	0.028
	T1b	5.37	
	T25a	3.68	0.55
	T25b	4.00	
	M1a	9.06	0.098
	M1b	7.65	
	M2a	16.31	0.00
	M2b	9.34	
	M3a	14.71	0.00
	M3b	9.43	
	M4a	10.81	0.00
	M4b	7.37	
	M5a	7.09	0.059
	M5b	5.00	
	MFa	6.87	0.018
	MFb	5.65	
	Mha	11.56	0.00
	MHb	6.59	
	Lha	11.71	0.00
	LHb	5.87	

Research (Farzadi et al., 2014) peak pressure on the hallux, metatarsal 1,3 and 5 decreased after using foot orthosis after 1 month, seen a significant increase in the midfoot when using foot orthosis. Increased pressure on the hallux and 1st metatarsal will be associated with a change in the angle of the 1st ray. And with the intervention of Medial arch support foot orthosis can improve and control changes in the angle of the 1st ray and hallux. Mechanically, the medial arch foot orthosis can change the axis of metatarsal head 1 from a vertical position to a transverse direction, and this can prevent excessive pronation of the 1st ray which will affect the occurrence of progressive hallux valgus.

Data processing was carried out using univariate and bivariate analysis, and the results of the univariate test can be seen in table 1 which is the distribution of the characteristics of the participants in this study. And based on the inclusion criteria of this study, mild-moderate hallux valgus was obtained using measurements from the Manchester scale. It can be seen that each side of the right or left hallux has a different degree of valgus. Participants in this study had an age range of late adolescence, where in the age of This is a risk factor for hallux valgus. Because at that age is a productive period, and usually women use pointed shoes or high heels more often which can also be a risk factor for hallux valgus.

Discussion

Patients with hallux valgus in female students majoring in prosthetic orthotics can be observed and classified with the Manchester scale. Some of them have mild hallux valgus to moderate hallux valgus. Biomechanical changes in Hallux valgus feet can result in an imbalance that causes a lateral displacement of body weight and increases excess pressure on the area until pain occurs (W. Glasoe et al., 2008). The pressure distribution in people with HV will be different from other normal people. This uneven pressure distribution difference can cause pain and fatigue in the soles of the feet

in people with HV (Wen et al., 2012). The resulting pressure distribution in patients with hallux valgus has a small percent value on the forefoot, due to the high pressure point on the hallux when standing (Zhang et al., 2018).

The average comparison before and when using the Medial arch support foot orthosis is shown in table 2 where the largest increase is in the right rearfoot, and the reduction is in the left rearfoot. Of the four data that have been tested paired T test, in all parts of the sole of the foot does not show significant changes, and the average change becomes close to normal. The right rear foot is away from the normal number for the average when using Medial arch support foot orthosis. So that the purpose of this study can be said to be successful but not significant in pressure distribution data.

It is shown in tables 3 and 4 that in the toe 1, metatarsals 2 - 5 on both sides of the foot have a significant reduction change when using the Medial arch support insole. While in the metatarsal 1 on the left foot had a significant reduction with $p < 0.05$. And in the metatarsal 1 of the right foot there is a reduction in peak pressure, but the reduction is not significant with $p>0.05$.

The results of the analysis of peak pressure comparison before and when using the Medial arch support insole in tables 4.7 and 4.8 are divided into two parts of the right and left foot sides. Each side has ten areas, namely, toe 1, toe 2-5, metatarsal 1, metatarsal 2, metatarsal 3, metatarsal 4, metatarsal 5, midfoot, medial heel, and lateral heel. Of the 20-point areas, 7 points had a significance value of $p<0.05$, namely toe 1, metatarsal 3, metatarsal 4, metatarsal 5, medial heel, and lateral heel on both sides of the foot. The main pressure points on the sole of the foot during standing and walking are at metatarsal 1, metatarsal 5, and heel. Medial arch support insole has the effect of reducing the highest pressure point at the 3 main pressure points on the sole of the foot, namely, metatarsal 1, metatarsal 5, and heel.

This is in line with research (Farzadi et al., 2014) that mentioned the effect of using Medial arch support insoles has significant results for reducing peak pressure on the hallux part and provides effectiveness for reducing peak pressure within a period of 1 month of use.

Conclusion

There is a change in pressure distribution before and while using the Medial arch support insole, but the change is not significant. Changes in peak pressure in the toe and forefoot before and while using the Medial arch support insole have significant changes. Reduction of peak pressure at the forefoot area point can improve the pressure distribution in the forefoot. Because the distribution is evenly distributed in the area compared to before using the insole where the highest-pressure point is only on the hallux (toe 1).

Based on the above, it can be concluded that the Medial arch support insole has an influence on pressure distribution and peak pressure with different significance values from each side of the foot. Lack of peak pressure at the point of the forefoot area and affects the distribution of pressure in the forefoot. So that Medial arch support insole can be used as one of the treatments for hallux valgus sufferers to reduce pressure on the sole of the foot.

Recommendations

Participants or the public are encouraged to utilize foot orthoses/insoles equipped with arch support features. These features are designed to distribute pressure evenly, thereby mitigating the risk of excessive pressure concentrated at specific points and reducing the likelihood of discomfort and pain during standing and walking.

Future researchers are encouraged to explore additional variables, such as spatiotemporal differences before and after wearing prefabricated medial arch support foot orthoses, over an extended duration.

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