ESTABLISHING ANTHROPOMETRIC FOOT SIZES OF THE MALE POPULATION IN ROMANIA IN ORDER TO DEVELOP AN ORIGINAL ROMANIAN STANDARD

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The purpose of this scientific paper is to present aspects related to a pre-project to develop an Original Romanian Standard by establishing anthropometric foot sizes of Romanian male population, specifying the size systems used in the design and development of lasts used to make shoes in the footwear industry. In the anthropometric survey conducted in Romania, the 3D shape of the foot in order to calculate anthropometric parameters was captured using the INFOOT USB system made up of the 3D scanner and the dedicated MEASURE 2.8 software. Anthropometric studies were conducted on a sample of 300 male subjects from three geographic regions of Romania: South (100 subjects), East (100 subjects) and Centre and West (100 subjects), aged between 24 and 72. Subjects with particular anthropometric features, including deformities and structural abnormalities of the foot, were excluded. Sizes obtained by processing are itemised in an individual anthropometric chart. A data base comprising 300 anthropometric charts was compiled. Values of each dimensional parameter were centralized in a table that constitutes a database. Anthropometric data were grouped for each foot size. The interdimensional interval was determined for each anthropometric size, for each size and standardized values were established.

Keywords: anthropometric parameter, size, foot.

INTRODUCTION

Making high quality footwear with an optimal comfort degree is conditioned by mastering processing techniques of anthropometric data from 3D foot scanning, by transposing anatomic-morphological and biomechanical information into design and modelling parameters for lasts and footwear models. Correlating the inner sizes of shoes with anthropometric foot sizes is particularly important in order to meet comfort conditions (Mochimaru *et al.*, 2000; Nácher *et al.*, 2006; Reel *et al.*, 2010). Building the anthropometric database and studying it will enable us to make anthropometric standards in accordance with the current sizes of the population.

MATERIALS AND METHODS

3D Image Capturing of the Foot and Processing Data Required to Make a Database for Anthropometric Parameters

In the anthropometric survey conducted in Romania, the 3D shape of the foot in order to calculate anthropometric parameters was captured using the INFOOT USB system (Fig. 1) made up of the 3D scanner and the dedicated MEASURE 2.8 software. The system enables scanning the foot shape and is intended for use in research, to design suitable footwear lasts (Sarghie, 2013).

Figure 1. 3D Scanner (INFOOT) - Capturing foot sizes using the 3D scanner

As a result of foot shape scanning operations and placing anatomical points on the surface of the scanned foot shape, values are determined for 20 anthropometric parameters (Table 1).

Table 1. Anthropometric parameters of the foot

1.	Foot length	Lp	(mm)	11.	Toe 1 height	Hd1	(mm)
2.	Ball girth circumference	Pd	(mm)	12.	Toe 5 height	Hd5	(mm)
3.	Foot breadth	ld	(mm)	13.	Height of navicular	Hn	(mm)
4.	Instep circumference	Pr	(mm)	14.	Height of Sphyrion fibulare	Hsf	(mm)
5.	Heel breadth	lc	(mm)	15.	Height of Sphyrion	Hs	(mm)
6.	Instep length	Lr	(mm)	16.	Height of the most lateral point of lateral malleolus	Hme	(mm)
	Toe height			17.	Height of the most medial point of medial malleolus	Hmi	(mm)
7.				18.	Heel angle	Uc	(°)
8.	Instep height	Hr	(mm)	19.	Heel girth	Pc	(mm)
9.	Toe 1 angle	Ud1	(°)	20.	Ankle girth	Pg	(mm)
10.	Toe 5 angle	Ud5	(°)				

Developing a Database of Anthropometric Foot Parameter Values of Adult Male Population in Romania

Anthropometric studies were conducted on a sample of 300 male subjects from three geographic regions of Romania: South (100 subjects), East (100 subjects) and Centre and West (100 subjects), aged between 24 and 72. Subjects with particular anthropometric features, including deformities and structural abnormalities of the foot, were excluded. Sizes obtained by processing are itemised in an individual anthropometric chart (Fig. 2). A data base comprising 300 anthropometric charts was compiled (Fig. 3).

Figure 2. Individual anthropometric file

Figure 3. Database of anthropometric files

Statistical processing of data will enable the development of anthropometric standards in accordance with the current sizes of the population.

RESULTS AND DISCUSSIONS

Pre-project for Developing an Original Romanian Standard

In order to establish anthropometric foot sizes of Romanian male population, the 20 anthropometric parameters are presented and described in Table 2.

Table 2. Anthropometric foot parameters of adult male population

No.	Name and u.m.	Image	Description
1	Foot length Lp (mm)		Distance measured in the horizontal plane, between the perpendiculars to the extremities of toe 2 and the most protruding part of the heel
2	Ball girth circumference Pd (mm)		The circumference of the foot measured through the points that mark toe 1 and toe 5

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No.	Name and u.m.	Image	Anthropometric parameters	Description
3	Foot breadth ld (mm)			Projection on a horizontal plane of the toe circumference, which represents the horizontal distance between the perpendiculars in contact with the first and fifth metatarsophalangeal joints
4	Instep circumference Pr (mm)			The circumference of the foot measured through the point marking the instep
5	Heel breadth lc (mm)			Projection of heel girth on a horizontal plane
6	Instep length Lr (mm)			The distance measured horizontally between the perpendiculars passing through the point marking the instep and the most protruding part of the heel
7	Toe height Hd (mm)			The vertical distance measured between the highest point on the line marking the ball girth and the horizontal plane tangent to the plantar part of the foot
8	Instep height Hr (mm)			The distance measured vertically between the point marking the instep and the horizontal plane tangent to the plantar part of the foot
9	Toe 1 angle Ud1 °			The angles formed by the tangents in the vertical plane at the first and the fifth metatarsophalangeal joint and the lines joining the points marking the two joints with the ends of the heel width
10	Toe 5 angle Ud5 °			The angles formed by the tangents in the vertical plane at the first and the fifth metatarsophalangeal joint and the lines joining the points marking the two joints with the ends of the heel width
11	Toe 1 height Hd1 (mm)			The measured vertical distance between the point marking the joint of toe 1 and the point marking the joint of toe 5 and the horizontal plane tangent to the plantar part of the foot
12	Toe 5 height Hd5 (mm)			The measured vertical distance between the point marking the joint of toe 1 and the point marking the joint of toe 5 and the horizontal plane tangent to the plantar part of the foot

Anthropometric parameters			
No.	Name and u.m.	Image	Description
13	Height of navicular Hn (mm)		The distance measured vertically between the point of the navicular and the horizontal plane tangent to the plantar part of the foot
14	Height of Sphyrion fibulare Hsf (mm)		The measured vertical distance between the lower point of the lateral malleolus and the horizontal plane tangential to the plantar part of the foot
15	Height of Sphyrion Hme (mm)		The measured vertical distance between the point marking the center of the lateral malleolus and the horizontal plane tangent to the plantar part of the foot
16	Height of the most lateral point of lateral malleolus Hs (mm)		The measured vertical distance between the lower point of the medial malleolus and the horizontal plane tangent to the plantar part of the foot
17	Height of the most medial point of medial malleolus Hmi (mm)		The distance measured vertically between the point marking the center of the medial malleolus and the horizontal plane tangent to the plantar part of the foot
18	Heel angle Uc °		The angle formed by the horizontal perpendicular through the most prominent part of the heel and the inclined axis of the foot
19	Heel girth Pc (mm)		The circumference of the foot measured through the junction and the extreme rear points of the foot
20	Ankle girth Pg (mm)		The circumference of the foot measured through the points marking the malleoli

The interdimensional interval was determined for each anthropometric size, for each size and standardized values were established.

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Basic sizes required for making lasts are: foot length (Lp), ball girth (Pd), instep girth (Pr), ball width (ld) and heel width (lc). Standardized variants for these parameters, for each size are presented in Table 3.

Table 3. Standardized variants for basic parameters, for each size

Anthropometric parameter (u.m.)	39	40	41	Foot size				
				42	43	44	45	46
Lp (mm)	245	253	261	269	277	285	293	301
Pd (mm)	248	254	260	266	272	278	284	290
Pr (mm)	250	255	260	265	270	275	280	285
ld (mm)	102.3	104.5	106.7	108.9	111.1	113.3	115.5	117.7
lc (mm)	64.8	66.2	67.6	69	70.4	71.8	73.2	74.6

Limits of interdimensional intervals for parameters Lp and Pd are indicated in Tables 4 and 5.

Table 4. Limits of interdimensional intervals for foot length

Standardized value (mm)	Interdimensional interval (mm)	Standardized value (mm)	Interdimensional interval (mm)
245	241-248.9	277	273-280.9
253	249-256.9	285	281-288.9
261	257-264.9	293	289-296.9
269	265-272.9	301	297-304.9

Table 5. Limits of interdimensional intervals for ball girth

Standardized value (mm)	Interdimensional interval (mm)	Standardized value (mm)	Interdimensional interval (mm)
248	245-250.9	272	269-274.9
254	251-256.9	278	275-280.9
260	257-262.9	284	281-286.9
266	263-268.9	290	287-292.9

CONCLUSIONS

As a result of 3D scanning and processing anthropometric data, a database of anthropometric foot parameters of Romanian adult male population was developed. Statistical processing of data enabled the development of a pre-project for an Original Romanian Standard.

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