

Footwear innovations for people with the diabetic foot with ergonomic design

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ABSTRACT

Background: The foot is one of the organs of the body that have a major role in health, especially in diabetics. During the day, a lot of pressure is transmitted through the legs to the knee, pelvis, and spine, and any motivation in the shoe may put pressure on the gait parameters. Shoes should be such that diabetics can feel comfortable enough and also not suffer from neuropathy or ulcers caused by wearing them after work.

Method: In this study, 5 types of shoes available in the market that are offered as medical shoes were selected and compared with quality ergonomic indicators. In the second stage, the effect of these shoes for wearing for a long time was evaluated, and also the ratio of increase and comfort of the person in the sole of the feet and knees was examined.

Results: Only one of the shoes had relatively good conditions for people with diabetes, which by adding new items such as choosing the right fabric for ventilation of the foot area, considering the appropriate anthropometric measurements in the toe area for more comfort, and having a suitable insole to prevent the occurrence of musculoskeletal disorders in the lumbar region could be sufficient.

Conclusion: In general, a design framework with specific tools is provided to have the right shoes for the proper use of diabetics in the long run. Further research should focus on outsole design tools and other shoe components.

KEYWORDS

Footwear, Diabetic, Comfort

Introduction

Historically, the foot is known as the second human heart; in addition to transmitting pressure-induced reactions to the ground, it plays a key role in creating a balanced and uniform pressure on the joints and upper treatment parts, creating the correct position. The foot environment changes throughout life, and factors such as age, pregnancy, obesity, and daily stress cause the foot to become flat. [1-4].

Almost all causes of foot pain can be classified into 3 groups: Improper shoes, certain diseases, and heavy and inappropriate exercise. Above all, various diseases such as diabetes can cause pain and sores in the legs over time. In general, 15% of diabetics experience diabetic foot ulcers. Diabetic foot ulcers are one of the leading causes of death and disease [5, 6].

Diabetic foot syndrome is one of the main and late complications of this disease and the main cause of disability and hospitalization of patients with diabetes and accounts for 58% -50% of non-

traumatic lower extremity amputations [7, 8]. Therefore, having the right shoes for these people, which can prevent possible injury to the foot area even for a long time, can be very important.

In addition to providing proper foot coverage, a good shoe adapts to the ground without putting pressure on the foot. Careful selection of shoes and observance of standard principles in its production is one of the most essential needs to maintain people's health. Prescribing and modifying shoes is a very useful tool in protecting the joint, preventing skin problems, and increasing optimal performance in patients with problems such as arthritis, diabetes, and peripheral vascular disease. Medical shoes reduce the treatment of building problems and functional problems related to foot problems to some extent. People with healthy feet do not need medical shoes. The shoes have different designs and heights and depending on the type of correction required, they may be made of different materials. Ordering medical shoes for each person is like special medicine. Medical shoe standards are determined by the type of deformity and disease of the individual and the purpose of treatment. This study aimed to evaluate and design ergonomic shoes suitable for diabetics.

Methods

In the present experimental study, 40 employees, all of whom had diabetes, participated, 30 of whom were female and 10 male. 20 of them had type 1 diabetes and another 20 had type 2 diabetes. Information about the samples was collected by the form and the minimum age was 44/05 years, height 168/12 cm, weight 70/43 kg, and BMI 25/02. After examining their condition, it was found that 37.5% of them had knee pain, 27.5% had pain in the sole and 35% of them did not report any specific disease.

Equipment used

In this study, 4 types of shoes available in the market with the names of SLS, Melli, Adak, Shahir, and Iran teb have been used. From each type of shoe, 10 pairs were prepared and given to the samples. The form is used to compare these shoes with the standard. The samples are selected under the supervision of the researcher and according to the size of their feet, they select the shoe and then put the sample on it and compare the researcher according to the condition of the individual foot, the compatibility of the studied parts of the shoe with the foot and scores as 1 (low), 2 (medium) and 3 (high) are specified.

Ergonomic standards and indicators used in the study

To compare the shoes, the quality indicators in Table (1) were used.

Table (1): Ergonomic indicators of shoes

Shoe upper	The sole of the shoe should be made of leather to neutralize the sweat produced by the foot, and it should also be flexible and Maintain the shape of the shoe and its durability is high
Toe box	It should be wide, long, and round and the fingertips should be 0.5 inches away from the toe box

Vamp	Must be sufficient height and width; the widest part of the Vamp, the Ball, must conform to the Metatarsal heads or the bones that make up the foot (Metatarsal); So that the toes and shoes can be broken at the MP joint during the Laster stance phase. Enough should be considered in Vamp shoes; because when bearing the weight, the foot circumference in the Ball increases by 0.5 inches
Quarter	This area should be large enough to cover the midfoot and back of the foot; Quarter in the heel area should be firm and cover the heel so that the foot does not protrude from the shoe when walking.
Insole	It is usually made of leather, which in addition to durability, can expand and be flexible during long-term use.
Heel	Heel height should not be more than 3.5 cm for men and 4.5 cm for women

Method of determining the performance score

The knee position assessment form was used to determine performance scores. This form had 10 questions, at the end of which the IRDC score was calculated and the performance score was set as a percentage. A 10-point scale (VAS) was used to score the sole and was expressed as a percentage at the end. How to use these forms was that the forms were completed once before use and once after the use of shoes by the samples and the difference between the two scores was compared. The samples used the shoes for two months and an average of 4 hours a day.

Statistical Methods

Estimation of the standard deviation of change in performance score before and after use and minimum difference in performance score before and after shoe use were determined. Finally, the results were analyzed using SPSS software and Paired-t and Kruskal–Wallis ANOVA tests.

Findings

The results of comparing shoes with ergonomic indicators showed that none of the shoes in the studied sections fully comply with these indicators and only one of them can be closer to the standard type by making changes. The comparison results are summarized in Tables (2-3). The experiment also showed that Adak and the famous shoes in the toe box are more compatible than the other three shoes. In the Vamp section, the SLS and Melli shoes were less compatible with ergonomic performance than other shoes. So that only 10% of the samples received the highest score of full compliance in this section. In this part, Adak shoes with 40% excellent game points are reported to be better than Iran Tab. The Kruskal-Wallis test showed that in the Quarter, the Adak and Iran Teb shoes are not significantly different, but are more compatible than the SLS shoes. In terms of insoles, most shoes had a mediocre score. The results are given in Table (2).

Table (2): The degree of compliance of the examined shoes with ergonomic indicators

Compliance with ergonomic indicators (percentage)																		
Heel			Insole			Quarter			Vamp			Toe box			Shoe upper			Shoe type
High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low	
30	70	0	20	60	20	20	40	40	10	70	20	20	70	10	20	0	10	SLS
30	70	0	30	70	0	50	50	0	40	60	0	30	70	0	50	50	0	Adak
10	90	0	20	80	0	40	60	0	30	70	0	20	80	0	40	0	60	Iran Teb
10	90	0	30	70	0	0	10	0	30	70	0	20	80	0	40	60	0	Shahir
30	70	0	30	70	0	20	40	40	10	70	20	20	70	10	20	70	10	Melli

In the second stage, the effect of these shoes on reducing pain samples was investigated. For example, the ANOVA test showed that the mean age, height, weight, and BMI were not significantly different between the four groups and the samples were usually the same in terms of variables. Paired t-test showed that in all shoes, the average foot performance has significantly improved so that using SLS shoes, outsole performance score from 53 to 64%, Adak shoes from 53 to 65%, Iran Tab shoes From 55 to 66 percent, and using Shahir and Melli shoes, the score increased from 56 to 63 percent.

Table (3): Foot and knee function score before and after using shoes

Shoe type	Knee performance score (percentage)		Foot performance score (percentage)	
	Before use	After use	Before use	After use
SLS	40/48	42/73	53	64
Adak	46/14	48/67	53	65
Iran teb	49/63	51/08	55	66
Shahir	59/63	59/63	56	63
Melli	59/75	59/75	56	63

Discussion and Conclusion

The human foot has a complex structure made up of bones, joints, nerves, and muscles, about a quarter of the body's bones. The small size of this complex organ compared to the size of the whole body and that it plays an essential and supporting role in the whole body. Therefore, choosing the right shoes is very important; According to research, by adding appropriate items and indicators such as choosing more suitable fabric for ventilation, more attention to more accurate anthropometric measurements in the toe area for more comfort, and having a suitable insole to prevent musculoskeletal disorders in the sole and Kneeling to one of the shoes is very important for people with certain diseases such as diabetes. Therefore, it is recommended that more research be done on the design tool of the outsole and other components of this shoe to find a suitable shoe to prevent wounds during long-term use. It should be noted that all these items should be done and selected under the supervision of a specialist and ergonomists do.

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