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Original Article

Morpho-biomechanical characteristics of female students as a basis for the development of differentiated health-related programs

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Abstract
Introduction. Nowadays, an increasing proportion of women of the first period of a mature age are characterized by impaired posture. The state of human posture, which determines the distribution of individual bio-links of the human body in space, depends on the type of physique that affects their physical condition. **Purpose** – to identify morpho-biomechanical pecularities of students of different somatotypes, as a prerequisite for differentiated health programs development. **Methods**. Anthropometric parameters, biogeometric ptofile and physical fitness measurements were conducted in one hundred and twenty-one 17–18-year-old female students including 64 mesomorphs, 35 ectomorphs and 22 endomorphs. The participants were submitted to a routine of measurements (body weight, height and body circumferences (chest, shoulder, waist, buttock, thigh, calf)) to characterize the anthropometric profile of student of different somatotypes. Body weight was recorded on a portable scale (Smart-Weight Scale scl-001bl). Body height was measured by a stadiometer TV1-200. The perimetry measurements were collected with a flexible tape measure (Mabis). Somatotype was determined according to Chernorutsky's scheme with Pinier's index calculation. A digital video camera connected to Torso program was used to record students' posture quantitative characteristics. The students' physical fitness was assessed using a 12-minute Shuttle Run Test, Sit and Reach Test, Push-up Test, Standing Long Jump Test and Incline Sit-up Test. Sit and Reach Test results were obtained using sit-and-reach box. **Results**. When analyzing the girth dimensions of the body bio-links of female students with an endomorphic body type, it was established that with the smallest body height, in comparison with students of ectomorphic and mesomorphic body types, the greatest body circumferences were revealed. We found that students of ectomorphic somatotype have the lowest cardiorespiratory endurance and flexibility indicators; students of endomorphic somatotype have the lowest strength of different muscle groups. A mesomorph female students have positive correlation with all motor skills. The factor analysis results showed that only for students of mesomorphic somatotype biogeometric posture profile have little effect on physical fitness, and for students of ectomorphic and endomorphic somatotypes they are closely related. **Conclusions**. Female students of 17-18 years old of different somatotypes have distinctive parameters of motor skills and reliable difference in a number of functional characteristics body muscular systems and posture biogeometric profile. The received data concerning constitutional features of motor skills and functional body characteristics of students of different somatotypes allow to concretize provisions for planning of individually differentiated fitness training based on results of factor analysis.
Key words: somatotype, female students, posture, biogeometric profile.

Introduction

In today's reality, the health of adults in general and children and young people in particular is an unprecedented challenge to society (Eurostat…, 2021). Science advanced ideas sublimation into the strategy of student youth rehabilitation involves the creation and implementation of effective innovative technologies. In this context, it should be noted that on modern background of current physical education paradigm transformation, which is related to interests range and needs clarifying of students related to their physical and mental improvement, remain unresolved issues of body composition correction of female students taking into account the peculiarities of their body mass geometry (Lee et al., 2016).

As it was pointed out by a scientists, the problem of body components deviations of student youth from optimal values and functional posture disorders are the most common disorders of student youth musculoskeletal system and their obvious negative impact on both physical and mental status increases its relevance (Kashuba et al., 2020).

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Since Sheldon's first studies on somatotypes, many researchers have attempted to determine the effects of somatotype on physical performance (Çinarli & Kafkas, 2019). Its importance originated from its relation to many components of motor and physical fitness. In addition, one of the important motives for studying somatotypes is what has been achieved regarding the relationship between the body's structure and its quality of life (Sakibaev et al., 2019; Kashuba et al., 2020). Most studies that have addressed somatotypes indicate that the body is composed of three basic compounds known as Ectomorph, Mesomorph, and Endomorph (Subramanian et al., 2016; Mundi, Patel &Martindale, 2019).

A close correlation was established between the somatotype and human motor qualities characteristics (Tutelian et al., 2017; Kashuba et al., 2017; Alyoshyna, Matiichuk & Ostap'iak, 2020), physical development (Nikbakht, 2011; Ryan-Stewart, Faulkner & Jobson, 2018; Kashuba et al., 2019) and and posture biogeometric profile (Kashuba, Asaulyuk & Dyachenko, 2017; Mytskan, Vypasnyak&Shankovs'kyy, 2018). Posture disorders, according to M.V. Dudko (2016) affects the body spatial organization of women, is characterized by body angular and linear dimensions changes, violation of the interdependence and interrelation of biogeometric, biodynamic and morphofunctional human body indicators. The same results were obtaining by I.Vypasnyak, O.Leshchak & A.Shankovs'kyy (2018).

The study of physical development indicators pecularities of women with different somatotypes and posture types and presence of different deviations, in our opinion, is of primary importance for health programs construction and health activities motives implementation.

Material & methods

Participants

To achieve this goal, anthropometric parameters, biogeometric ptofile and physical fitness measurements were conducted in one hundred twenty one 17–18-year-old female students including 64 mesomorphs, 35 ectomorphs and 22 endomorphs. At the time of the study all students became to basic medical group according to medical examination.

Task and apparatus

Body mass was recorded on a portable scale to the nearest 0.1 kg (Smart-Weight Scale scl-001bl). Height was measured on a stadiometer TB1-200 to the nearest 0.1 cm. The perimetry measurements were collected with a flexible tape measure (Mabis) to the nearest 0.1 cm. A digital video camera connected to Torso program was used to record students' posture quantitative characteristics (Kashuba, 2003).

Measurements

The participants were submitted to a routine of measurements (body weight, body height and body circumferences (chest, shoulder, waist, buttock, thigh, calf)) to characterize the anthropometric profile of student of different somatotypes. Somatotype was determined according to the scheme of M. V. Chernorutsky the types of the girls' body constitution with Pinier's index calculation (Fefelova et al., 2015).

Photography and analysis of female posture were performed using "Torso" program identifying three angular characteristics of biogeometric posture where α_1 is the head inclination angle formed by vertical and line connecting the spinous process of the seventh cervical vertebra C_{VII} and MC of the head; α_2 – sagittal shoulder-C_{VII} angle formed by horizontal and line connecting the most prominent point of frontal bone and chin; α_3 – inferior angle of the scapula symmetry formed by the vertical and the line connecting the spinous process of the seventh cervical vertebra (C_{VII}) – the most prominent part of the spine at the cervical - thoracic junction - and the spinous process of the fifth lumbar vertebra (L_V) – the most lordically deepened label of transverse lordosis (somatic coordinate system center) (Kashuba, 2016).

Video recording was proceeded in compliance with the basic biomechanical requirements, including: marking joints centers and anatomical foot marks with contrast markers; setting the object in the plane of removal of the scale ruler (removal of the foot required the division of the latter into two-centimeter colored areas, and video recording of walking and posture required a meter ruler setting); fixing the camera on a tripod still and at 3 meters distance from the subject (for static poses) (Kashuba, 2016).

The students' physical fitness was assessed using 12-minute Shuttle Run Test, Sit and Reach Test, Push-up Test, Standing Long Jump Test and Incline Sit-up test. Sit and Reach Test results were obtained uding sit-and-reach box to the nearest 0.1 cm (Serhiienko, 2015).

Data analysis

The results have been processed with SPSS Statistics v.17.0 program package. Variables that presented normal values (anthropometric and physical fitness data) were expressed as mean and standard deviation (mean; SD). The comparison between the groups (mesomorphs, ectomorphs and endomorphs) was performed from the t-test for independent samples. For the variables where there was no normality (angular characteristics), the values were expressed as median (Me) and interquartile range (25–75 %). The comparison between the groups was performed from the Wilcoxon T-test. Common factor analysis by principal-axis method using Varimax

rotation with Kaiser normalization was used to identify a set of more general latent variables, or factors, that explain the covariances among the measured variables. Statistical significance was set not less than $p < 0.05$.

Results

Analyzing the body mass indicators of 1st year students with different body types, we have established that representatives of the endomorphic type have the greatest body weight on average 63.4; 3.9 kg, and the smallest body weight on average of 54.5; 2.0 kg.was observed in female students with an ectomorphic body type. First-year female students with a mesomorphic body type have an average body weight of 58.0; 3.8 kg.

Female students with ectomorphic body type are characterized by the highest body height on average 168.9; 4.1 cm. In students with endomorphic body type, body length is on average 164.7; 4.71 cm, which is the smallest indicator among 1st year students, and for students with mesomorphic body type, body height is on average 166.7; 4.61 cm (Table 1). It should be noted that in the analysis of the circumferential measurements of body bio-units of 1st year students with an endomorphic body type, it was established that with the smallest body height, in comparison with ectomorphic and mesomorphic body types students, there had place the highest indicators of chest circumference – 91.6; 6.02 cm, shoulder circumference – 28.0; 3.80 cm, waist circumference – 75.4; 4.83 cm, buttock circumference 97.8; 6.53 cm, thigh circumference – 58.3; 4.25 cm and calf circumference – 35.9; 2.15 cm (Table 1).

Table 1. **Anthropometric profile chart for female students (n = 121)**

Somatometric dimentions	Body type					
	Ectomorphs n=35		Endomorphs n=22		Mesomorphs n=64	
	mean	SD	mean	SD	mean	SD
Body weight, kg	54.5***•••	3.81	63.4***	4.90	58.1	4.52
Body height, cm	168.7*••	4.12	164.7	4.71	166.7	4.61
Chest circumference, cm	77.5***•••	5.80	91.2***	6.02	85.3	5.50
Shoulder circumference, cm	23.3***•••	3.71	28.0	3.80	26.2	3.81
Waist circumference, cm	64.9***•••	4.44	75.4***	4.83	68.1	5.51
Buttock circumference, cm	88.8***•••	5.50	97.8*	6.53	94.5	4.22
Thigh circumference, cm	52.1**•••	4.94	58.3**	4.25	55.0	3.80
Calf circumference, cm	33.3*•••	2.81	35.9*	2.15	34.6	1.84

* – statistically significant differences compared with mesomorphs (* – $p<0.05$; ** – $p<0.01$; *** – $p<0.001$);
• – statistically significant differences between endo- and ectomorphs (•• – $p<0.01$; ••• – $p<0.001$)

In mesomorphic type student circumferential body measurements were on average: chest circumference – 85.3; 5.50 cm, shoulder circumference – 26.2; 3.81 cm, waist circumference – 68.1; 5.51 cm, buttock circumference – 94.5; 4.22 cm, thigh circumference – 55.0; 3.80 cm and calf circumference – 34.6; 1.84 cm. The smallest circumferential body measurements values were observed in ectomorphic body type representatives. Thus, chest circumference averaged 77.5; 5.80 cm, shoulder circumference – 23.3;3.71 cm, waist circumference – 64.9;4.44 cm, buttock circumference – 88.8;5.50 cm, thigh circumference – 52.1;4.94 cm, calf circumference – 33.3;2.81 cm. In the process of 1st year students physical fitness research, assessing cerdiorespiratory endurance, muscle endurance, flexibility and static vertical stability, we used a number of tests.

Results analysis of 12-minute Shuttle Run Test (Table 2). indicates that in first-year students with ectomorphic body type, the endurance level indicators averaged 1725.7; 107.90 m, from endomorph – 1750.5; 130.60 m, and from mesomorphic – 1823.7; 140.10 m.

Table 1. **Physical fitness indicators of first-year students with different body types (n = 121)**

Tests	Body type					
	Ectomorphs n=35		Endomorphs n=22		Mesomorphs n=64	
	mean	SD	mean	SD	mean	SD
12-minute Shuttle Run Test, m	1725.7***	107.90	1750.5*	130.60	1823.7	140.10
Sit and Reach Test, cm	4.0***•••	3.20	7.1**	2.80	9.3	2.75
Incline Sit-up Test, times	20.4*	4.26	19.0***	3.66	22.6	3.71
Push-up Test, times	10.1	6.29	8.3*	5.29	11.4	3.80
Standing Long Jump Test, cm	157.5**	14.21	151.2	16.62	148.9	15.80

* – statistically significant differences compared with mesomorphs (* – $p<0.05$; ** – $p<0.01$; *** – $p<0.001$);
• – statistically significant differences between endo- and ectomorphs (•• – $p<0.01$; ••• – $p<0.001$)

The test results of "Sit and Reach Test" among first-year students with ectomorphic body type indicate that flexibility indicators of the lower back and hamstring muscles are on average 4.0; 3.20 cm, from endomorph – 7.1; 2.80 cm and from mesomorphic – 9.3; 2.75 cm. Analyzing the "Incline Sit-up Test" test results we have established that the average statistical indicator of first-year students with ectomorphic body type is 20.4; 4.26 reps, from endomorphic – 19.0; 3.66 reps, and from mesomorphic – 22.6; 3.71 reps. The "Push-up Test" results indicate that first-year students with an ecomorphic body type have an average upper body strength and endurance of 8.3; 5.29 reps, с ендоморфного – 10.1; 6.29 reps, and from mesomorph – 11.4; 3.80 reps. The Standing Long Jump Test results indicate that first-year students with an ectomorphic body type have an average explosive leg power of 157.5; 14.21 cm, from endomorph – 151.2; 16.62 cm, and from mesomorphic – 148.9; 15.80 cm. Analysis of goniometric characteristics of sagittal posture profile in female students showed that the medians of an angle between true vertical and a line connecting C_{VII} (α_1) in female students with an ectomorphic body type with normal posture averaged 31.03°(30.75°; 31.30°), mean 31.03°; with scoliotic posture –31.25° (30.68°; 32.60°), mean 30.71°, with round back – 29.75° (29.43°; 30.05°), mean 29.83°; with round-concave back – 30.45° (30.18°; 30.73°), mean 30.45° (Fig. 1).

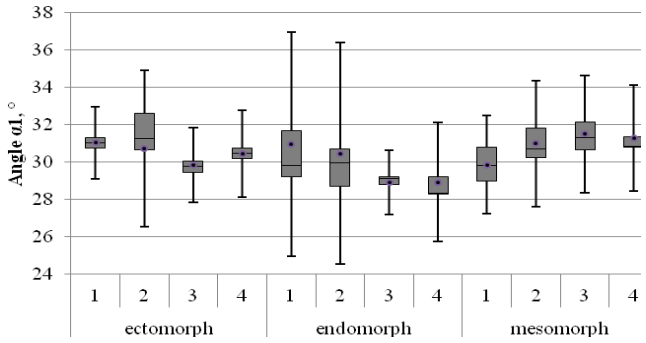

Figure 1. The angle formed by the vertical and the line connecting the C_{VII} spinous process and the centre of mass of the head (α_1) of female students: 1 – normal posture; 2 – scoliotic posture; 3 – round back; 4 – round-concave back

It should be noted that the median of angle (α_1) of first-year students with endomorphic body type without posture disorders was 29.80°(29.20°; 31.70°), mean 30.95°; with scoliotic posture – 29.95° (28.68°; 30.70°), mean 30.46°; with round back –29.10° (28.81°; 29.21°), mean 28.91°; and with round-concave back – 28.32° (28.26°; 29.20°), mean 28.93°.

Among mesomorphs with a normal posture median of angle (α_1) was 29.80° (28.98°;30.80°), mean 29.85°; with scoliotic posture – 30.70° (30.25°;31.80°), mean 30.99°; with round back – 31.30° (30.68°;32.13°), mean 31.50°; with round-concave back –30.85° (30.78°;31.35°), mean 31.28°.

The data obtained indicate that any insignificant increase or decrease change in the studied can be accompanied by various changes in head position in orthograde position and characterize the possible human body violations of the spatial organization.

When screening posture state, the sagittal shoulder-C_{VII} angle (α_2) is of great importance. So, for students with an ectomorphic body type with normal posture, median of this angle was 89.90° (89.85°; 90.40°), mean 90.20°; with scoliotic posture – 90.30° (89.88°; 90.83°), mean 90.08°; with round back – 88.80° (88.48°; 88.90°), mean 88.58°; with round-concave back – 88.90° (88.40°; 89.40°), mean 88.90° (Fig. 2).

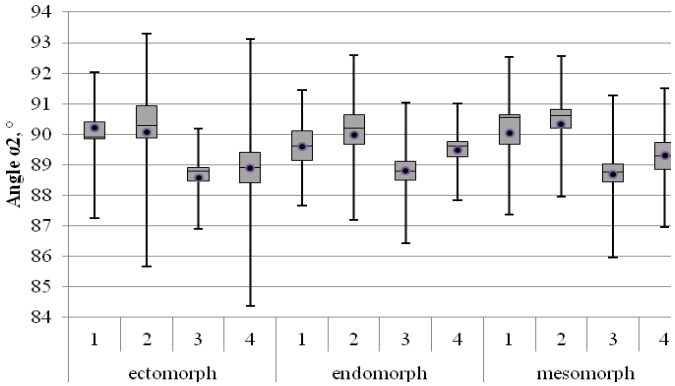

Figure 2. The angle formed by the horizontal and the line connecting the frontal eminence and mental eminence (α_2) of female students: 1 – normal posture; 2 – scoliotic posture; 3 – round back; 4 – round-concave back

First-year students with a endomorphic body type with no posture disorders had median of angle (α_2) 89.61° (89.15°; 90.10°), mean 89.61°; with scoliotic posture – 90.20° (89.68°; 90.65°), mean 89.99°; with round back – 88.80° (88.50°; 89.10°), mean 88.80° and in female students with a round-concave back – 89.60° (89.25°; 89.75°), mean 89.47°.

At the same time, first-year students with a normosthenic body type with a normal posture the mrdian of angle (α_2) was 90.55° (89.68°; 90.63°), mean 90.03°; in female students with scoliotic posture – 90.60°(90.20°; 90.80°), mean 90.33°; with round back – 88.75° (88.43°; 89.03°), mean 88.70°; with a round-concave back 89.30° (88.85°; 89.73°), mean 89.30°.

Median of angle formed by the vertical and the line connecting the spinous processes of the C_{VII} and L_V vertebra students with a ectomorphic body type with a normal posture was 2.50°(2.45°; 2.50°), mean 2.47°; in female students with scoliotic posture – 2.50° (2.43°; 2.73°), mean 2.57°; with round back – 3.45° (3.38°; 3.53°), mean 3.45°; with round-concave back – 3.35° (3.33°; 3.38°), mean 3.35° (Fig. 3).

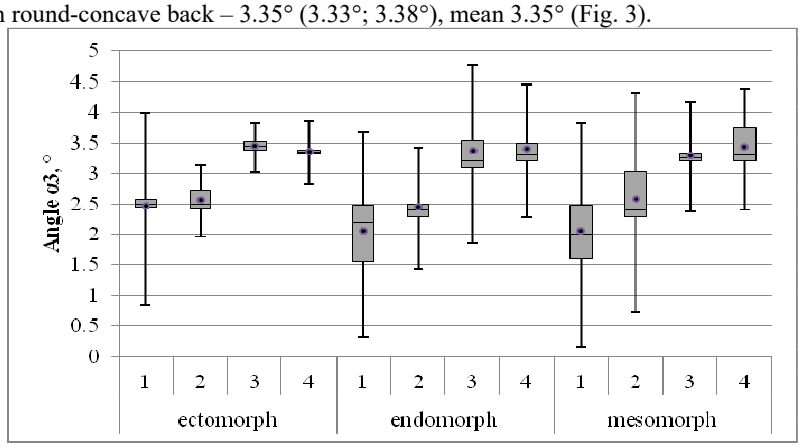

Figure 3. The angle formed by the vertical and the line connecting the spinous processes of the C_{VII} and L_V vertebra (α_3) of female students: 1 – normal posture; 2 – scoliotic posture; 3 – round back; 4 – round-concave back

In female students with endomorphic body type without posture disorders median of angle (α_3) was 2.20° (1.55°; 2.48°), mean 2.05°; with scoliotic posture this angle was 2.40° (2.30°; 2.50°), mean 2.46°; with round back – 3.20° (3.10°; 3.55°), mean 3.37°; with round-concave back – 3.20° (3.20°; 3.50°), mean 3.40°.

In female students with mesomorphic body type with a normal posture the median of angle formed by the vertical and the line connecting the spinous processes of the C_{VII} and L_V vertebra (α_3), was 2.00° (1.60°; 2.48°), mean 2.06°; in female students with scoliotic posture this angle was 2.39° (2.30°; 3.03°), mean 2.59°; with round back – 3.20° (3.20°; 3.33°), mean 3.29°; with round-concave back –3.30°(3.20°; 3.75°), mean 3.43°.

In order to develop comprehensive physical education programs that will have a direct impact on female students physique taking into account body mass geometry peculiarities and physical fitness, a factor analysis there was applied.

As a result of factor analysis procedure application there was secreted 5 factors that explain 78.24% of the total dispersion for ectomorphs, 73.42% – for mesomorphs and 92.53% – for endomorphs (Table 3).

In the research process we established the physical development factor structure, fitness and posture biogeometric profile of female students of different somatotypes. The obtained factor indicators after Varimax-rotation for female students of different somatotypes are presented in Table 4–6.

For representatives of the mesomorphic somatotype unipolar Factor I "Physical Development" (31.769%) combines all anthropometric indicators: body weight (r = .950), buttock circumference (r = .878), thigh circumference (r = .836), calf circumference (r = .831), shoulder circumference (r = .766), chest circumference (r = .649), body height (r = .624) i waist circumference (r = .535) (Table 4).

This data indicates of harmonious physical development of mesomorphs, where all these variables move in tandem – that is, in the same direction.

Factor II "Strength" (12.501%) combines upper body strength and endurance (r = .863) and explosive leg power (r = .581).

Bipolar factor III "Posture biogeometric profile" (10.745%) contains indicators posture biogeometric profile state in the sagittal plane: head inclination angle (α_1) (r = .740), inferior angle of the scapula symmetry (α_3) (r = -.642), as well as sagittal shoulder-C_{VII} angle (α_2) (r = .854). Thus, we see that this factor indicates the posture state importance of students of higher education in physical state factor structure, physique and posture biogeometric profile.

Table 3. **Evaluation of eigenvalues of first-year female students of different somatotypes (n = 121)**

Factor	Total	% of Variance	Cumulative %
Ectomorphs			
I	3,647	22,794	22,794
II	2,535	15,844	38,638
III	2,241	14,005	52,643
IV	2,095	13,097	65,740
V	2,000	12,500	78,239
Mesomorphs			
I	5,083	31,769	31,769
II	2,000	12,501	44,271
III	1,719	10,745	55,015
IV	1,500	9,378	64,393
V	1,444	9,027	73,419
Endomorphs			
I	3,649	22,808	22,808
II	3,168	19,801	42,609
III	2,814	17,590	60,199
IV	2,625	16,405	76,604
V	2,548	15,927	92,531

Note. Items with less than .50 factor loadings are not specified

Table 5. **Factor physical state structure, physique and posture biogeometric profile of first-year female students of mesomorphic somatotype (n = 64)**

Indices	Factors				
	1	2	3	4	5
Body weight, kg	.950*				
Buttock circumference, cm	.878*				
Thigh circumference, cm	.836*				
Calf circumference, cm	.831*				
Shoulder circumference, cm	.766*				
Chest circumference, cm	.649				
Body height, cm	.624				
Waist circumference, cm	.535				
Push-up Test, repetitions		.863*			
Standing Long Jump Test, cm		.581			
Sagittal shoulder-C_{VII} angle (α_2), °			.854*		
Head inclination angle (α_1), °			.740*		
Inferior angle of the scapula symmetry (α_3), °			-.642		
12-minute Shuttle Run Test, m				.687	
Sit and Reach Test, cm					.848*
Incline Sit-up Test, repetitions					-.510

* – factor loadings statistically significant ($p < 0.05$)

Factor IV "Cardiorespiratory endurance" with a total load of 9.378% contained 12-minute Shuttle Run Test results (r = .687), which indicates the importance of this indicator in the overall factor structure of first-year students.

In the factor V "Flexibility" (9.027%) there was secreted flexibility (r = .848), which has an inverse correlation with the abdominal muscle strength (r = -.510). It can be argued that the greater abdominal muscle strength is, the worse their flexibility.

For ectomorphic somatotype representatives the unipolar factor I "Lower body physical development" (22.794%) combines all anthropometric indicators: thigh circumference (r = .863), calf circumference (r = .829), body weight (r = .759), buttock circumference (r = 0.710) and explosive leg power (r = .563) (Table 5).

This location indicates that the greater the body weight and thigh, calf and buttock circumferences, the better the leg muscles strength of female students of the ectomorphic somatotype.

Table 5. **Factor structure of physical state, physique and biogeometric posture profile of first-year female students of ectomorphic somatotype (n = 35)**

Indices	Factors				
	1	2	3	4	5
Thigh circumference, cm	.863*				
Calf circumference, cm	.829*				
Body weight, kg	.759*				
Buttock circumference, cm	.710*				
Standing Long Jump Test, cm	.563			.563	
Chest circumference, cm		.848*			
Body height, cm		.770*			
Head inclination angle (α_1), °		.725*			
Shoulder circumference, cm		.625			
Sit and Reach Test, cm			-.942*		
Waist circumference, cm			.611		
Push-up Test, repetitions				.846*	
Incline Sit-up Test, repetitions				.743*	
Inferior angle of the scapula symmetry (α_3), °					.887*
Sagittal shoulder-C_{VII} angle (α_2), °					.839*
12-minute Shuttle Run Test, m					-.546

* – factor loadings statistically significant ($p < 0.05$)

Factor II "Upper part physical development" (15.844%) combines chest circumference (r = .848), body height (r = .770), head inclination angle (α_1) (r = .725) and shoulder circumference (r = .625). Thus, the higher the ectomorphic somatotype representatives, the greater the upper body circumferences and head inclination angle.

Factor III "Flexibility" (14.005%) contains indicators of waist circumference (r = .611) and flexibility (r = -.942), which have an inverse correlation.

Factor IV "Strength" with a total load of 13.097% contained the push-up test results (r = .846), incline sit-up test (r = .743) та standing long jump test (r = .563), which indicates the importance of strength qualities development of different muscle groups of ectomorphic somatotype students.

Factor V "Cardiorespiratory endurance" (12,500%) included inferior angle of the scapula symmetry (α_3) (r = .887), sagittal shoulder-C_{VII} angle (α_2) (r = .839) та endurance (r = -.546). Running is an aerobic cyclic load that involves large muscle groups, not only the lower extremities, but also the torso, shoulder and upper extremities. That is, the greater these angles deviation from the norm, the worse the human cardiorespiratory endurance: head inclination angle (α_1) (r = .740), inferior angle of the scapula symmetry (α_3) (r = -.642), and sagittal shoulder- C_{VII} angle (α_2).

In girls of endomorphic somatotype, factor I "Strength" (22.808%) included body height (r = .948), chest circumference (r = .924), результати standing long jump test (r = .844) and incline sit-up test result (r = .715) (Table 6). Thus, the greater the body height and chest circumference in girls of endomorphic somatotype, the better developed explosive leg power and abdominal muscle strength.

Unipolar factor II "Physical Development" (19.801%) combines buttock circumference (r = .951), thigh circumference (r = .843), calf circumference (r = .773) and body weight (r = .610). Thus, the greater the body weight of students of endomorphic somatotype, the greater the lower body circumferential sizes.

Bipolar factor III "Strength qualities of shoulder girdle" (17.590%) contains the indicator head inclination angle (α_1) (r = -.895) and push-up test results (r = .824), which have an inverse correlation. Thus, it can be suggested that the greater head inclination angle deviation of endomorphic students, the worse the upper body strength.

Bipolar factor IV "Cardiorespiratory endurance" (16.405%) included cardiorespiratory endurance (r = -.885), sagittal shoulder-C_{VII} angle (α_2) (r = .822) and inferior angle of the scapula symmetry (α_3) (r = .807). Thus, like to ectomorphic somatotype female students, the greater the deviation of these angles from the norm, the worse their cardiorespiratory endurance.

Bipolar factor V "Flexibility" with a total load of 15.927% contains indicators of shoulder circumference (r = .922), waist circumference (r = .871), sit and reach test result (r = -.684) and body weight (r = .557). Hence, the greater the values of the body girth-weight dimensions, the less developed the flexibility of students of endomorphic somatotype.

The obtained factor results showed that only for students of mesomorphic somatotype indicators of posture biogeometric profile have little effect on physical fitness indicators, and for students of ectomorphic and endomorphic somatotypes they are closely related, and the connection is inverse.

Table 6. **Factor structure of physical state, physique and posture biogeometric profile of first-year female students of endomorphic somatotype (n = 22)**

Indices	Factors				
	1	2	3	4	5
Body height, cm	.948*				
Chest circumference, cm	.924*				
Standing Long Jump Test, cm	.844*				
Incline Sit-up Test, repetitions	.715*				
Buttock circumference, cm		.951*			
Thigh circumference, cm		.843*			
Calf circumference, cm		.773*			
Body weight, kg		.610			.557
Head inclination angle (α_1), °			-.895*		
Push-up Test, repetitions			.824*		
12-minute Shuttle Run Test, m				-,885*	
Sagittal shoulder-C_{VII} angle (α_2), °				,822*	
Inferior angle of the scapula symmetry (α_3), °				,807*	
Shoulder circumference, cm					.922*
Waist circumference, cm					.871*
Sit and Reach Test, cm			.603		-.684

* – factor loadings statistically significant ($p < 0.05$)

Discussion

The data of our experimental researches allowed to confirm researches results of a number of experts W. Ibrahim, H. Hussein&Amir Abdul (2012), M.V. Dudko (2016), O.O. Kuts-Burdeyna (2016), I. Vypasniak, A. Shankovsky (2017) according to student's youth distribution on body types. Thus, according to our data, 52.9% of students had a mesomorphic somatotype, 28.9% ectomorphic and 18.2% – endomorphic, coordinated with the data of other researchers – 55-60% of students belong to the mesomorphic somatotype, 13–18% – to ectomorphic and 19–25% – to endomorphic.

Research data (Dudko, 2016; Vypasniak&Shankovsky, 2017) that indicate that the number of female students who need body spatial organization correction is increasing have been confirmed. The greatest concern is the growing number of students with scoliotic posture (Bettany-Saltikov& Kandasamy, 2020). Our data, as well as data from scientific and methodological literature analysis (Kuts-Burdeyna, 2016; Alyoshina et al., 2020) allowed to claim that posture disorders are a common musculoskeletal system disorder among student youth, especially females. According to our data, 28.9% of first-year students had a normal posture, and according to V. Kashuba, I. Asaulyuk, A. Dyachenko (2017) about 80% of students have posture disorders, M. V. Dudko (2016) notes that only 15.2% students have a normal posture, O. O. Kuts-Burdeyna (2016) claim that 19.4% of students and 12.3% of female students have a normal posture.

At the same time, there is a certain relation between posture functional disorders frequency and human somatotype, hence they are most expessed in ectomorphs (Podrigalo, 2019; Tkachova et al., 2020; Nesterchuk et al., 2020; Kashuba et al., 2020).

In the study of B. Mytskan, I. Vypasnyak & A. Shankovs'kyy (2018), M. Kolokoltsev, L. Kuznetsova, W. Jagiello, E. Romanova (2020) it was shown the connection between physical fitness indicators and students' somatotype typology. Further studies have confirmed the role of motor activity in body formation. Thus, N. Goncharova, V. Kashuba, A. Tkachova et al. (2020) showed the relationship of body type with motor activity. Since the samples selected for the present research were untrained and unathletic, this test had a considerable effect on their records randomly and hereby there were some nonmeaningful relationships. We found that students of ectomorphic somatotype have the lowest rates of cardiorespiratory endurance and flexibility, which was confirmed in (Tkachova et al., 2020); students of endomorphic somatotype have the lowest indicators of strength qualities of different muscle groups (Saha, 2015; Çinarli, Kafkas, 2019; Çinarli, 2021). Probably it is due to the fact obese people are less active. A mesomorph female students have positive correlation with all body movements (Kelch, 2015). Differences in muscle strength are associated with androgenism degree. The authors note that somatic androgenism can be a factor in both gender and intrasexual differences in muscle strength. In the studies of N. Chidi-Ogbolu and K. Baar (2019) it is shown that estrogenic activity level is higher in girls and women of mesomorphic type.

Conclusions

Female students of 17–18 years old of three somatotypes (ectomorphic, mesomorphic, endomorphic) have distinctive parameters of motor skills and reliable difference ($p < 0,05$) in a number of functional characteristics muscular systems of the body and posture biogeometric profile.

We determined for the first time the factor structure of physical development indicators, physical fitness, somatotype and posture biogeometric profile of female students.

The factor analysis results allowed to select 5 factors that explain 78.24% of the total dispersion for ectomorphs, 73.42% for mesomorphs and 92.53% for endomorphs.

The received data concerning constitutional features of motor skills and functional body characteristics of students of different somatotypes allow to concretize provisions of methodology of planning of individually differentiated process of physical training and health activities with the female students based on results of factor analysis.

Conflict of Interest. The authors declare that there is no conflict of interest that could be perceived as interfering with publication of the article.

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