SETTING THE ANATOMICAL AND MORPHS-FUNCTIONAL PARTICULARITIES OF THE DIABETIC FOOT PATIENTS USEFUL WHEN DESIGNING SPECIFIC FOOTWEAR

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The study allowed us to establish a set of criteria for rational classification of foot typologies in patients with diabetic based on parameters obtained from the planting footprint analysis. Pathological deviations were determined by comparison with normal foot plantografic parameter values. Thus coefficient previous area in patients with diabetic foot pathology-associated longitudinal flat foot (K1 = 1.24 ± 0.51, RF, K1 = 1.09 ± 0.14 - LF) presents the deviation as both adducted and the abduction of the area and flat foot pathology associated with hallux valgus transverse (K1 = 0.94 ± 0.35, RF, K1 = 0.85 ± 0.83 - LF)- slight deviation in abduction. Transverse arch flattening coefficient and angle of deviation of the big toe associated longitudinal flat foot - K2 = 0.39 ± 0.02, α2 = 8.9 ± 4.5 (RF) K2 = 0.38 ± 0, 01, α2 = 9.2 ± 4.3 (LF) is degree and flat foot hallux valgus associated with cross grades II and III. Longitudinal arch flattening coefficient and the angle of deflection of a flat foot heel longitudinal axis associated - K3 = 1.23 ± 0.62, α3 = -7.4 ± 1.35 (RF), K3 = 1.18 ± 0, 91, α3 = -6.8 ± 1.47 (LF) indicates the deviation degree and valgus. The design of diabetic footwear must be based on a in-depth understanding of the interaction between the footwear design features and the biomechanical characteristics and anatomic-morphs-functional parameters of the foot.

Keywords: foot, diabetes, pathology, anatomic-morphs-functional parameters

INTRODUCTION

Morphological changes of feet encountered within the framework of the different pathologies represent a challenge for the specialists of footwear industry. Thus in terms of their frequency they occupy first place in the structure of orthopedic disease. Diseases of the foot may occur in the case of diseases which are not related to the musculoskeletal system such as, for example, diabetes mellitus.

Diabetic foot is a common complication of diabetes. Diabetic foot care is very important because any injury, even a minor one can lead to serious complications. Due to peripheral nerve lesions (diabetic neuropathy) and blood vessel injuries, small injuries occurring at this level can be easily overlooked and can get over infected. The patient does not feel pain caused by various injuries, in some cases even the discomfort caused by inappropriate footwear. These injuries can cause the foot deformation.

The callus is commonly encountered in people with diabetes, without the peripheral pulse, at the Pedi or posterior tibia, in people with peripheral nerve damage, peripheral neuropathy in people with foot deformities, such as "hammer toes" Charcot arthropathy or "Charcot foot ". All these things can increase the risk of developing diabetic foot ulcers. The blisters are a special form of callus appearing on the fine hairless surfaces of the skin, due to pressure forces acting in an ellipsoidal direction. The most common location for blisters being the dorsum of the foot and the fingers. Unlike callus the blisters have a specific structure with a central core very hard and a soft peripheral area. Often these calluses are painful when putting pressure on their level. They can be removed surgically, but in the most cases they reappear and is a recurring problem for diabetic foot.

THE DESCRIPTION OF THE SUBJECTS INCLUDED IN THE STUDY AND RESEARCH METHODS

The work was developed based on complex examinations of 158 diabetic patients (316 feet) of which 92 were women and 66 men, aged between 21-68 years and weighing 47-110 kg. Examinations and studies have been conducted mainly in the Republican Center Experimental Prosthesis, Orthopedics and Rehabilitation (CREPOR), Republican Clinical Hospital and the Hospital "St. Spiridon" in Chisinau, Republic of Moldova during 2006-2013.

In the study group 38.4 % of the patients (61 persons) were examined by addressing in the clinic of the CREPOR center, and 97 people (61.6%) – in ambulatory conditions. In the study group the patients with diabetes of the type I (insulin-dependent) constituted 68 patients (42.8%), type II (insulin-nondependent) - 82 patients (51.6 %) and diabetes latent (or hidden) - 8 patients (5.6 %).

The primary patients (diabetes was detected for the first time to his addressing) constituted 14.5% (23 patients). The duration of diabetes was to 10 years 67 patients (42.1%), while 68 patients (43.4 %) - more than 10 years. When examining the patients were detected neuro-trophic complications in the distal part of the foot and lower limbs of different forms of severity at 41 patients (25.8%). In 9 patients (5.7%) were determined lesions, ulcers or wounds with relapse in the forefoot and in 32 patients (20.1%) - cracks and fissures in the heel area. The histories of the diseases, these complications were followed from 68 (42.8%) of the patients to who were detected and trophic and fungal damages of the toes' nails and mutilations (hammer toes, claws, etc.). In order to establish the typology of the foot were taken the fingerprints images tree front and side views of the lower limbs. Retrieving images and fingerprint legs planting and its processing was performed using computerized photometric system "Plantovizor".

The digital photometer APC "Plantovizor 2006" is composed of: a plantoscop mirror, double lighting, thick glass graduated two digital cameras, two cameras telescopic stands (Figure 1).

Figure 1. Images taken by shooting for the study

The studied subject climbs on the plantoscop in an orthostatic position. Afterwards are take four pictures from different views: the bottom (plantar); the back (posterior); of the middle side (including the knee and ankle) for the right and the left foot. After shooting, the obtained pictures are downloaded to your computer and processed using specialized software "Casting Sozvezdie" according to the scheme shown in Figure 2.

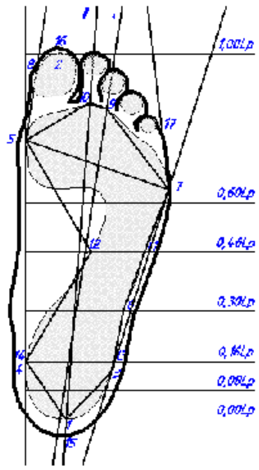

Figure 2. The processing scheme of the Footprint

The analysis of the footprint enables the establishment of the transversal and longitudinal parameters and of the specific angles:

1) The coefficient (shape) of the anterior leg - K1 determines the position of the front part of the foot against the back part and the foot shape which can be: straight K1 = 1.08; flared towards the heel (pes abductus) K1 > 1.08, flaring to the top (pes abductus) K1 < 0.92.

2) The coefficient of the transverse flattening - K2 usually it is between 0.30-0.35. In the case of the transverse flattening there are three degrees of deformation:

3) The coefficient of the longitudinal flattening - K3, is determined as the ratio of the footprint's width, and the width of the contour, measured perpendicular to the tangent line. For the normal foot this coefficient value between 0.51 to 1.00.

Angles:

1) The angle of the Chopart joint (angle α1) - characterizes the lateral deviation of the foot in the mediotarsian area. The value of this angle is in the range of 170-180° for the normal foot and open to the outside. Reducing the amount of the angle down to 130-140 ° indicates the valgus position in the medial zone of the leg. If there is the varus position angle α 1 is open on the inside.

2) The angle of deviation of the big toe (hallux) - α2 is obtained at the intersection of the tangent lines of the thumbprint. Characterizes the position of the thumb, the normal value of which is up to 10°. Exceeding the normal value indicates the presence of the hallux valgus abnormality.

3) The deflection angle of the heel α3 – characterizes the heel's position to the vertical line. Normative value of this angle is between -6° to 1°. The deviation of the heel from the standard values outside leads to the foot anomaly-valgus and the deviation to the inside-the anomaly varus.

The "Plantovizor" enables printing of the results of the investigation on the paper with the form of some records containing information about anthrop-functional and parameter values of the investigated leg (Figure 3).

Figure 3. Images resulted from processing the "Plantovizor" system

EXPERIMENTAL RESULTS AND INTERPRETATIONS

Estimation of the Amount and Severity of Foot Pathologies in Patients with Diabetes

Depending on the type of pathology in patients with diabetic foot have been divided into 12 distinct groups, to which was added the group with diabetes without anatomical changes at the level of the leg (Table 1).

Table 1. The proportion of the foot pathologies in patients with diabetes

Group	Pathologies and deseasof the foot	The number of legs	The percentage of the total number of legs %
1	Flat foot flattening of the longitudinal arch	89	28.2
2	Flat foot flattening of the transversal arch	97	30.7
3	Flat foot flattening of the transversal arch associated with the flattening of the longitudinal arch	86	27.2
4	Hollow foot (pes cavus)	27	8.5
5	Hollow foot it associated with the flattening of the transversal arch	39	12.3
6	Hallux valgus	51	16.1
7	Hallux valgus associated with the flattening of the transversal arch	54	17.4
8	Hindfoot valgus (pes valgus)	48	15.2
9	Hindfoot varus (pes varus)	12	3.8
10	Hammer fingers or claws	69	21.8
11	Blisters, calus and hyperkeratosis	204	64.6
12	Amputation of the fingers	48	15.2
13	Lack of anatomical changes in the foot	36	11.4

Anatomic-morphed-functional parameters of the foot in patients with diabetes

The results of investigations carried plantographic lower limb and foot diabetic patients divided into two groups, enabled the setting global parameters which were calculated anatomic-morph-functional statistical indicators (Table 2). Statistical significance of values for the left leg, respectively as compared to the mean left foot /

right foot was tested using Student t test (T -test). In the case of an n number of subjects with a high degree of freedom, df = 2 x (n-1), an acceptable probability of P = 65 % and the value of $\alpha = 0.05$, Student's t test is applied (T-test). As a working hypothesis it is considered that the variation in group 1 (left leg) is not significantly different statistically from the change to group 2. The obtained value of the test statistic, the value of t and p, where p = 0.05 compared, the higher is acceptable thus, the initial hypothesis, whereby the size of the group 1 (left foot) is not significant statistically different those of group 2 (right foot).

Table 2. The global values of anatomic-morphs-functional parameters in patients' foot who have diabetes

The anatomorphofunctional parametres	The foot of the patients with diabetes				Normal foot
	With the associated longitudinal flat foot patology		With the transversal flat foot associated with hallux valgus		
	Right foot (RF) M±σ	Left foot (LF) M±σ	Right foot (RF) M±σ	Left foot (LF) M±σ	
The coefficient of the anterior zone of the foot (K1)	1,24±0,51 **	1,09±0,14 *	0,94±0,35***	0,85±0,83 *	0,92-1,08
The coefficien of fllatening of the transversal vault (K2)	0,39±0,02 *	0,38±0,01 *	0,45±0,18**	0,43±0,07 *	0,25-0,35
The coefficien of fllatening of the longitudinal vault (K3)	1,23±0,62 **	1,18±0,91 *	1,01±0,47*	0,89±0,60 **	0,51-1,00
The angle of the Chopart jointα1,º	175,7±1,2 **	174,7±1,6 *	145,7±1,3**	132,7±1,9 ***	170-180º
The deviation angle of the big toe α2,º	8,9±4,5*	9,2±4,3**	18,4±3,8 *	19,2±4,1 ***	till 10º
The deviation angle of the sole's axis towards the vertical α3,º	-7,4±1,35 ***	-6,8±1,47 *	-2,7±1,08 *	-4,6±1,16 **	from -6 till +1º
The deviation angle of the leg's axis towards the vertical,º	1,2±0,5*	0,9±0,47 **	1,3±0,45 *	1,4±0,32 ***	0-5º

Note: * - $p<0.05$, ** - $p<0.01$, *** - $p<0.001$

Pathological deviations were determined by comparison with normal foot plantografic parameter values. Thus coefficient previous area in patients with diabetic foot pathology - associated longitudinal flat foot (K1 = 1.24 ± 0.51, RF, K1 = 1.09 ± 0.14 - LF) presents the deviation as both adducted and the abduction of the area and flat foot pathology associated with hallux valgus transverse (K1 = 0.94 ± 0.35, RF, K1 = 0.85 ± 0.83 - LF)- slight deviation in abduction. Transverse arch flattening coefficient and angle of deviation of the big toe associated longitudinal flat foot - K2 = 0.39 ± 0.02, $\alpha2$ = 8.9 ± 4.5 (RF) K2 = 0.38 ± 0,01, $\alpha2$ = 9.2 ± 4.3 (LF) is degree and flat foot hallux valgus associated with cross - K2 = 0.45 ± 0.18, $\alpha2$ = 18.4 ± 3.8 (RF), K2 = 0.43 ± 0.07, $\alpha2$ = 19.2 ± 4.1 (LF) grades II and III. Longitudinal arch flattening coefficient and the angle of deflection of a flat foot heel longitudinal axis associated - K3 = 1.23 ± 0.62, $\alpha3$ = -7.4 ± 1.35 (RF), K3 = 1.18 ± 0,91, $\alpha3$ = -6.8 ± 1.47 (LF) indicates the deviation degree and valgus and flat foot hallux valgus associated transverse K3 = 1.01 ± 0.47, α3 = -2.7 ± 1.08 (RF), K3 = 0.89 ± 0.60, α3 = -4.6 ± 1.16 (LF) degree without axis deviation heel.

CONCLUSION

The anatomical proportions of the foot in patients with diabetes have specific features and represent an association of pathologies and disorders. The study allowed us to establish a set of criteria for rational classification of foot typologies in patients with diabetic based on parameters obtained from the planting footprint analysis. Examination of the fingerprints planting is a quick and simple method which led to obtaining configuration parameters for the quantification of the foot and creation of a data base. The usefulness of this classification can be found both in the subsequent analyzes of anthropometric parameters and in modeling and designing specific footwear. The design of diabetic footwear must be based on a in-depth understanding of the interaction between the footwear design features and the biomechanical characteristics and anatomic-morphs-functional parameters of the foot. The obtained information by morph-structural setting foot type designer footwear is used in the design of the customized products for each subject, depending on the complex manifestations of structural change identified and the risk in the foot areas.

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