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ANALYSIS OF THE MAIN STATISTICAL PARAMETERS CHARACTERIZING ANTHROPOMETRIC SIZES

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Abstract: *The present paper shows an analysis of the main statistical parameters used to characterize selected anthropometric measurements, aimed at creating a database representative of a sample of 150 men, aged 20-29 years.*

Key words: anthropometry, anthropometric characteristics, statistical processing

1. INTRODUCTION

This paper was developed based on research conducted on a sample of 150 men aged 20-29 years, with stages of the research previously presented in various works [1]… [5]. A database of anthropometric measurements was created for this sample, enabling statistical processing aimed at developing a modern methodology for the scientific design of men's clothing for the specified age group, based on research into anthropomorph logical characteristics.

2. GENERAL INFORMATION

The statistical processing involves going through some stages that in a logical sequence bring us closer to the purpose of the research, as follows:

a) *Observation:* collection and verification of primary data obtained through censuses, statistical reports, surveys, monographs, polls, etc.;
b) *Processing:* systematization of collected data into tables, series, and graphs; calculation of statistical indicators (averages, relative sizes, variability indicators, correlation indicators, indices, etc.);
c) *Analysis and interpretation:* comparison and confrontation of results, hypothesis verification, conclusion formulation, and basis for forecasting calculations;
d) *Database creation*.

Industrial clothing design is carried out for mass-produced items, using anthropometric standard dimensions for specific body types as the basis for calculations. A dimensional typology is established based on a precise understanding of morphological differences between population types.

Studying the entire population is practically impossible, so the selection method is used to characterize the community. This involves conducting anthropometric surveys on a predetermined and studied sample of subjects selected from the general population, known as a sample, to characterize the entire population.

For the results obtained from processing data provided by the selection to be extended to the entire population, the selection must be:

- *homogeneous* (when subjects share common traits: age, sex, race, geographic environment, social environment, work conditions) and
- *representative* for the entire population (when it includes all characteristic elements of the group from which it is drawn, and these elements are represented in the sample in the same proportion as in the general population).

Mass-produced clothing excludes the possibility of direct measurement of each consumer, even though the industry is concerned with satisfying the entire population with industrially produced clothing. This can only be achieved if the diversity of subjects is represented by a sufficient number of body types selected in such a way that clothing items designed for these figures will meet the needs of the majority of consumers. The collection of these body types is referred to as dimensional typology, which is regulated by the current anthropometric standards (body type system).

Dimensional typology must be established based on precise knowledge and characterization of the morphological differences in the types encountered within the population and the frequency of these types. To achieve this, anthropometric surveys are conducted, and data obtained from them are processed.

Data obtained from anthropometric measurements require unidimensional or bidimensional statistical processing. This is necessary because, to characterize the size and variability of anthropometric indicators within a population sample, mathematical statistical methods are employed.

For analyzing the distribution shape and determining the statistical parameters that characterize each anthropometric measurement, unidimensional statistical processing is applied. In this process, each anthropometric measurement is treated as an independent variable, and the recorded data from a sample of volume "n" are processed sequentially for each measurement separately.

The main stages in this processing are:

1. Determining the sample volume representative of the population to be studied;
2. Ordering the data series, grouping them into classes, and determining the frequencies;
3. Graphical representation of the variation series (experimental distribution curve);
4. Calculating the mean sizes and variation indicators;
5. Analyzing the form of the variation curve and adopting the mathematical model that best characterizes the experimental distribution.

The calculations and interpretations in this work are based on the notions presented below, which have broad applicability in processing anthropometric data:

- Creating the "n" variation string and establishing its extreme values (x_{min}, x_{max}), between which the remaining values are ordered in ascending order;
- The number of classes, which is determined by the relationship:

$$k=1+3{,}322\lg n \qquad (1)$$

k = number of classes;

n = total number of measurements;

- The interval between two successive classes:

$$c=\frac{A}{k}=\frac{x_{\max}-x_{\min}}{1+3{,}322\lg n} \qquad (2)$$

A = the amplitude of the variation parameter in the selection.

- The number of classes in the classical grouping of measured values (m), the middle of the class (x_j) and the absolute frequency corresponding to "m" in a classical grouping of measured values (f_m):

$$m=\frac{x_j-\overline{x_a}}{c} \qquad (3)$$

- the meeting frequency within the variation string (absolute frequency "n_i" or relative frequency „f_i”):

$$f_i=\frac{n_i}{n}\times 100 \qquad (4)$$

For data grouped by classes, the cumulative frequency for each class is calculated.

The variation series can also be graphically represented, appearing in different forms: histogram, polygon or frequency curve, cumulative frequency curve, etc.

The variation series and its graphical representation provide an overview of how an anthropometric size varies.

For the complete characterization of the anthropometric variables, in numerical form, a series of statistical parameters for the characterization of the anthropometric variables (average sizes and variation indicators) must be calculated, according to the calculation relations below:

- Arithmetic mean of selection ($\bar{x}$):

$$\bar{x}=\frac{\sum_{i=1}^{n}x_i}{n} \quad \text{(cm)} \qquad (5)$$

- Median (Me):

$$Me = x_{\frac{n+1}{2}} \quad \text{(cm)} \qquad (6)$$

$$\text{Me} = \frac{x_{\frac{n}{2}} + x_{\frac{n}{2}+1}}{2} \qquad \text{(cm)} \qquad (7)$$

- Mode (Mo):

$$\text{Mo} = \bar{x} - 3(\bar{x} - Me) \qquad \text{(cm)} \qquad (8)$$

- Amplitude (A):

$$A = x_{max} - x_{min} \qquad \text{(cm)} \qquad (9)$$

- Selection dispersion (s_x^2):

$$s_x^2 = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 \qquad (10)$$

- Mean squared deviation of the selection (s_x):

$$s_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \qquad (11)$$

- Coefficient of variation (C_v):

$$C_v = \frac{s_x}{\bar{x}} \times 100 \qquad (\%) \qquad (12)$$

- Significance test applied to the selection mean ($t_{\bar{x}}$):

$$t_{\bar{x}} = \frac{\bar{x}}{s_x} \qquad (13)$$

- Average squared deviation of the mean value ($s_{\bar{x}}$):

$$s_{\bar{x}} = \frac{s_x}{\sqrt{n}} \qquad (14)$$

- Limit error of the selection mean ($\Delta\bar{x}$):

$$\Delta\bar{x} = t_{student} \times s_{\bar{x}} \qquad (15)$$

- Limits of a confidence interval for the average collectivity:

$$x_{inf} = \bar{x} - \Delta\bar{x} \ ; \ x_{sup} = \bar{x} + \Delta\bar{x} \qquad (16)$$

$$\bar{x} - \Delta\bar{x} < \bar{x} < \bar{x} + \Delta\bar{x} \qquad (17)$$

- Probable error of the average (e_M):

$$e_M = \frac{s_{\bar{x}}}{\bar{x}} \times 100 \qquad (\%) \qquad (18)$$

According to specialized literature, it is known that for the extreme values of a string, the absolute frequencies are lower, decreasing compared to the frequency of the average value. This phenomenon can be described using fundamental theoretical distributions in probability theory [7], by analogy with the theoretical Gauss-Laplace distribution, also called the normal distribution law.

An experimental value series is tested for compliance with such a distribution using the following methods:

- *Graphically representing the polygons of absolute frequencies of the analyzed measurements* and comparing the obtained graphs with theoretical representations of the normal distribution curve;
- *Applying the "hi-square" test" (χ^2)* and comparing the calculated value of χ^2 for a level of confidence (1-α), with the corresponding value for the same number of degrees of freedom;
- *Determining the values of the coefficients of asymmetry (β_1), vaulting (β_2) and excess (E) and the distribution error*, and comparing the obtained data with those characteristics of the Gauss-Laplace distribution.

In the case of the studied age group, for the complete appreciation of the variation of the main anthropometric sizes characterizing the male human body (body height, bust perimeter and waist perimeter), the checks mentioned above were carried out, checks which were presented in previous works [1], [4].

In addition to the primary dimensions, 33 other secondary anthropometric measurements were subjected to unidimensional statistical processing. These secondary measurements characterize the human body dimensionally and are part of the structural relations proposed for the anthropomorphological characterization of the male population in the studied age group.

The selected anthropometric sizes are grouped as follows:

- *Heights*: body height ($\hat{I}_c$), cervical point height ($\hat{I}_{pc}$), neck point height ($\hat{I}_{pbg}$), shoulder point height ($\hat{I}_{pu}$), nipple point height ($\hat{I}_{pm}$), waist line height ($\hat{I}_{lt}$), gluteal fold height ($\hat{I}_{pl.sf.}$), the height of the patellar point ($\hat{I}_{pr}$);
- *Perimeters:* head perimeter (P_{cap}), neck perimeter (P_g), third bust perimeter (P_{bIII}), waist perimeter (P_t), buttock perimeter including abdominal protrusion (P_{fa}), buttock perimeter (P_f), thigh perimeter (P_c) , knee perimeter (P_{gen}), flexed knee perimeter ($P_{gen.flex}$), thigh perimeter P($_p$), supramalleolar (ankle) perimeter ($P_{s\text{-}m}$), axillary perimeter of the arm ($P_{ax.br}$), perimeter of the joint of the hand ($P_{a.m}$), perimeter of the hand (P_m);
- *Lengths:* lateral length of the lower part of the body (L_{lc}), anterior length of the lower part of the body (L_{ac}), inner length of the lower limb (of the leg) ($L_{int.pic}$.), shoulder length (L_u), shoulder length and of the arm ($L_{u\text{-}br}$), shoulder and upper limb length ($L_{u\text{-}ms}$), front waist length (L_{tf}), back length to posterior axillary diameter (depth of the back) taking into account the prominence of the shoulder blade (ARS), the length of the back to the waist taking into account the prominence of the shoulder blade (L_{st}), the length of the upper limb to the joint of the hand (L_m);
- *Widths:* back width (l_s), distance between nipple points (D_{pm}), bust width (l_b);
- *Diameters*: shoulder diameter (d_u).

The primary data, representing the numerical values of the anthropometric sizes, correspond, as already specified, to a sample of 150 men, age group 20-29 years.

For all the mentioned dimensions, a series of statistical parameters were calculated to characterize the anthropometric variables (average sizes and variation indicators). The values of these statistical parameters used to characterize the selection were obtained following the application of the one-dimensional statistical processing algorithm and are centralized in the tables 1-3.

Table 1: Statistical parameters for the characterization of anthropometric variables - height group

Anthrop. sizes / Statistical param.	$\hat{I}_c$	$\hat{I}_{pc}$	$\hat{I}_{pbg}$	$\hat{I}_{pu}$	$\hat{I}_{pm}$	$\hat{I}_{lt}$	$\hat{I}_{pl.sf.}$	$\hat{I}_{pr}$
$\bar{x}$ (cm)	**178,70**	155,27	153,61	150,35	130,16	109,92	84,56	50,22
x_{min} (cm)	165,50	138,50	135,00	133,50	117,00	96,50	71,00	37,50
x_{max} (cm)	194,50	170,00	168,50	164,00	145,00	123,50	99,00	63,50
M_e (cm)	178,00	155,50	153,50	150,00	130,00	111,00	85,50	50,50
M_o (cm)	176,60	155,96	152,77	149,30	129,68	113,16	85,88	51,06
A (cm)	29,00	31,50	33,50	30,50	28,00	27,00	28,00	26,00
S_x^2 (cm)	31,05	51,22	52,10	53,89	30,79	25,62	28,25	13,37
S_x (cm)	5,57	7,16	7,22	7,34	5,55	5,06	5,32	3,66
C_v (%)	3,12	4,61	4,70	4,88	4,26	4,60	6,29	7,29
$t_{\bar{x}}$	32,08	21,69	21,28	20,48	23,45	21,72	15,89	13,72
$S_{\bar{x}}$	0,45	0,58	0,59	0,60	0,45	0,41	0,43	0,30
$\Delta_{\bar{x}}$ (cm)	0,89	1,14	1,16	1,18	0,53	0,81	0,85	0,59
x_{inf} (cm)	177,81	154,13	152,45	149,17	129,63	109,11	83,71	49,63
x_{sup} (cm)	179,59	156,41	154,77	151,53	130,69	110,73	85,41	50,81
e_M (%)	0,25	0,73	0,76	0,78	0,41	0,74	1,01	0,60

Table 2: Statistical parameters for the characterization of anthropometric variables - perimeter group

Anthrop. sizes / Statistical param.	P_{cap}	P_g	P_{bIII}	P_t	P_{fa}	P_f	P_c	P_{gen}	$P_{gen.flex}$	P_p	$P_{s\text{-}m}$	$P_{ax.br}$	$P_{a.m}$	P_m
$\bar{x}$ (cm)	56,69	40,04	**97,60**	**88,43**	103,80	100,09	60,33	38,78	42,09	37,25	24,52	34,86	17,91	24,48
x_{min} (cm)	54,50	34,50	82,00	78,00	88,00	86,00	51,50	33,50	36,50	31,50	31,50	26,50	14,00	20,00
x_{max} (cm)	60,50	45,50	111,00	101,00	120,00	116,50	85,50	44,00	47,00	43,00	43,00	42,50	21,50	27,00
M_e (cm)	56,50	40,00	97,75	88,25	104,00	100,00	60,50	39,00	42,00	37,00	37,00	35,00	18,00	24,50
M_o (cm)	56,12	39,92	98,05	87,89	104,40	99,82	60,84	39,44	41,82	36,50	36,50	34,86	18,18	24,54
A (cm)	6,00	11,00	29,00	23,00	32,00	30,50	34,00	10,50	10,50	11,50	11,50	16,00	7,50	7,00
S_x^2 (cm)	1,69	3,11	31,55	17,79	32,28	32,99	11,51	3,43	2,85	4,58	4,58	10,01	1,64	2,40
S_x (cm)	1,30	1,76	5,62	4,22	5,68	5,74	3,39	1,85	1,69	2,14	2,14	3,16	1,28	1,55
C_v (%)	2,29	4,40	5,76	4,77	5,47	5,73	5,62	4,77	4,02	5,74	5,74	9,01	7,15	6,33
$t\bar{x}$	43,61	22,75	17,37	20,95	18,27	17,44	17,80	20,96	24,91	17,41	17,41	11,10	13,99	15,79
$s\bar{x}$	0,11	0,14	0,46	0,34	0,46	0,47	0,28	0,15	0,14	0,17	0,17	0,26	0,10	0,13
$\Delta\bar{x}$ (cm)	0,22	0,28	0,91	0,67	0,91	0,92	0,55	0,30	0,28	0,34	0,34	0,51	0,19	0,26
x_{inf} (cm)	56,47	39,76	96,69	87,73	102,89	99,17	60,05	38,48	41,81	36,91	36,91	34,56	17,72	24,22
x_{sup} (cm)	56,91	40,32	98,51	89,07	104,71	101,01	60,61	39,08	42,37	37,59	37,59	35,58	18,10	24,74
e_M (%)	0,19	0,35	0,47	0,38	0,44	0,47	0,46	0,39	0,33	0,46	0,46	0,74	0,56	0,53

Table 3: Statistical parameters for the characterization of anthropometric variables – length, width and diameter group

Anthrop. sizes / Statistical param.	L_{lc}	L_{ac}	$L_{int.pic.}$	L_u	$L_{u\text{-}br}$	$L_{u\text{-}ms}$	L_{tf}	ARS	L_{st}	L_m	l_b	D_{pm}	l_s	d_u
$\bar{x}$ (cm)	104,78	101,93	78,39	15,13	51,53	78,89	49,34	22,89	46,88	63,81	39,02	23,91	39,59	41,61
x_{min} (cm)	89,00	86,00	65,00	13,00	46,50	69,00	38,50	21,50	38,00	55,00	35,50	18,50	34,50	38,00
x_{max} (cm)	122,00	119,50	90,50	18,00	56,00	88,00	56,50	24,50	56,50	72,00	42,50	39,00	43,00	44,50
M_e (cm)	104,00	101,5	78,25	15,00	51,50	79,00	49,50	23,00	48,00	64,00	39,00	23,50	39,50	41,50
M_o (cm)	102,44	100,64	77,97	14,74	51,44	79,22	49,82	23,22	50,24	64,38	38,96	22,76	39,36	41,28
A (cm)	33,00	33,5	25,5	5,00	9,50	19,00	18,00	3,00	18,50	17,00	7,00	20,50	8,50	6,50
S_x^2 (cm)	55,11	57,91	28,23	1,11	3,67	13,23	10,02	0,37	10,82	10,09	1,95	14,66	1,69	1,53
S_x (cm)	7,42	7,61	5,31	1,05	1,92	3,64	3,17	0,61	3,29	3,18	1,39	3,83	1,30	1,24
C_v (%)	7,08	7,47	6,77	6,94	3,73	4,61	6,42	2,66	7,02	4,98	3,56	16,02	3,28	2,98
$t\bar{x}$	14,12	13,39	14,76	14,41	26,84	21,67	15,56	37,52	14,25	12,81	28,07	6,24	30,45	33,56
$s\bar{x}$	0,61	0,62	0,43	0,09	0,16	0,30	0,26	0,05	0,27	0,26	0,11	0,31	0,11	0,10
$\Delta\bar{x}$ (cm)	1,20	1,22	0,84	0,18	0,31	0,59	0,51	0,10	0,53	0,51	0,22	0,61	0,35	0,19
x_{inf} (cm)	103,58	100,71	77,55	14,95	14,82	78,30	48,83	22,79	46,35	63,30	38,8	23,26	39,22	41,42
x_{sup} (cm)	105,98	103,15	79,23	15,31	15,44	79,48	49,85	22,99	47,41	64,32	39,24	24,48	39,92	41,80
e_M (%)	0,58	0,61	0,55	0,59	0,31	0,38	0,53	0,22	0,58	0,41	0,28	1,30	0,45	0,24

3. CONCLUSIONS

From the analysis of the statistical parameters calculated for the entire selection and centralized in tables 1-3, the following conclusions can be drawn:

- due to the fact that the selection mean test $t_{\bar{x}} > t_{P;f}$ ($t_{P;f}$ = 1,984), it can be said that the arithmetic means calculated for each anthropometric size are statistically significant;
- the variability of anthropometric sizes, expressed by the values of the mean square deviation and the coefficients of variation, varies from one size to another and depends on the type of anthropometric height;
- it is observed that the values of the parameter s_x are small, which makes the limits of the confidence interval x_{inf} and x_{sup} to be close;
- the values of the coefficient of variation are in the range of 0...10% and indicate a high degree of homogeneity, so the particular values of the analyzed size are around its average value, with the exception of the anthropometric size D_{pm}, whose coefficient of variation indicates an average homogeneity index (between 10...20%)
- small values of the parameter determine close limits for the extreme values of the interval in which the average is located;
- the values of the probable error of the mean indicate that the mean is highly representative, the sample being representative (e_M < 1%).

So, following the analysis of the results recorded in tables 1...3, it can be said that for the studied selection, the representative average body is characterized by the following average values of the main anthropometric dimensions: **$Î_c$=178,7 cm, P_b=97,6 cm,** şi **P_t=88,4 cm**

References

[1]. A.Iridon, "Contribuţii privind utilizarea rezultatelor cercetărilor antropometrice în proiectarea pe criterii ştiinţifice a îmbrăcămintei pentru bărbaţi, grupa de vârstă 20-29 de ani", Teză de doctorat, Iaşi, 2003.

[2]. A.Iridon, „Relaţii de interdependenţă între mărimi antropometrice principale şi secundare cu aceeaşi orientare, Revista Română de Textile-Pielărie, nr.2, Iaşi, 2001

[3]. A.Iridon, „Tipodimensiuni şi analize comparative cu datele înscrise în normativele în vigoare", Revista Română de Textile-Pielărie, Supliment 2004, Iaşi.

[4]. Iridon, A. - Algorithm for the unidimensional statistcical processing of the main anthropometric parameters that characterise the outer body shape for men, Annals of the University of Oradea, Fascicle of Textiles, Leatherwork, vol.XIII, nr.1, 2012, ISSN 1843813X, pag.92-97.

[5]. Iridon, A. - Bidimensional statistical processing of the main anthropometric parameters for men in view of the distribution on sizes and waist lenghts, , Annals of the University of Oradea, Fascicle of Textiles, Leatherwork, vol.XIII, nr.2, 2012, ISSN 1843813X, pag.87-91.

[6]. Filipescu, E. – Indicatori antropomorfologici în construcția imbrăcămintei pentru bărbați, Ed. Performantica, Iasi, 2003.

[7]. Cojocaru, N., Clocotici, V. - Metode statistice aplicate în industria textilă, Ed.Tehnică, Bucureşti, 1986.