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Short report

Harmonic Structure of Selected Ergonomic Anthropometric Sizes

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A B S T R A C T

Based on the anthropometric researches of the female population of the Dalmatian islands of Hvar, Korčula, Olib and Silba conducted by the Institute of Anthropology of the University of Zagreb[7], a sample of 200 clinically healthy women was performed. From the mean value of 25 anthropometric sizes, using a harmonic circle canon, a biomechanical model of harmonic structure of ergonomic anthropometric sizes was constructed. The model shows the accentuated structure and proportionality of the human body.

Key words: *anthropometry, harmonic circle, proportions of the human body*

Introduction

The relation between individual parts of the human body is historically observed. Art has taken different standards. The technical science was challenged with an urgent need to determine the size of human body, which will serve for construction of machines, traffic vehicles, furniture, clothes etc. Various forms of measures have been established that have not been harmonized to date. So, for example on clothing, we often have a list of different norms and form of norms which are applied in some countries. Special problem, except for incompatibility, also makes the need for modern design to determine the precise size of individual body parts. In this paper, we will show the relations of human body parts in the canon of the harmonic circle.

Harmonic circle

The useful contribution to the definition of the length of body parts gives the so-called the Zederbauer harmonic circle, which is shown in the Picture 1.(Figure 1)

The relations in the harmonic circle are defined as follows[1]:

$a=1$ Hypotenuse of the harmonic triangle

$b = \frac{\sqrt{2}}{2}$ Cathetus of the harmonic triangle side

$R = \frac{\sqrt{5}}{2}$ Radius of the harmonic circle

$$r = \frac{\sqrt{2}-1}{2} = b - \frac{a}{2}$$

$$d = \frac{\sqrt{5}-1}{2} = R - \frac{a}{2}$$

$$b + r = \frac{2\sqrt{2}-1}{2}$$

Calculated values of parts of the harmonic circle are:

a = 1	b = 0,7071	R = 1,118
r = 0,207	d=0,618	b + r = 0,914

Materials

In this paper the data of the Institute of Anthropology of the University of Zagreb were used to measure the population of the island Hvar (100 women examinees), Korcula (80 women examinees), Olib (10 women examinees) and Silba (10 women examinees)[7]. All participants were female, clinically healthy and without any obvious physical disadvantages or morphological aberrations regardless of age. Anthropometric measurements of the following body sizes A_n were performed:

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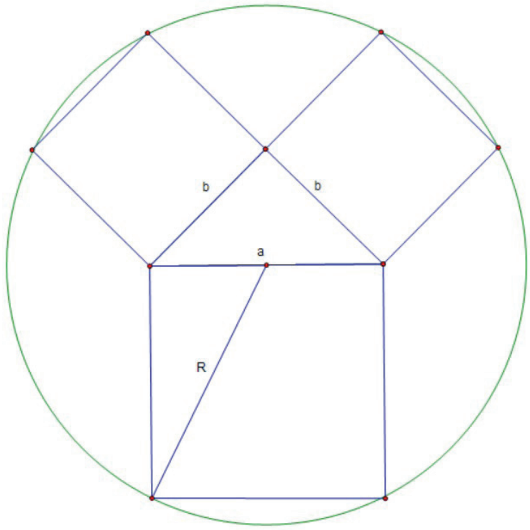

Fig. 1. Harmonic circle[9].

1.Standing height
2. Sitting height
3. Leg length
4. Length of the thigh
5. Lower leg length
6. Hand length
7. The length of the upper arm
8. The length of the forearm
9. Bi-chromium width
10. Chest width
11. Depth of chest
12. Bowl width
13. Head length
14. Head width
15. Face width
16. Lower jaw width
17. Morphological height of the face
18. Pelvic area
19. Abdominal circumference
20. Upper arm circumference
21. Forearm circumference
22. Thigh circumference
23. Lower leg circumference
24. Head circumference
25. Weight of the body

The measurements are described in the publication of the Institute of Anthropology „Practicum of Biological Anthropology"; Zagreb, 1975.[8]

If we return to the harmonic circle of the mean value off the standing height, we will associate it with the variable H that in the harmonic circle represents the diameter H = 2 R. For the so defined variable R we get the following value of the harmonic variables in the circle. (Table 1)

As for the mean values in Table 1.

R = 811 a = 725,38 b = 512,29

r = 150,23 d = 448,30

The variables R, a, b, r, d are with associating brought into dependency of H bonds, i.e. standing height, so they can express all other anthropometric sizes shown in Table 2. (Table 2)

A correlation analysis with two sets of AMOUNTED and CALCULATED values was performed and we get Table 3.[5]

The Person Correlation coefficient is 0.999, which confirms the extremely high degree of correlation. (Table 4)

TABLE 1

VALUES OF MEASURED ANTHROPOMETRIC SIZES

An	An (mean)	SD	Var	Min	Max
1	1622	60,691	3683,4	1431	1782
2	860,29	38,638	1492,9	741	967
3	962,25	51,476	2649,8	789	1096
4	495,16	49,895	2489,5	385	611
5	378,88	27,770	771,16	316	576
6	697,83	54,341	2953,0	370	781
7	310,62	19,217	369,31	260	370
8	241,36	16,725	279,74	200	286
9	363,63	18,863	355,80	299	414
10	255,65	19,183	367,98	200	300
11	188,61	19,076	363,91	106	256
12	286,33	23,202	538,34	218	350
13	180,68	6,7443	45,485	163	200
14	146,09	6,2780	39,413	119	159
15	132,77	5,8599	34,339	113	149
16	105,33	6,9030	47,651	86	140
17	118,02	7,9751	63,602	98	142
18	949,90	80,844	6535,8	730	1400
19	931,71	103,51	10714	652	1370
20	291,17	31,453	989,30	212	388
21	247,36	19,066	363,51	200	318
22	429,10	50,211	2521,1	215	630
23	356,61	30,637	938,63	234	452
24	559,70	18,328	335,92	500	603
25	684,44	108,38	11745	380	999

TABLE 2

CALCULATED VALUES ANTHROPOMETRIC SIZES IN CANON OF THE HARMONIC CIRCLE[4]

An	Measured values An	Harmonic sizes	Harmonic sizes (H)	Calculated harmonic values An
1	1622	2R	H	1622
2	860,29	R+r/3	0,53087 H	861,08
3	962,25	r+R	0,59262 H	961,24
4	495,16	b	0,31623 H	512,93
5	378,88	b-r	0,22361 H	362,70
6	697,83	a	0,44722 H	725,40
7	310,62	2r	0,18524 H	300,47
8	241,36	d/2	0,13819 H	224,15
9	363,63	a/2	0,22361 H	362,70
10	255,65	b/2	0,15811 H	256,46
11	188,61	a/4	0,11178 H	181,32
12	286,33	(b+r/2)/2	0,18127 H	294,03
13	180,68	a/4	0,11178 H	181,32
14	146,09	r	0,09262 H	150,24
15	132,77	b/4	0,07903 H	128,20
16	105,33	b/5	0,06325 H	102,60
17	118,02	d/4	0,06910 H	112,09
18	949,90	a+d/2	0,58544 H	949,59
19	931,71	a+d/2	0,58544 H	949,59
20	291,17	2r	0,18524 H	300,47
21	247,36	a/3	0,14908 H	241,81
22	429,10	(b+d)/2	0,29630 H	480,61
23	356,61	b+r	0,22361 H	362,70
24	559,70	a-r	0,35457 H	575,12
25	684,44	R-r	0,40738 H	660,78

TABLE 3

MEAN VALUES OF MEASURED SIZES

		Mean values of measured sizes	Calculated harmonic sizes
Mean values of measured sizes	**Pearson Correlation**	1	**,999****
	Sig. (2-tailed)		**,000**
	N	25	**25**
Calculated harmonic sizes	**Pearson Correlation**	**,999****	**1**
	Sig. (2-tailed)	**,000**	
	N	**25**	25

TABLE 4.

KENDALL'S TAU_B AND SPEARMAN'S RHO OF MEAN VALUES OF MEASURED SIZES

			Mean values of measured sizes	Calculated harmonic sizes
Kendall's tau_b	Mean values of measured sizes	Correlation Coefficient	1,000	,990**
		Sig. (2-tailed)	.	,000
		N	25	25
	Calculated harmonic sizes	Correlation Coefficient	,990**	1,000
		Sig. (2-tailed)	,000	.
		N	25	25
Spearman's rho	Mean values of measured sizes	Correlation Coefficient	1,000	,999**
		Sig. (2-tailed)	.	,000
		N	25	25
	Calculated harmonic sizes	Correlation Coefficient	,999**	1,000
		Sig. (2-tailed)	,000	.
		N	25	25

Also performed nonparametric test gives Kendall and Spearman coefficient 0,999, which are confirmed by the previous quotation. (Figure 2)

Let us take a look at the graph from which it is apparent that with high degree of certainty we can confirm that it is possible to calculate other anthropometric sizes from the height that will coincide with the exact size of the person with the condition that the person does not deviate from the statistical average obtained by the measurement.

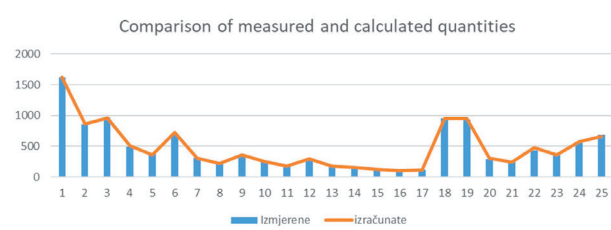

Fig. 2. Comparison of measured and calculated quantities.

Egronomic Anthropometric Sizes

In our work, problems are often caused by lack of familiarity with some of ergonomic anthropometric sizes. These sizes are sometimes impossible to measure, so we will try to calculate them. In the canon of the harmonic circle we will define the relations of anthropometric ergonomics as a linear function and we will be able to calculate them.[8] Such an attempt is given in Table 3.[5]

The following sizes and associated mean values were measured on a sample of 200 women:

(Table 5)

(Figure 3)

(Table 6)

TABLE 5

MEASURED VALUES IN 200 WOMEN

	MESURED VALUES	WOMEN
A	Standing height	165
B	Eye height	154
C	Shoulder height	134
D	Elbow height above floor	103
E	Knee height	49
F	Arm range	165
G	Hand length measured from the outline of the back	71
H	Length of forearm with fist	43
I	Shoulder width	40
K	The hull thickness in the chest	25
L	Width of thighs	34
M	Sitting height	84
N	Eye height when sitting	73
O	Shoulder height when sitting	54
P	Elbow height when sitting	21,5
R	Knee distance from back while sitting	56
S	Height of the thigh while sitting	46
T	Height of sitting above floor	43
U	Height of the thigh while sitting	14
V	Length of the foot	25
X	Width of the foot	9
Y	Length of the wrist	17,5

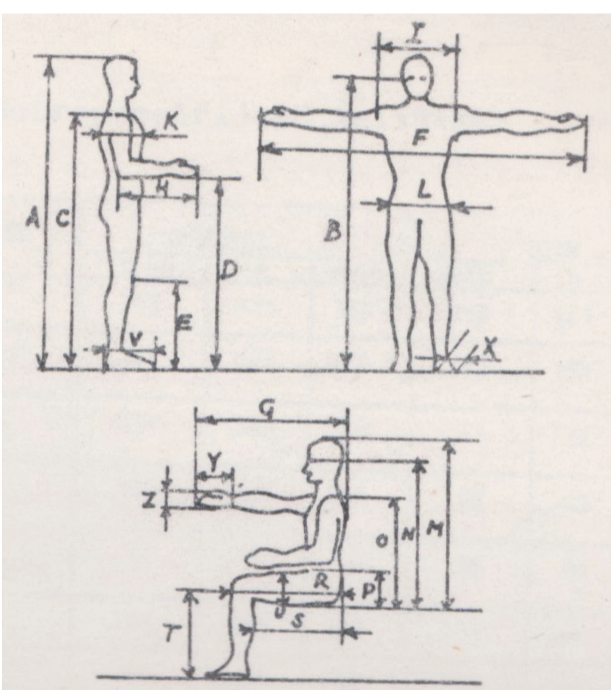

Fig.3. Defined ergonomic anthropometric sizes.[4]

TABLE 6

MEASURED VS. CALCULATED SIZES

	WOMAN		
	MESURED		CALCULATED
A	165	2R	165
B	154	R+a	156,30
C	134	2(b+r)	134,88
D	103	2b	104,34
E	49	b	52,17
F	165	2b+a	174,48
G	71	a	73,80
H	43	d	45,60
I	40	d	45,60
K	25	d/2	22,80
L	34	2r	30,54
M	84	R	82,50
N	73	a	73,80
O	54	b	52,17
P	21,5	d/2	22,80
R	56	4r	61,08
S	46	d	45,60
T	43		
U	14		
V	25	b/2	26,09
X	9		
Y	17,5		

The analysis is performed on data which is obtained by measurement and by counting. The missing variables are excluded (T, U, X, Y) by performing a correlation test in all pairs to get an extremely high degree of correlation (0.973 Kendall tau, 0.995 Spearman tau.) as it is shown in the analysis. (Table 7)

This is supported by the assumption that the other anthropometric sizes of females can be determined with high certainty from one measured anthropometric size.[3]

TABLE 7

CORRELATIONS

			measured	calculated
Kendall's tau_b	measured	Correlation Coefficient	1,000	,973**
		Sig. (1-tailed)	.	,000
		N	22	18
	calculated	Correlation Coefficient	,973**	1,000
		Sig. (1-tailed)	,000	.
		N	18	18
Spearman's rho	measured	Correlation Coefficient	1,000	,995**
		Sig. (1-tailed)	.	,000
		N	22	18
	calculated	Correlation Coefficient	,995**	1,000
		Sig. (1-tailed)	,000	.
		N	18	18

**. Correlation is significant at the 0.01 level (1-tailed).

Conclusion

Anthropometric measurements of multiple variables are demanding and long-lasting, so this method of calculation in the canon of the harmonic circle is advantageous to define the sizes required by anthropometric analyses. Furthermore, the ability to calculate accurately the ergonomic anthropometric sizes that we have no ability of measuring, is confirmed. In this paper the approach of estimation and calculations of ergonomic anthropometric measurements is shown. This leads to high degree of correlation with actual measurements on a representative sample.

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All authors have equally contributed to this work.

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HARMONIJSKA STRUKTURA ODABRANIH ERGONOMSKIH ANTROPOMETRIJSKIH VELIČINA

SAŽETAK

Na temelju antropometrijskih istraživanja ženske populacije dalmatinskih otoka Hvara, Korčule, Oliba i Silbe koje je proveo Institut za antropologiju Sveučilišta u Zagrebu izveden je uzorak od 200 klinički zdravih žena. Iz srednjih vrijednost 25 antropometrijskih veličina, pomoću kanona harmonijske kružnice, iskonstruiran je biomehanički model harmonijske strukture ergonomskih antropometrijskih veličina. Tim je modelom pokazana naglašena struktura i proporcionalnost ljudskog tijela.