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Comparison of plantar pressure parameters between normal insole and varus functional insole in running shoes

Yoo-Jung Lee [1], Joong-Sook Lee [2], Gun-Sang Cho[3] and KiHoon Han[4]

[1]Department of Kinesiology, Silla University, Pusan, Korea
[2]Department of Kinesiology, Silla University, Pusan, Korea
[3]Department of Physical Education, Pusan National University, Pusan, Korea
[4]Department of Physical Education, Pusan National University, Pusan, Korea

Abstract

The purpose of this study was to compare the plantar pressure parameters between normal insole and varus functional insole during treadmill walking and to collect basic data on the improvement of walk function in patient with varus. Sixteen university students with varus were recruited for this study. Novel's Pader-X Mobile System was used to measure plantar pressure during walking on the treadmill at a walking speed of 5.0 km/h. The maximum force and contact area during twenty steps were calculated for the analysis. Based on the results in this study, it was concluded that: First, wearing B Insole reduced the dependence on A2 in the propulsion cycle of gait through varus correction. Second, Wearing functional A and B insoles was effective in dispersing the pressure by increasing the A3 contact area.

Index Terms

Varus, Functional insole, Maximum force, Contact area,

Corresponding author : KiHoon Han
happyhan@pusan.ac.kr

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Ⅰ. INTRODUCTION

Varus and valgus are terminology used to describe the increase in joint angle or decrease in joint angle in the frontal plane. In a standing upright posture, varus refers to the distal portion of the tibia being more medial relative to the proximal portion which gives an appearance of an O-shape (commonly referred to as ‘bow legged’). Varus posture is caused by the combination of pronation of both feet, hyperextension of the knee, and medial rotation of the femur, which causes the knee to spread [1]. Extreme pronation of the foot caused by varus knees causes various musculoskeletal disorders of the lower extremities, causing excessive external rotation of the tibia and femur, and increasing rotational stress in the pelvis and knee [2]. Since varus due to lower extremity malalignment itself is a knee joint disease and a major cause of abnormal gait, varus treatment is essential for preventing abnormal gait [3].

A typical solution to improve varus alignment is surgical prescription, but it is expensive and reoperation to remove the fixed pin is essential [4]. On the other hand, the foot orthotic insole can affect the angle of the femur and tibia by adjusting the foot orientation. In order to reduce the rotational stress of the knee joint, it is possible to prevent knee joint pain by changing the dynamics of the ankle joint and the knee joint by wearing a flexible orthosis in the shoe [5]. Therefore, it could be one of the representative correction methods of varus knee alignment.

Considering that varus alignment is a cause of abnormal gait and a knee joint disease that accounts for 15 to 20% of the total population, research to find a way to improve varus alignment is needed. Plantar pressure provides data that elucidate the relationship between foot structures and walk function. Therefore, the purpose of this study was to compare the plantar pressure between normal insole and varus functional insole during treadmill walking and to collect basic data on the improvement of walk function in patient with varus.

Ⅱ. METHOD

Sixteen university students were selected based off a criteria of 5 cm or more between the knee joint. The V company shoes with a flat outsole shape were used for the experiment and all participant utilize the same shoe type for this study. The experimental insoles were a flat normal insole and two functional insoles to improve varus alignment. The insoles are as shown in <Figure 1>.

(a) (b) (c)

Figure 1. Normal insole and two functional insoles. (a) - Normal, (b) and (c) - Functional A and B, respectively.

Functional A insole reduces the load on the knee by supporting the arch of the foot, thereby reducing fatigue and pain in the foot, holding the calcaneus. Functional B insole has a strong function to gather the knees. It is a fixed insole that strongly balances the sacrum, inner knee, and inner ankle at the beginning of wearing.

Novel's Pader-X Mobile System was used to measure plantar pressure. As shown in <Figure 2>, the foot were divided into six regions to analyze: A1 (medial forefoot), A2 (lateral forefoot), A3 (medial midfoot), A4 (lateral midfoot), A5 (medial rearfoot), and A6 (Lateral rearfoot). The inclination of the treadmill was set to 0 degree and the walking speed was 5 km/h. The maximum force and contact area during twenty steps were calculated for the analysis. The maximum force was normalized by body mass of each participant.

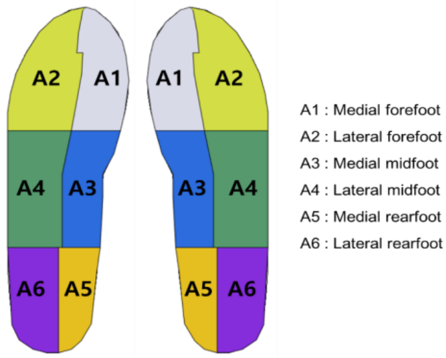

Figure 2. Plantar pressure divided into six regions

All statistical analyses were conducted using SPSS V. 25.0 (SPSS, Inc., Chicago, IL). One-way ANOVA was used to examine if differences in the maximum force and contact area between different insoles were present. Duncan methodology was used for post-hoc test. An alpha level of .05 was used to determine statistical significance.

Ⅲ. RESULT

1) Maximum force

At a walking speed of 5.0 km/h, the maximum force for each insole type were shown in <Table 1>. There was a statistically significant difference in A2 of both the left and right foot. In the case of A2 in the left foot, the maximum force in the normal insole (1.65 N/kg) and A insole (1.52 N/kg) were a statistically higher value than that in B insole (0.65 N/kg). In A2 of the right foot, the normal insole (1.43N/kg) and A insole (1.20 N/kg) showed a statistically higher maximum force than B insole (0.66N/kg).

Table1. Maximum force unit: N/kg

Resion		Type			F	p	*Post -hoc*
		Normal	A	B			
		M±SD	M±SD	M±SD			
L	A1	5.65 ±1.27	4.87 ±1.16	4.70 ±1.28	2.67	.080	
	A2	1.65 ±0.57	1.52 ±0.55	0.65 ±0.29	19.98	.000*	N, A>B
	A3	2.48 ±0.63	2.33 ±0.55	2.26 ±0.63	.56	.575	
	A4	4.12 ±0.61	3.66 ±0.90	3.96 ±1.14	1.05	.357	
	A5	2.41 ±0.52	2.74 ±0.79	2.54 ±0.67	.94	.396	
	A6	3.52 ±0.61	3.64 ±0.83	3.46 ±0.82	.23	.795	
R	A1	5.65 ±1.09	5.40 ±1.13	4.93 ±1.34	1.53	.227	
	A2	1.43 ±0.40	1.20 ±0.41	0.66 ±0.30	18.29	.000*	N, A>B
	A3	2.56 ±0.62	2.39 ±0.46	2.35 ±0.51	.71	.493	
	A4	4.03 ±0.63	3.65 ±0.76	3.88 ±0.87	.96	.388	
	A5	2.36 ±0.41	2.52 ±0.75	2.41 ±0.66	.28	.754	
	A6	3.46 ±0.65	3.70 ±0.85	3.45 ±0.79	.54	.583	

*$p<.05$, N means the normal insole. L-left foot, R-right foot.

2) Contact area

The contact area for three different insoles were shown in <Table 1>. There was a statistically significant difference in A1 of both the left and right foot and A3 of the right foot. On A1 of the left foot, the normal insole (21.61cm^2) showed a smaller contact area than A insole (22.22cm^2) and B insole (24.56cm^2). In the case of A3 in the left foot, the contact area in the normal insole (18.65cm^2) and A insole (17.75cm^2) were a statistically higher value than that in B insole (7.01cm^2). Also, on A1 of the right foot, the normal insole (20.57cm^2) showed a wider contact area than A insole (17.98cm^2) and B insole (8.61cm^2).

Table2. Contact area unit: cm^2

Resion		type			F	p	*Post -hoc*
		Norma l	A	B			
		M±SD	*M±SD*	*M±SD*			
L	A 1	21.61 ±3.31	22.22 ±2.79	24.56 ±2.07	5.052	.001*	N <A, B
	A 2	28.67 ±3.76	27.61 ±3.26	28.40 ±2.81	.448	.642	
	A 3	7.01 ±3.19	17.75 ±4.61	18.65 ±4.21	40.902	.000*	N < A, B
	A 4	26.31 ±3.52	27.00 ±2.96	27.67 ±2.42	.825	.445	
	A 5	16.16 ±0.98	16.33 ±0.84	25.67 ±37.60	1.005	.374	
	A 6	21.67 ±1.28	21.68 ±1.22	21.60 ±1.69	.013	.987	
R	A 1	24.62 ±1.99	24.22 ±2.40	23.14 ±3.61	1.248	.297	
	A 2	28.93 ±3.40	28.15 ±3.32	27.94 ±4.09	.333	.718	
	A 3	8.61 ±3.76	17.98 ±4.14	20.57 ±2.56	50.091	.000*	N <A<B
	A 4	26.93 ±3.29	27.65 ±2.85	28.02 ±3.36	.488	.617	
	A 5	16.12 ±1.25	16.38 ±0.96	16.54 ±0.87	.654	.525	
	A 6	21.56 ±0.74	21.57 ±0.66	21.47 ±0.69	.091	.913	

*$p<.05$, N means the normal insole. L-left foot, R-right foot.

Ⅳ. DISCUSSION

1) Maximum force

The reason for calculating and comparing the maximum force for each area during walking is to identify the part where the more pressure is generated during walking. Through this, the impact force can be dispersed by using a shock absorber when designing a shoe [6]. It was reported that the maximum impact force occurs when the center of pressure is in the center of the back of the foot [7]. In this study, when walking on a treadmill at 5 km/h, the participants showed a fairly large amount of maximum force in A6 of the both right and left foot. This means that all the participants showed a rearfoot landing type.

A patient with varus alignment of the knee is characterized by a lot of dependence on the lateral forefoot when generating propulsion in gait. As a result of this study, the maximum force of A2 in insole B was a smaller value than that of normal insole and A insole, and there was a statistically significant difference. It is considered that when a patient with varus wears insole B, the effect of improving the gait function was shown by reducing the dependence on the lateral forefoot in the propulsion cycle of gait through the correction of the varus.

2) *Contact area*

The contact area can accurately evaluate the pressure distribution of the foot and is one of the essential indicators for judging abnormal gait patterns. [8]. Pressure is the ratio of the force applied to the entire contact area where the force is applied (i.e., P = F/A). According to previous studies related to the contact area of the foot during walking, when the same force is applied to a larger contact area, the pressure per unit area becomes smaller. Also, it was reported that the contact area on the medial midfoot in the pronation group showed a larger value at 3 degrees and 7 degrees than at 0 degrees according to the angle of the orthodontic insole [9]. As for the contact area in this study, the contact area at A3 of A and B insoles showed statistically significant bigger values compared to the normal insole. These results indicate that the contact area of the foot can be adjusted when walking by applying an orthodontic or insole to abnormal skeletal and lower extremity structures such as varus and valgus.

Ⅴ. CONCLUSION

The following conclusions were obtained based on the results of measuring the maximum force and contact area when walking on the treadmill at a walking speed of 5.0 km/h. First, wearing B Insole reduced the dependence on A2 in the propulsion cycle of gait through varus correction. Second, Wearing functional A and B insoles was effective in dispersing the pressure by increasing the A3 contact area.

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REFERENCES

[1] Kendall, F. P., McCreary, E. K., & Provance, P. G. (2005). *Muscles: testing and function with posture and pain.* Lippincott Williams & Wilkins.

[2] Blake, R. L., & Denton, J. A. (1985). Functional foot orthoses for athletic injuries. A retrospective study. *Journal of the American Podiatric Medical Association, 75*(7), 359.

[3] Lee, H. I. (2016*). Effect of self myofascial release, band, stretching exercise on the lower extremity alignment and gait in female genu varum* (Doctoral dissertation, Chung-Ang University).

[4] Han, K., Bae, K., Levine, N., Yang, J., & Lee, J. S. (2019). Biomechanical effect of foot orthoses on rearfoot motions and joint moment parameters in patients with flexible flatfoot. *Medical science monitor: international medical journal of experimental and clinical research*, *25*, 5920.

[5] Eng, J. J., & Pierrynowski, M. R. (1993). Evaluation of soft foot orthotics in the treatment of patellofemoral pain syndrome. *Physical therapy, 73*(2), 62-68.

[6] Jung, S., Kim J., & Kim B. (2001). A study on gait characteristics for the elderly footwear design. *Archives of Design Research*, 211-220.

[7] Cavanagh, P. R., & Lafortune, M. A. (1980). Ground reaction forces in distance running. *Journal of biomechanics, 13*(5), 397-406.

[8] Kim, J., Lee, E. Y., & Kim, D. (2018). Analysis of Abnormal Gait and Over Pronation/Supination Gait Using Smart Insole. In *Proceedings of the Korea Information Processing Society Conference* (pp. 907-910). Korea Information Processing Society.

[9] Lee, H., & Kim, Y. (2010). The Effect of the Wedge Insole Angle of Supinated Group on Foot Contact Time, Foot Contact Area and Foot Pressure. *Journal of the Korean Society for Fisheries and Marine Sciences Education*, *22*(4), 508-515.