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A Study of Motor Pressure Measurement in Patients with Diabetes Mellitus

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ABSTRACT

This article provides information on changes in the distribution of plantar foot pressure, the incidence of side effects and complications of prophylactic footwear, and a study of the typical movement of the rear of the foot during walking. Measurements of the angular displacement of the calcaneus, scaphoid and first metatarsal relative to the tibia; the 3D motion models for all three bones were very similar. This study provides additional information on how the leg functions while walking. The results of the effectiveness of providing preventive footwear to the contingent of patients with diabetes mellitus at the Endocrinological Dispensary of the Bukhara region were analyzed (based on a sample survey and dynamic observation of 50 patients).

1. Introduction

The human foot is a perfect universal mechanism that provides balance and movement of a person with a variety of physical activity.

Approximately 75% of the contact time with the ground is provided by the forefoot, but biomechanically, it is safest to land on the midfoot. Incorrect gait biomechanics lead to uneven weight distribution over the foot and excessive muscle stretching. In addition, studies show that one of the main causes of the occurrence and development of foot deformities is the wearing of irrational shoes. Unfortunately, there is no middle ground between preventive footwear and mass-produced footwear. The leading role in ensuring the comfort of the shoe is its supporting surface, which bears the bulk of the load when standing and walking.

High pressure on the leg is usually found in places with the sesamoid bones and is closely related to the thickness of the plantar tissue. In addition, foot deformities are closely related to and predictive of increased plantar pressure and foot ulceration. Prominent metatarsal heads have traditionally been associated with weakness in the internal muscles of the foot resulting in deformities of the toes [1].

Many people with diabetes develop leg ulcers. Shoes are the main cause of foot ulcers, but research is limited to the effectiveness of shoe combinations and to prevent reinforcement [2].

2. Materials And Method

As a result of the conducted studies of women's feet, the location of the longitudinal arch on the horizontal projection of the footprint of the shoe for women's preventive shoes was established: the rear border of the calculation is in the section 0.31D, the front border is 0.64D; the place of the greatest width of the arch calculation corresponds to the narrowest place of the foot print in the section 0.46 D; the place of the greatest height of the longitudinal arch on the inner side corresponds to the location of the tuberosity of the scaphoid bone on the foot and is 0.4 D, on the outer side it is displaced posteriorly and is in section 0.34 D. The heel of the footprint of preventive footwear has a depression up to 8 mm. This prevents the calcaneus from turning to a horizontal position and is the prevention of longitudinal flat feet [3,4].

When developing the footprint of the shoes of superior comfort [5,6] and preventive footwear for different age and gender groups, it is necessary to in the course of additional research to determine the average values of soft tissue collapse in different parts of the plantar surface of the foot. In addition to determining the values of the soft tissue crushing of the foot, we investigated the change in the position of the foot gauge line in width, depending on the case of support.

For the casts obtained, the distances from the base plane to the foot dimension line in width were found, as well as the foot width in dimension (Table 1).

From table 1 and fig. 1 it is seen that the position along the height of the foot gauge line from the inside for the positions of uniform support on a flat base and support on a soft base practically coincide. From the outside, in the underwater area (sections 0, ZD; 0.4D; 0.5D), the curves of the dimensions practically coincide for the position of uniform support on a soft base and the unsupported position of the foot.

Table 1: Values of the height and width of the foot gauge line(L = 250 mm)

Foot position	Cross-vertical section											
	0,3Д		0,4Д		0,5Д		0,62Д		0,68Д		0,73Д	
	Dimension line height, mm											
	Inter.	Out.	Inter.	Out.	Inter	Out.	Inter.	Out.	Inter.	Out.	Inter.	Outer.
Unsupported	8	6	12	7	9,5	8,5	2,5	14	4	13	5,5	12
Uniform support on a flat base	4	7	8,5	11	6	11	4	14	9	14	11	13
Uniform support on a soft base	4	7	8,5	6	6	8	4	9	9	8,5	11	5
Dimension line width, mm												
Unsupported	37	31	39	35	41	36	44	43	44	43,5	44	44
Uniform support on a flat base	41	29	43	35	43	38	46	46	47	45	47,5	45
Uniform support on a soft base	39,5	29	43	35,5	44	36	46	44	47	44	47,5	45,5

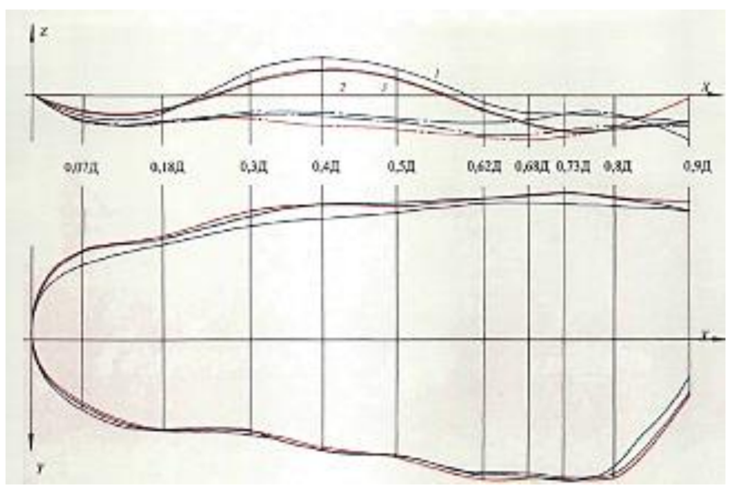


Figure1: Projections of the foot dimension lines in width (1-unsupported position; 2-uniform support on a flat base; 3-uniform support on a soft base).

Studies of the phases of movement of the foot and the state of the ankle joint, performed on the basis of the NPROP, showed that the time of foot support and the area of support are associated with the complexity of the shoe design. So, in the case of maximum support on the toe of the foot, the construction of the shoe is performed with an increase in the degree of rigidity of the frame parts in the toe-tuft part. With a longer phase of support on the heel, the frame parts in the calcaneal-gel part are reinforced. Depending on the foot support area, it is proposed to build 4 groups of structures. Thus, the biomechanics of movements of children with this type of disease determines the choice of constructive and technological solutions for making shoes [7,8].

Robert G.C., Peter A.L., Saumaeswar Y., analyzed plantar loads increasing in people with longstanding diabetes-related foot ulcers. They argue that high plantar pressure affects the development of diabetes-related foot ulcers.

Plantar pressure assessed during gait is higher in diabetic patients with chronic foot ulcers than in controls at multiple plantar sites during long-term follow-up. Prolonged exercise is required to facilitate healing of ulcers in diabetic patients with diabetic foot ulcers.

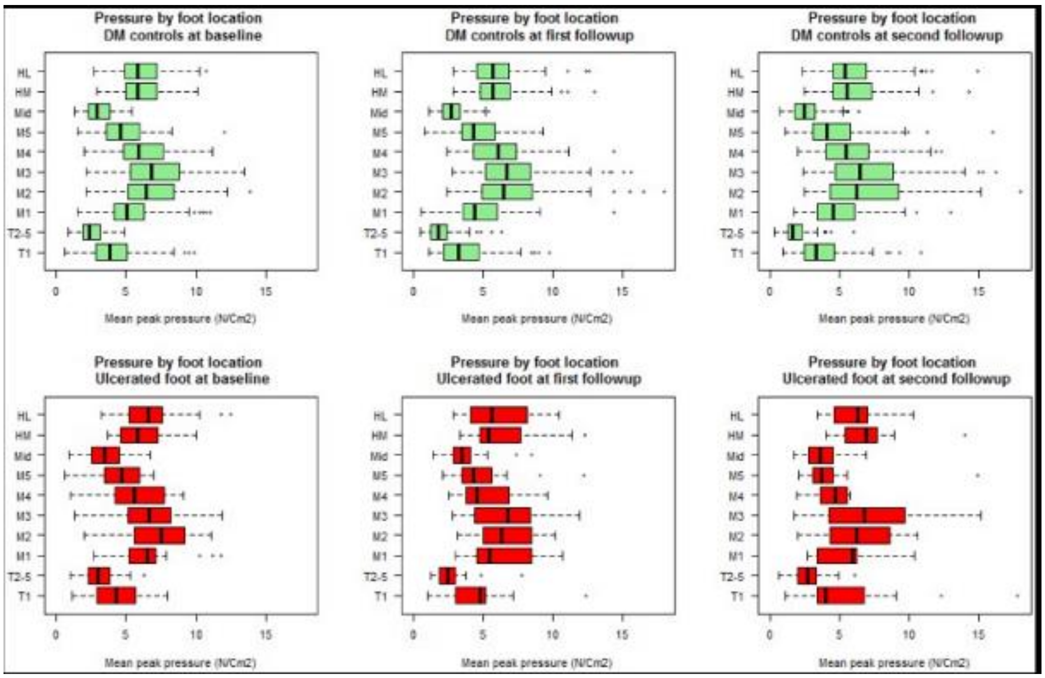


Figure 2: Average peak pressures over time for participants with DFU and participants without DFU

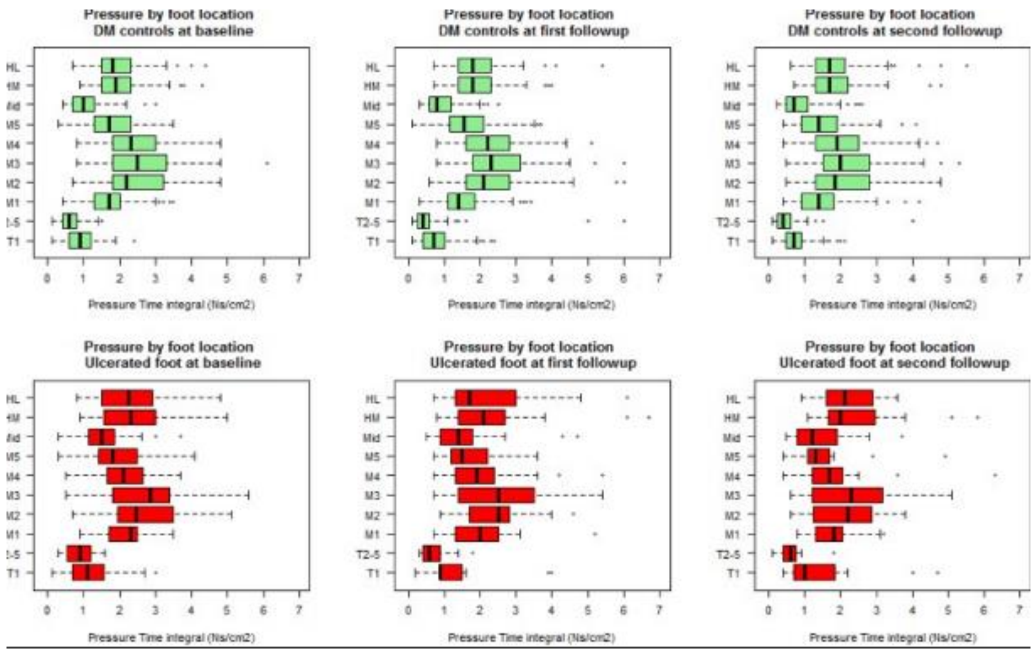


Figure 3: Site-specific pressure and time integrals over time for competitors with DFU and non-DFU competitors

In this study, 21 cases with diabetic foot ulcers, 69 patients with diabetes and 56 healthy patients were selected by the case-control method. Plantar pressures at ten locations on both legs and the length of the standing phase were measured using a pre-established protocol. Primary results were mean peak plantar pressure, pressure-time integral and standing phase duration. Nonparametric analysis was used with Holm's correction to correct for multiple testing. Binary logistic regression models were used to adjust the results for age, gender, and body mass index. Median differences with 95% confidence intervals and Cohen's d values (standardized mean difference) were recorded for all significant results.

Most of the ulcers were located on the plantar surfaces of the fingers and toes. When adjusted for age, sex, and body mass index, mean peak plantar pressure and the integral of pressure and time between the toes and midfoot were significantly higher in cases compared with diabetes and healthy controls ($p < 0.05$). The duration of the stance phase was also significantly longer in the cases compared to both control groups ($p < 0.05$). The main limitations of the study were the small number of cases studied and the inability to adjust the analysis for multiple factors.

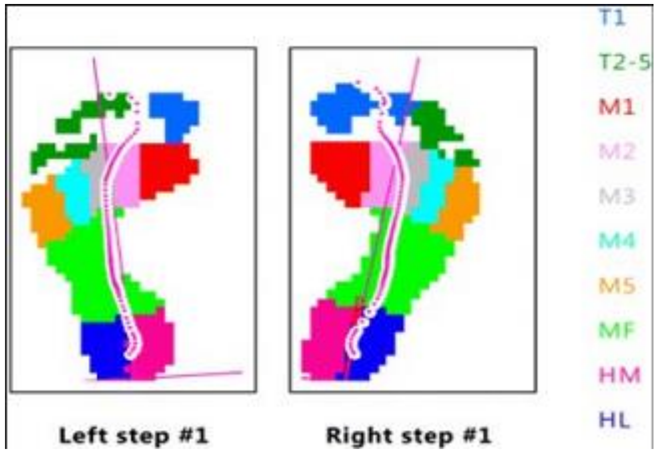


Figure 4: An example of placing masks on plantar areas.

T1 = toe 1, T2-5 = toes 2-5, M1 = metatarsal 1, M2 = metatarsal 2, M3 = metatarsal 3, M4 = metatarsal 4, M5 = metatarsal 5, MF = midfoot, HM = medial heel, HL = lateral heel

This study shows that plantar pressure is higher in cases with active diabetic foot ulcers, although the duration of the standing phase is longer, which is expected to lead to a decrease in plantar pressure. Whether changes in plantar pressure can predict ulcer healing should be at the center of future research. These results highlight the importance of unloading the legs during active ulceration in addition to pre-ulceration.

3. Results And Conclusions

The definitions of the method for calculating the pressure of the plantar surface of the foot are of wide interest to researchers. Plantar pressure measurements are used to diagnose problems in people with diabetes. The support of the foot in a standing position in statics and in dynamics characterizes a change in pressure that leads to deformations of soft tissue in a standing position or while walking; plantar pressure emphasizes the compression of soft tissues (skin, fat layer, ligaments and muscles) of the plantar surface of the foot.

50 patients with diabetes mellitus were examined. The volumetric dimensions of the anterior and middle sections were measured, as well as the geometric parameters of the foot. The severity of foot deformities and the patients' daily activities were assessed.

The efficacy of stress relieving and redistribution of two full contact insoles with different material combinations was compared to the efficacy of a conventional flat insole used as a baseline.

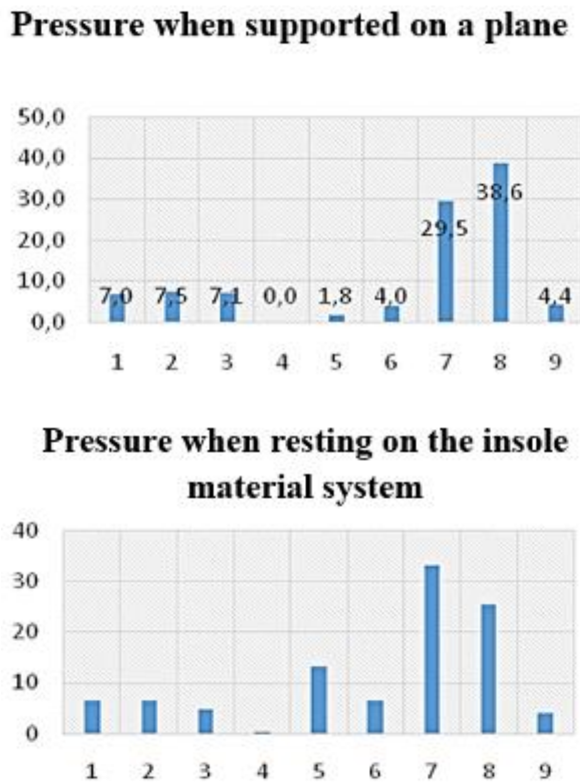
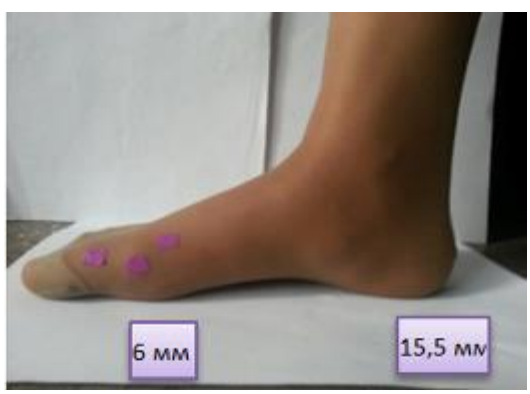
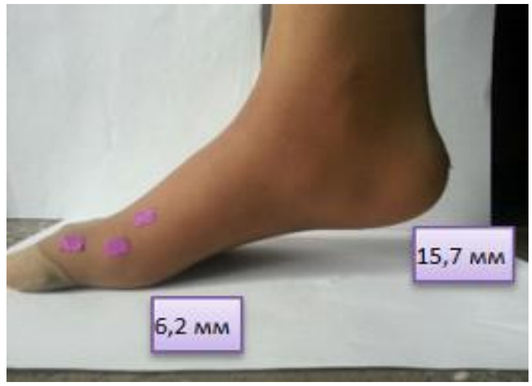


Figure 5: Plantar pressure study using nine load cells

When walking, one leg is a support, the other moves forward and lowers onto the support with the heel, then rolls from the heel to the front and pushes off the support with stoves and fingers.



a)



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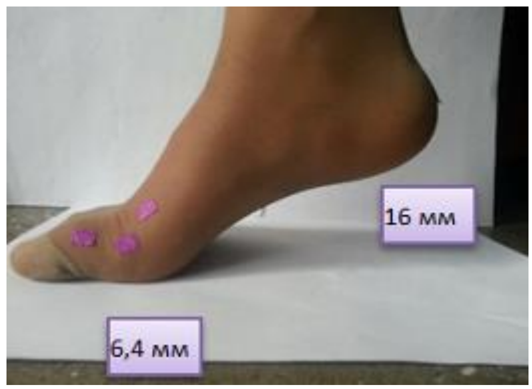

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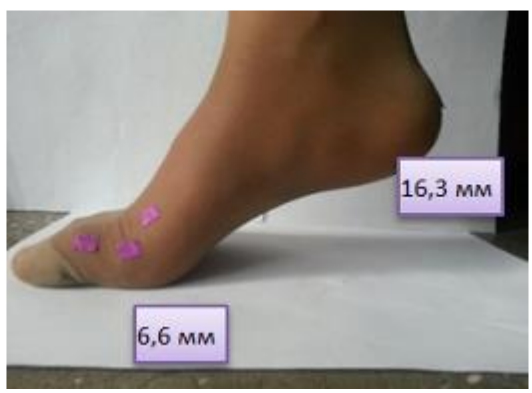

d)

Figure 6: Consecutive foot flexion positions

a) The first phase of movement - the moment of the vertical of the supporting leg - the foot touches the entire plantar surface of the support;

b) In the second phase of movement, the foot is separated from the surface;

c) In the third phase of the movement, the weight of the body is transferred to the forefoot. The phase ends with a push, flexion of the foot, extension of the foot, extension of the lower leg and hip;

d) In the fourth phase, the free leg is bent at the knee and ankle joints.

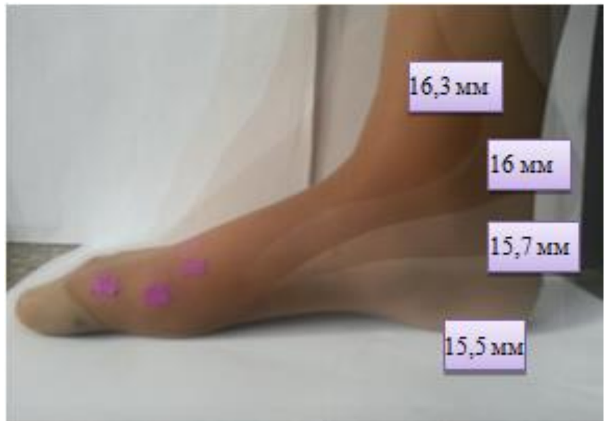

Figure 7: Bending position of the foot

In the standing position, balance is controlled by muscular action that moves the distribution of plantar pressure by changing the rotation of the foot around the ankle (anteroposterior) and redistributing the total body weight to both legs (lateral). The force applied to the ankle compresses the foot. Compression naturally increases plantar pressure. In the standing position, perceived on the surface of the two legs, corresponds to the force arising from the total body mass.

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