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Differentiation of the somatic composition of students physical education specialising in various sports

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: A special interest for researchers is the issue of the physical composition of youth studying at different types of universities. The main objective the study was the characteristics of body composition among students at Gdansk University of Physical Education and Sport (AWFiS) pursuing different sports specialisations in comparison to people the same population (a reference group) not practising sports professionally.

Material & Methods: The study involved 25 final-year graduate students at AWFiS, pursuing the following sports disciplines: swimming (n = 5), bodybuilding (n = 7), football (n = 7) and volleyball (n = 6). The subjects' age ranged 24 to 26 years (24.85 ±0.80), body weight 64 to 92 kg (79.28 ±7.14), body height 168 to 187 cm (178.92 ±5.39 cm), and the BMI 17.99 to 28.40 (24.37 ±2.24). The reference group were students of Warsaw University of Technology (WUT, Poland) based on the 1996 publication. Anthropometric measurements (a total of 16 basic characteristics) were taken in accordance with the accepted principles, using standard tools. The assessment of internal proportions of the body composition was made by means of Perkal's natural indicators method with Milicerowa's modifications.

Results: From among the sixteen selected somatic features, students are significantly differentiated (in comparison to the reference group) by: 2 features in students pursuing the bodybuilding specialization, 5 features in students pursuing specialization in football and 7 features in students pursuing specialization in Students practising swimming are characterised (among others) by greater shoulder (4.26 Z) and elbow (3.47 Z) width and a greater circumference of the forearm (1.81 Z) in comparison to the control group. Swimmers are also shorter in body height than the control group and the other examined groups (−0.45 Z) and have lower adiposity – as measured by the sum of three fat skinfolds (−1.76 Z). However, the noted differences are not statistically significant ($p>0.05$).

Conclusions: Internal proportions of body composition factors of students pursuing various sports specializations are distinguished by a very large contribution of the stoutness factor; additionally, in students practising swimming (an extremely low contribution of the adiposity factor), in bodybuilders (an extremely low contribution of the length factor, and in those practising soccer) and volleyball (low importance of the length factor and of the adiposity factor).

Keywords: body composition • combat sports • Perkal's method • Perkal's natural indicators • skinfold

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INTRODUCTION

The issue of different determinants of human morphofunctional development is often tackled in scientific research in a variety of contexts. Of special interest for researchers is the issue of the physical composition of youth studying at different types of universities. Many scholars have attempted to evaluate youth's physical development, among others: Bocheńska [1], Piechaczek, Łaska-Mierzejewska, Skibińska [2], Pilicz [3], Wieczorek [4], Mleczko and Januszewski [5], or Asienkiewicz [6]. The results of their studies indicate differences in shaping somatic features and underline the fact that the pace of ontogenetic development and the level of morphofunctional characteristics are shaped by both genetic and environmental factors. Among the latter ones, the importance of socio-economic factors, such as the level of education, organisation of leisure time, marital status, social background, etc. are the most often enumerated [7].

Studies on the somatic composition of physical education (PE) students have an important place in the Polish research on the subject. Young people studying PE are considered as "a good reference point" in inter-population comparisons, as well as in monitoring changes taking place in the population over time [8-10]. A substantial body of research conducted in recent times by Polish researchers has also concerned combat sports: judo [11-13], karate [14, 15], and wrestling [16, 17].

However, in the literature of the subject, there is extremely little information on the differentiation of body composition among PE students pursuing different sports specialisations, based on Perkal's [18] natural indicators.

Taking these general assumptions, the main objective the study was the characteristics of body composition among students at Gdansk University of Physical Education and Sport (AWFiS) pursuing different sports specialisations in comparison to people the same population (a reference group) not practising sports professionally.

So defined objective of the study required answering the following questions: which somatic characteristics determine the specific body composition of students of different specialisations? Which internal proportions of body composition are characteristic of them?

MATERIAL AND METHODS

The study involved 25 final-year graduate students at Gdansk University of Physical Education and Sport, Poland (AWFiS), pursuing the following sports disciplines: swimming (n = 5), bodybuilding (n = 7), football (n = 7) and volleyball (n = 6). The subjects' age ranged 24 to 26 years (24.85 ±0.80), body weight 64 to 92 kg (79.28 ±7.14), body height 168 to 187 cm (178.92 ±5.39), and the BMI 17.99 to 28.40 (24.37 ±2.24). The study was conducted in May 2016. The reference group were students of Warsaw University of Technology, Poland (WUT) [8].

Anthropometric measurements (a total of 16 basic characteristics) were taken in accordance with the accepted principles, using standard tools [19].

The general profile of body composition was defined by means of standardisation of features: $Z = x_j - x_s / SD_s$ (where: Z the standardised value; x_j the mean value of the feature in the group of judokas; x_s the mean value of the feature in the reference group; SD_s standard deviation in the reference group).

The assessment of internal proportions of the body composition was made by means of Perkal's natural indicators method [18] with Milicerowa's [20] modifications. To this end, the following have been defined:

- composition factor m – by summing up the standardised values within each factor and dividing the total by the number of characteristics identifying that factor. The adiposity factor, which is the standardised value of fat skinfolds: Z = m, is an exception;
- the total body size indicator (M) for the group: $M = m_1 + m_2 + m_3 / 3$;
- assessment of internal proportions of the body composition was made through calculating Perkal's natural indicators for each composition factor: m_1-M; m_2-M; m_3-M;
- evenness of the composition was determined by means of the intrapersonal (intragroup) variability index – the difference between the natural indicator with the highest numerical value and the natural indicator with the lowest one;
- the code of internal proportions of the group was defined on the basis of the point scale of Perkal's natural indicators (Table 1);
- the assessment of internal proportions of the body composition within each of the factors was made by taking away the value of the m factor from the standardised features.

Academy of Physical Education – an institution of university type providing education in the field of sports science, having full academic rights (from bachelor to a professor with the right to confer a "***doctor honoris causa***" title). In Poland, there are six academies of physical education: the Academy of Physical Education in Katowice, Krakow, Poznan, Warsaw, Wroclaw and the Academy of Physical Education and Sport in Gdansk [33].

PE – *abbreviation* physical education [34].

Adipose – *adjective* fatty [34].

Bodybuilding – *noun* the practice of developing the muscles of the body through weightlifting and diet [34].

Body composition – athlete's predisposition in terms of the proportion of active mass and inactive mass in the body.

Skinfold – *noun* a test for subcutaneous fat deposits that measures how much skin and tissue can be 'pinched' at various sites on the body [34].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [34].

Combat sports – are competitive contact sports with one-on-one combat. Determining the winner depends on the particular contest's rules. In many combat sports, a contestant wins by scoring more points than the opponent or by disabling opponent [35].

RESULTS

Body composition of students at AWFiS pursuing different sports specialisations is diversified. From among the sixteen selected somatic features, students are significantly differentiated (in comparison to the reference group) by 2 features in students pursuing the bodybuilding specialisation, 5 features in students pursuing a specialisation in football and 7 features in students pursuing a specialisation in volleyball (Table 2).

The specific body composition profile of students at AWFiS practising various sports disciplines has been specified as a result of standardisation of features (Figure. 1). Students practising swimming are characterised by greater shoulder (4.26 Z) and elbow (3.47 Z) width and a greater circumference of the forearm (1.81 Z) in comparison to the control group. Swimmers are also shorter in body height than the control group and the other examined groups (−0.45 Z) and have lower adiposity – as measured by the sum of three fat skinfolds (−1.76 Z). However, the noted differences are not statistically significant (p>0.05).

Table 1. Point scales of Perkal's natural indicators.

Points	Values of Perkal's natural indicators	
1	X to −1.07	values less than average
2	−1.06 to −0.57	
3	−0.56 to −0.18	
4	−0.19 to 0.18	average value
5	0.19 to 0.57	
6	0.58 to 1.06	values greater than average
7	1.07 to X	

Table 2. Features of body composition in students at AWFiS (n = 25) pursuing different sports specialisations and students of WUT (n = 165) [8] and an assessment of the significance of differences.

Variable	Students of WUT (n = 165)		Swimmers (n = 5)			Bodybuilders (n = 7)			Football players (n = 7)			Volleyball players (n = 6)		
	X	SD	X	SD	t	X	SD	t	X	SD	t	X	SD	t
body mass	72.11	8.96	71.00	6.04	−0.168	81.71	6.92	1.298	80.14	7.27	1.034	82.33	2.34	4.048**
standing body height	179.36	6.19	176.6	6.46	−0.390	177.36	4.52	−0.415	178.14	5.49	−0.207	183.58	3.07	1.272
sitting body height	93.86	3.06	91.54	7.53	−0.281	91.71	4.26	−0.471	93.24	5.75	−0.100	98.98	3.26	1.453
length of upper extremity	78.30	3.51	77.08	3.72	−0.299	77.90	3.45	−0.109	75.67	3.69	−0.666	83.03	1.61	2.729*
length of lower extremity	85.50	4.10	85.06	1.70	−0.236	85.64	1.04	0.128	84.90	1.23	−0.456	85.60	0.68	−1.229
foot length	26.86	1.30	27.42	1.06	0.480	27.90	1.13	0.861	27.30	0.61	0.680	28.88	0.45	4.131**
shoulders width	40.67	1.59	47.44	2.25	2.745	50.47	2.09	4.378**	48.86	1.60	4.790**	47.82	0.75	8.86***
elbow width	6.98	0.34	8.16	0.82	1.318	8.38	0.66	1.987	7.94	0.22	4.047**	8.10	0.18	5.797**
knee width	9.82	0.45	10.52	0.47	1.372	10.06	0.47	0.470	10.43	0.50	0.295	11.10	0.35	3.365*
forearm perimeter	26.02	1.80	29.28	1.38	2.161	31.71	1.10	4.853**	28.77	1.12	2.227	30.75	0.35	12.49***
shank perimeter	38.71	1.28	38.76	1.37	0.033	39.64	1.04	0.837	38.90	1.23	0.144	38.60	0.68	−0.150
slenderness index	43.21	1.66	42.70	1.85	−0.251	40.90	1.16	−1.869	41.35	0.52	−3.341*	42.18	0.61	−1.548
Rohrer's index	1.25	0.15	1.30	0.18	0.233	1.47	0.13	1.594	1.41	0.05	2.889*	1.33	0.06	1.358
BMI index	22.44	2.46	22.83	2.52	0.141	24.57	3.39	0.588	25.21	1.03	2.516*	24.46	0.77	2.418
Manouvrier's index	91.09	2.82	93.67	9.66	0.244	93.55	4.35	0.528	91.36	6.02	0.043	85.55	3.22	−1.591
the sum of three fat skinfolds	4.69	0.89	3.12	0.50	−2.851	5.53	0.58	1.354	4.57	0.75	−0.147	5.24	0.37	1.382

***p≤0.001; **p≤0.01; *p≤0.05

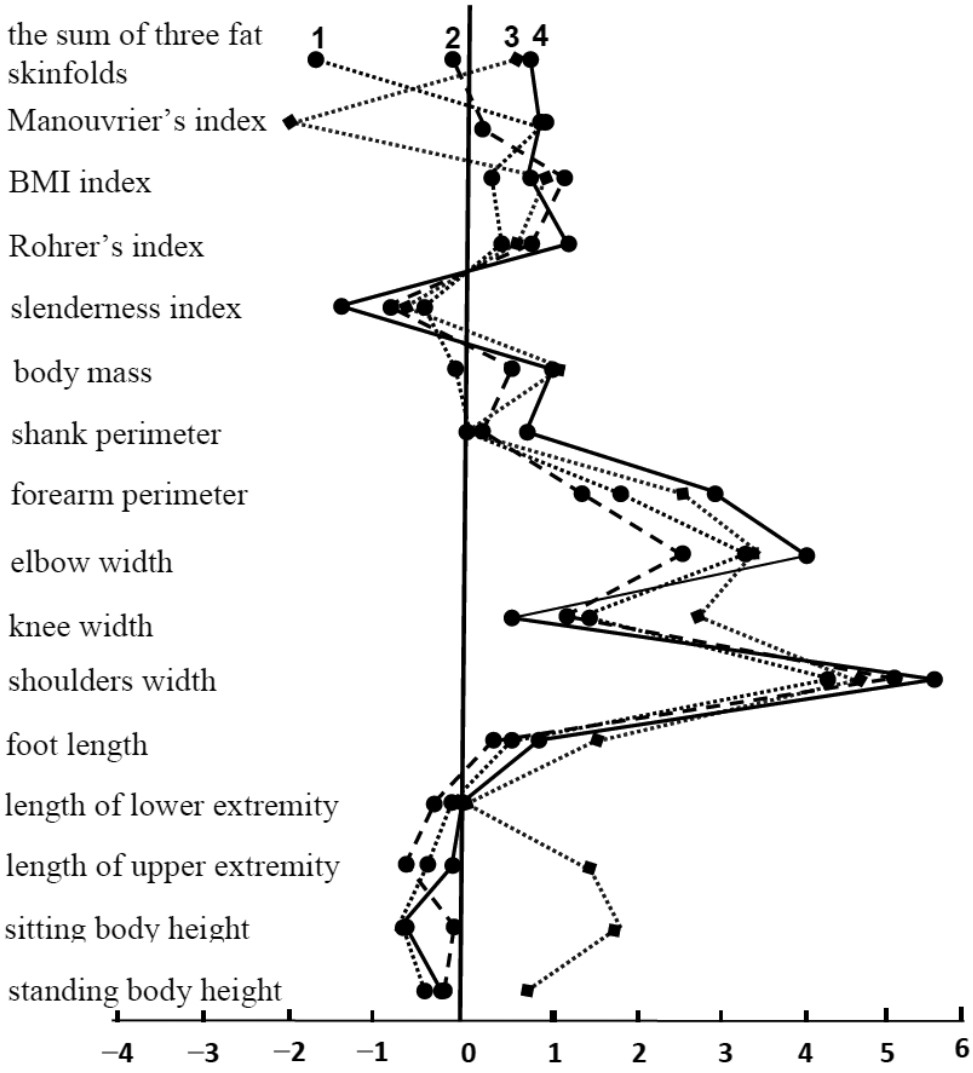

Figure 1. Profiles of body composition of students at AWFiS (n = 25) pursuing various sports specialisations (codes of sports specialisations: 1 swimming; 2 football; 3 volleyball; 4 bodybuilding).

Students practising football are characterised by a greater shoulder width (5.15 Z), the elbow width (2.82 Z), the forearm circumference (1.53 Z) and the BMI and Rohrer's index (respectively: 1.13 and 1.07 Z). They are the most inferior to the control group in terms of the slenderness index (−1.12 Z).

The characteristic feature of volleyball players' body composition (as compared to the reference group) is a much higher shoulder width (5.15 Z), the elbow width (2.82 Z), and the forearm circumference (1.53 Z) and the knee width (1.35 Z).

Students who pursue bodybuilding differ the most in terms of the shoulder width (6.16 Z), the elbow width (4.12 Z), the forearm circumference (3.16 Z) and Rohrer's index (1.47 Z).

Among the distinguished three factors in all the examined students, the stoutness factor (m_2) is dominant Table 3.

Swimmers are characterised by the total body size (M = 0.06) similar to students of WUT. The adiposity factor (m_3 = −1.76) is considerably lower in this group of students than in the general population of students, while the stoutness factor (m_2 = 2.23) is higher. Bodybuilders are superior in their body composition to general students (M = 1.22). The length factor in this group of students is little different from the values of this factor in the reference group (m_1 = −0.13).

Table 3. Factors of body composition in students (n = 25) pursuing various sports specialisations.

Factor	Swimmers (n = 5)	Bodybuilders (n = 7)	Football players (n = 7)	Volleyball players (n = 6)
Length (m_1)	−0.30	−0.13	−0.37	0.68
Stoutness (m_2)	2.23	2.94	2.20	2.63
Fatty tissue (m_3)	−1.76	0.84	−0.14	0.62
Overall size index M	0.06	1.22	0.56	1.31

Table 4. Natural indicators of body composition factors in students (n = 25) pursuing various sports specialisations.

Natural indicators of the factors	Swimmers (n = 5)	Bodybuilders (n = 7)	Football (n = 7)	Volleyball (n = 6)
Length factor (m_1)	−0.36	−1.35	−0.93	−0.63
Stoutness factor (m_2)	2.17	1.72	1.66	1.32
Adiposity factor (m_3)	−1.82	−0.38	−0.7	−0.69
Intra-group variability index	3.99	3.07	2.59	2.01

Students practising football are characterised by factor values similar to students of WUT (except for the stoutness factor m_2 = 2.20). Persons training volleyball outweigh the reference group in terms of the total body size indicator (M = 1.31).

In an analysis of the mutual proportions between the factors of body composition of students pursuing different sports specialisations, great differences in particular groups of the composition features become apparent (Table 4). From among the four sports specialisation, volleyball players are the most proportionately built. The value of intragroup variability index amounts to 2.02.

Swimmers stand out the most in terms of the specificity of body composition from among all students (the intra-group variability index is 3.99). Adiposity constitutes the most variable factor among students of different specialisations. However, stoutness is a factor the most significantly affecting the total body size.

The code of swimmers' internal proportions of body composition is 3-7-1 (according to codes of internal proportions of body compositions). This means that the total body size (M) results from the average value of the body length features, a very large one of stoutness and extremely low adiposity. The code of internal proportions of bodybuilders is 1-7-3, and of soccer players and volleyball players: 2-7-2.

Calculations of internal proportions of features of body composition within each of the factors provide very important information about the body composition of students of various specialisations (Figure 2). In the features expressing skeletal stoutness, all subjects (except for swimmers) manifested a significant advantage of the shoulder and elbow widths over the knee width. A disproportionately smaller contribution of the stoutness factor was found as regards the shank and the forearm circumference.

The length factor in all the studied groups is the least diversified (it does not exceed ±1 Z). The most proportional contribution of the features in this factor was found in swimmers and bodybuilders.

DISCUSSION

Continuous transformations of the environment and socio-economic changes necessitate the need to conduct research and observation of the development processes and the determinants of the morphofunctional level depending on different variables [21]. These changes also apply to academic youth [8-10, 22-24].

The results presented in this paper fall within the current trend of research. Application of Perkal's natural indicators method [18] with Milicerowa's modifications [20] in this study promotes comparisons with results of other authors studying athletes of different disciplines with this method already since 1956.

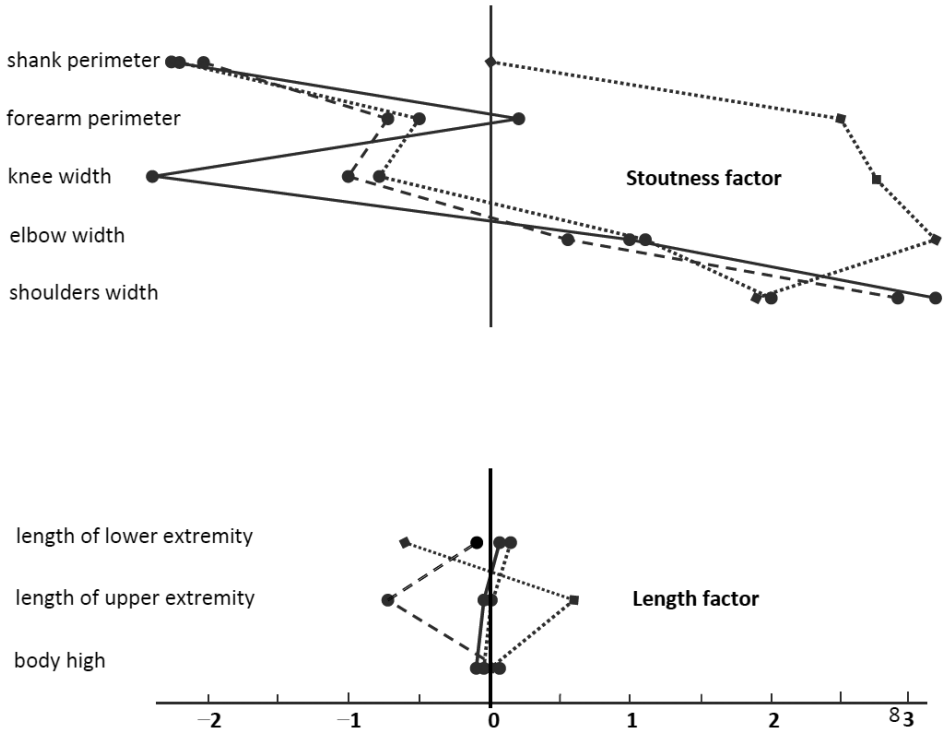

Figure 2. Natural indicators of the somatic features within factors for students at AWFiS (n = 25) pursuing various sports specialisations (codes of sports specialisations as in Figure 1).

The study found that AWFiS students exhibit differentiation of the somatic composition depending on the practised sports discipline. As Władysław Jagiełło notes [15], it is a resultant of two processes – on the one hand, the sports selection process and, on the other hand, the body's adaptation to environmental conditions. The most similar profile to the reference group of non-training students was found in students practising swimming. No statistically significant differences between particular features of body composition of these students in comparison to the reference group were found. One may also find a great similarity in body composition of AWFiS students practising bodybuilding to the profile of non-training students. Bodybuilders differ from students of the reference group only in greater shoulder width and a longer forearm circumference. The biggest differences in comparison to non-training students were found in the group of volleyball players, who differ from students of WUT with greater body weight, a longer upper limb and foot, greater shoulder, elbow and knee widths, as well as a greater forearm circumference.

The examined students, regardless of the practised sport, manifested body height similar to the reference group. It should be noted here that students of WUT, constituting the reference group, are considered one of the most developed youth groups in terms of physical development (with the mean body height of 179.36 cm) [8].

The mean body height of the examined students from AWFiS training swimming was 176.6 cm, of those training bodybuilding 177.36 cm, soccer 178.14 cm, and volleyball 183.58 cm.

Similar values of students' body height were also noted by other authors. The mean body height of students of AWF Warsaw examined by Piechaczek [25] was 180.04 cm, of AWF students in Wrocław, examined by the Burdukiewicz and Janusz [26] 179.99 cm, candidates for students of AWF Poznan tested by Wawrzyniak [27] 178.58 cm, and of PE students from Pedagogical University in Częstochowa examined by Wojtyna and Rodziewicz-Gruhn [28] 179.90 cm.

In terms of the total body size, AWFiS students training swimming (M = 0.06) were the closest group to students of WUT. Similar total body size values were found in athletes training tennis M = 0.22 [29], modern pentathlon M = 0.02 [30], baseball M=0 [31], taekwondo athletes of the heavyweight category M = −0.02 and the middle-weight category M = −0.90 [15] and middleweight judo athletes M = 0.55 [12]. Significantly lower values of the total body size were found in light-weight competitors training taekwondo M = −1.44 [15] and judo M = −1.19 [12], while higher ones in heavyweight judo athletes M=3.4 [12] and super heavyweight taekwondo athletes M = 1.22 [15]. Władysław Jagiełło's research [12, 15] shows that athletes of the lightweight and middleweight categories usually have smaller bodies than non-training students, while athletes of super heavyweight category bigger ones.

The code of internal proportions of body composition factors for swimmers was 3-7-1, for bodybuilders 1-7-3 and soccer and volleyball players 2-7-2. Thus, the dominant importance of the stoutness factor was manifested in all the examined students. Such a clear advantage of one factor, according to Łaska-Mierzejewska [32], is characteristic of athletes. For example, tennis players are characterised by the predominance of the length factor 6-3-3 [29], lightweight judo athletes 2-6-1 and middle-weight judokas 2-6-4 by the predominance of the stoutness factor, and heavyweight judo athletes by the adiposity factor 1-3-7 [12].

As Wieczorek emphasises [4], PE students are enrolled in the university after meeting certain fitness criteria. However, in the course of the study, there are considerable differences in physical activity, connected with pursuing different sports specialisations. For these reasons, a seemingly uniform group of students of the same field of study may exhibit substantial morphofunctional diversity. Also, Asienkiewicz's research [6] confirmed this phenomenon is indicating that intense sports activities are resulting from the implementation of the study programme, along with practising a selected sports discipline personally, can be an important factor influencing a change in students' body composition.

Many authors' study results [5, 9, 22, 25] indicate a perfect physical development of people studying PE, but most attention is drawn to the selection factor, being correlated with the requirements of entrance exams.

CONCLUSIONS

1. The somatic composition of students pursuing various sports specialisations is characterised by mainly greater (than in the control group) shoulder and elbow width and forearm circumference. In addition, volleyball players stand out more than other students in the length features (body height and the upper extremity length).

2. Internal proportions of body composition factors of students pursuing various sports specializations are distinguished by a very large contribution of the stoutness factor; additionally, in students practising swimming (an extremely low contribution of the adiposity factor), in bodybuilders (an extremely low contribution of the length factor, and in those practising soccer) and volleyball (low importance of the length factor and of the adiposity factor).

3. Internal proportions of the somatic features within the stoutness factor distinguish students pursuing volleyball specialisations the most. Students majoring in bodybuilding, swimming, and football are characterised by a very large contribution of the shoulders width with a disproportionately low shank circumference and the knee width.

4. Internal proportions of the somatic features within the factor length indicate a more proportional contribution to features of students pursuing various sports specialisations. The most harmonious contribution of features in this factor is represented among students specialising in swimming and bodybuilding.

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