

Physical education of girls from different somatotypes and health groups

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Published online: March 31, 2021

(Accepted for publication March 15, 2021)

DOI:10.7752/jpes.2021.02106

Abstract:

Research aim – is to conduct a comparative assessment of constitution types, motor qualities and body components of adolescent girls with different health levels to correct the physical education methods.

Research materials and methods. 246 female students of Irkutsk Technical University (Russia) of functional health groups I (n=132) and III (n=114) were examined. According to the scheme of M. V. Chernorutsky the types of the girls' body constitution with Pinier's index calculation were evaluated, arterial pressure was measured, heart rate before and after graduated exercise was determined, as well as recovery time pulse after exercise and muscle strength of the hands. Robinson's index and power index were counted. The content of bone, fat and muscle tissue in the girls' bodies was calculated using Mateyko's formulas. The main motor qualities of the girls were determined using a set of motor tests. *Research results.* In the first group of students, high functional indicators of the cardiovascular and muscular systems were reliably established in girls of all types of constitution. In this group, girls of the normosthenic somatotype had an advantage in motor qualities. In the third group of students, the girls of normosthenic and asthenic somatotypes had significantly high indicators of motor qualities. In comparison with the results of the study of the component composition in the body of all girls of the first group, the girls of the third group had a lower content of the muscle component, and more fat mass in all types of constitution. The highest content of fat mass was found in girls - hypersthenic somatotype of group III.

Conclusions. The indicators of girls from different functional groups and types of constitution, cardiovascular and muscular system activity, motor qualities and body component composition significantly differ. Of all the students surveyed, more than a third of the girls have an asthenic body type. Functional indicators of the cardiovascular and muscular systems, motor qualities and muscle component content in the body, maintaining fat mass below the girls of all somatotypes from the first group, in comparison with girls, having such somatotype from the third group. In both groups, the motor tests results and the cardiovascular system reserve of activity during exercise were higher in girls with normosthenic and asthenic body types than in girls with hypersthenic type. The research results allow adjusting the PE and sports classes curricula in educational institutions.

Key Words: types of constitution, functional health groups, students, physical education (PE)

Introduction

The problem of life quality improving and the level of the population health are urgent. Regular and optimal physical activity with the use of physical culture means and methods (Talović et.al., 2015) is one of the most effective areas of health-saving for young people

In the scientific literature of various countries, reports are presented on the positive impact of the optimal amount of physical activity on students' health in Romania and Spain (Potop et.al., 2017; Zurita-Ortega

et.al., 2019), China (Zhang et.al., 2019), the Republic of Belarus (Savko, Hojempo, 2018), Russia (Golovin, Romanova, 2017).

The methodology and technology of conducting PE classes in educational institutions need to be modernized to eliminate the reasons reducing the effectiveness of the educational process in health saving direction (Drachuk et.al., 2018). In recent years, research on students' constitutional physique and physical education integration has intensified (Miroshnichenko et.al., 2019; Kolokoltsev et.al., 2020). A close correlation was established between the somatotype and human motor qualities characteristics (Cruz et.al., 2017), physical development and manifestation of the influence of acceleration and retardation processes on the body (Satarov, Karelina, 2018).

To assess the metabolic processes occurring in human body, the body's component composition characteristics are often used (Kharlamov, 2018). There are reports on training process in sports effectiveness dependence on the ratio of athletes' muscle and fat components of the body composition indicators (Ramos-Jiménez et.al., 2018; Kutseryb et.al., 2019; Rybakova et.al., 2020).

The results of somatotypes assessment of those involved in sports are taken into account in the sports selection (Vovkanych et.al., 2015), for body correction in fitness programs (Aftimichuk, Varvarich, 2013). When developing methods and technologies of physical education, some researchers suggest taking into account the features of students' constitutional typology to improve their health and motor qualities (Miroshnichenko et.al., 2019; Ustseleмова, & Ilyina, 2015). During the university study period, the body development ends and the final type of the human constitution is formed. In adolescence, the morphological and functional development of the body is completed and the final somatotype is formed. It is relevant to study the issue of girls with different types of constitution and health groups, physical education. However, the literature does not sufficiently cover the topic of comparative assessment of young girls with different health groups, constitution types and motor qualities manifestation. It allows making adjustments to the organization and conduct of training sessions on PE of female students in educational institutions and increases the effectiveness of the health-saving process.

Research aim is to conduct a comparative assessment of constitution types, motor qualities and body components of adolescent girls with different health levels to correct the physical education methods.

Material & methods

In 2019, 246 girls aged 17-20, studied at Irkutsk National Research Technical University (Russia) were examined.

For PE classes at the university, 132 girls were assigned to Ist functional group of health, without restrictions on physical activity, and 114 girls to the III functional group with restrictions on physical activity.

All students attended classes on physical culture and sports at Physical Culture department of the university 2 times a week. In the Ist functional group, classes are held using modern fitness aerobics technologies. In group III, training sessions on general physical training were conducted with the dosage of physical activity.

A pedagogical screening of all the examined students' anthropometric, functional indicators and motor qualities state was conducted.

For the girls' body constitution type assessment, the scheme of M. V. Chernorutsky (Fefelova et.al., 2015) was chosen:

$I = L - (P + T)$, where L - standing body length (cm), P – body mass (kg), T - circumference of the chest on the exhale (cm).

The presence of the hypersthenic type (H) of body constitution in girls was evaluated at the value of the Pinier index < 10 , if the Pinier index value was in the range from 10 to 30 it was considered to be the normosthenic (N) type. When the value of the index Pinier index > 30 - the type of constitution of the girls was considered as asthenic (A). The choice of this somatotyping scheme using Pinier's index was explained by its simplicity, accessibility for wide use and the ability to compare the data obtained with the results of other researchers.

To characterize the relationship between the female students' constitution types and functional indicators of both groups, we measured:

- heart rate before loading (HR), beat/10 s
- heart rate after 20 squats in 30 s (HR), beat/10 s;
- recovery time of heart rate after 20 squats, min;
- systolic blood pressure (SBP) and diastolic blood pressure (DBP), mm Hg;
- dynamometry of both hands, kg (Hand grip Strength Test, kg).

To assess the girls' body energy potential, we calculated the indicator of the cardiovascular system reserve – the Robinson index: $I_{Rob} = (HR \times SBP) / 100$ c.u. (Robinson, 1967). To assess strength abilities, the strength index was calculated: $SI = (\text{hand muscle strength} / \text{body weight}) \times 100\%$ $SI = (\text{muscle strength of the hand} / \text{body mass}) \times 100\%$ (Nikitina et.al., 2016).

The component composition of the girls' body according to the absolute and percentage content of bone, fat and muscle tissue was calculated according to Mateyko method (1921).

The girls' conditioning abilities were determined according to the testing requirements (Schmidt, Lee, 2013; Fitness Testing Requirements, 2017). We used a battery of motor tests to assess speed and agility, test # 1 (shuttle run 10 times x 5 m, s); general endurance, test #2 (run 1000 m, m/s); test # 3 strength and strength endurance of the upper shoulder girdle muscles, (hanging on the crossbar, s); test #4 strength of the torso flexor muscles, (lifting the torso from the prone position, number of times in 30 s); test #5 arm strength, (push-up from the floor, number of times); test # 6 active joint flexibility, (leaning forward from a sitting position, cm); dynamic strength of the muscles of the lower extremities, test #7 ((standing long jump, cm).

The present work does not infringe on the rights and does not endanger the well - being of girls in accordance with the ethical standards of the Human Rights Committee of the Helsinki Declaration of 2008 (WMA Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects, 2008).

The arithmetic mean (M), standard deviation (σ) and standard error (m) were processed with the help of software package «StatSoft Statistica 6.1», «Microsoft Excel». Parametric methods were used to evaluate the reliability of differences in the average values of the samples with the Student's t-test (Ustseleмова et al., 2019).

Results

The distribution of girls from different functional groups by body constitution type is shown in Figure 1.

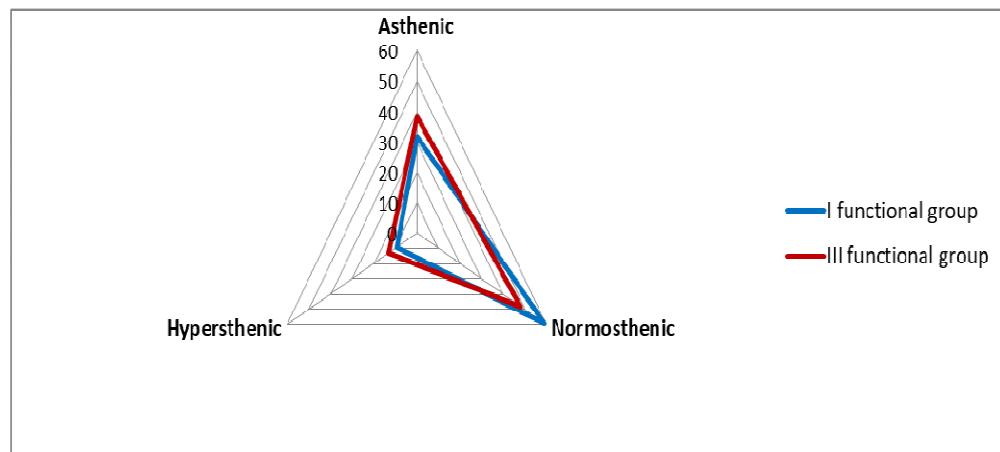


Figure1. The distribution of girls from different functional groups by body constitution type (%)

It was found that the number of girls with an asthenic body composition in the I functional group is 33.8% less, girls with a hypersthenic type of constitution is 44.7% less than the number of asthenic and hypersthenic girls in the III group. There were 18.3% more girls with the normosthenic type of constitution in the first functional group than in the third one.

The human body physical capacity is largely determined by the functional state of the cardiovascular and muscular systems. Table 1 shows the characteristics of these systems indicators in all the examined girls.

Table 1. Values of girls' of health groups I and III with different somatotypes functional indicators (M±m).

Functional indicators	I st group				III rd group			
	G (n=12)	N (n=78)	A (n=42)	P< 0,05	G (n=15)	N (n=55)	A (n=44)	P< 0,05
Systolic blood pressure mm Hg.	115,4 ± 0,4	113,9± 0,29	112,2± 0,91	p ₁ -p ₂ p ₁ -p ₃	114,6± 0,72	114,1± 0,44	110,1± 1,02	p ₁ -p ₃ p ₂ -p ₃
Diastolic blood pressure mm Hg.	73,4 ± 0,4	72,5± 0,23	72,2± 0,72	-	75,9± 0,74	73,8± 0,46	71,1± 1,04	p ₁ -p ₃ p ₂ -p ₃
Heart rate at rest, beat/10 sec	16,6± 0,57	14,26± 0,03	14,1± 0,42	p ₁ -p ₂ p ₁ -p ₃	17,9± 0,72*	16,2± 0,63*	16,0± 0,66*	p ₁ -p ₂ p ₁ -p ₃
Heart rate after 20 squats in 30 s (HR), beat/10 sec	23,3± 0,24	19,1± 0,12	19,7± 0,34	p ₁ -p ₂ p ₁ -p ₃	25,41± 0,82*	22,63± 0,19*	23,90± 0,63*	p ₁ -p ₂ p ₁ -p ₃

Recovery time of heart rate, min	0,96± 0,09	0,98± 0,04	0,99± 0,03	-	1,25± 0,07*	1,20± 0,01*	1,23± 0,04*	-
Robinson index, c.u.	116,3± 1,72	104,2± 0,41	108,4± 0,84	p ₁ -p ₂ p ₁ - p ₃ p ₂ -p ₃	128,6± 0,93*	112,2± 0,72*	118,9± 0,94*	p ₁ -p ₂ p ₁ - p ₃ p ₂ -p ₃
Left hand dynamometry, kg	21,90± 1,03	22,45± 0,36	21,92± 0,26	-	20,2± 0,52*	21,1± 0,28*	20,0± 0,61*	-
Right hand dynamometry, kg	24,30± 0,81	24,98± 0,36	24,16± 0,28	-	22,5± 0,54*	23,0± 0,34*	22,8± 0,64*	-
Left hand strength index, %	33,6± 0,39	35,98± 0,33	39,78± 0,82	p ₁ -p ₂ p ₁ - p ₃ p ₂ -p ₃	28,4± 0,68*	32,7± 0,58*	35,2± 0,73*	p ₁ -p ₂ p ₁ - p ₃ p ₂ -p ₃
Right hand strength index, %	37,3± 0,58	41,9± 0,36	43,8± 0,80	p ₁ -p ₂ p ₁ - p ₃ p ₂ -p ₃	34,9± 0,71*	35,6± 0,62*	32,2± 0,83*	p ₁ -p ₃ p ₂ - p ₃

Note. G – hypersthenic, N- normosthenic, A- asthenic constitution type.

* - statistically significant differences (p < 0,05)

It was found that the heart rate values at rest and after 20 squats, recovery time after physical activity, and the Robinson index in girls of group I of all somatotypes were significantly lower than in girls of group III of all types of constitution (p < 0.05). These data indicate a higher reserve capacity of the cardiovascular system and a better adaptation of group I girls during the academic year to perform aerobic exercise in PE classes at the university.

In both examined groups, the heart rate at rest indicators values after performing 20 squats and Robinson index were lower in comparison with the hypersthenic girls' results (p < 0.05). This indicates that girls of normosthenic and asthenic constitution types have an advantage in performing physical activities, compared with those of the hypersthenic type of constitution.

In the observed groups, the girls' with different somatotypes hands muscles' dynamometry values of both hands did not significantly differ. The highest values of the both hands strength index were found in asthenic girls, the lowest in hypersthenics ones. The strength index in normosthenics, asthenics and hypersthenics girls from the first group was significantly higher than in girls from the third group with the same types of constitution (p < 0.05).

Table 2 shows the motor qualities characteristics of girls from both groups.

Table 2. Motor tests indicators values of girls from different groups and different somatotypes (M±m)

Tests	I st group				III rd group			
	G (n=12)	N (n=78)	A (n=42)	P< 0,05	G (n=15)	N (n=55)	A (n=44)	P< 0,05
Shuttle run 10 times x 5 m, (sec)	21,89± 1,22	17,2± 0,08	17,97± 0,09	p ₁ -p ₂ p ₁ -p ₃ p ₂ -p ₃	29,88± 0,84*	20,14± 0,09*	19,82± 1,14*	p ₁ -p ₂ p ₁ -p ₃
Run 1000 m, (m/sec)	7,3± 0,94	5,2± 0,06	5,3± 0,05	p ₁ -p ₂ p ₁ -p ₃	9,4± 0,08*	7,3± 0,09*	7,6± 0,83*	p ₁ -p ₂ p ₁ -p ₃
Hanging on bent arms, (sec)	5,45± 1,56	9,48± 0,62	7,12± 0,09	p ₁ -p ₂ p ₁ -p ₃ p ₂ -p ₃	1,29 ± 0,04*	3,43± 0,03*	4,48± 0,72*	p ₁ -p ₂ p ₁ -p ₃ p ₂ -p ₃
Sit-up, in 30 sec, (number of times)	24,76±0 ,22	26,65± 0,04	24,87± 0,02	p ₁ -p ₂ p ₂ -p ₃	24,53± 0,12	24,12± 0,13*	24,67± 0,23	-
Push-up from the floor, (number of times)	36,44± 2,84	43,06± 0,63	42,12± 0,14	p ₁ -p ₂ p ₁ -p ₃	19,56± 0,45*	21,27± 0,82*	20,12± 1,31*	-
Leaning forward from a sitting position (cm)	13,36±1 ,22	15,58± 0,29	13,24± 0,01	p ₁ -p ₂ p ₂ -p ₃	12,78± 0,62	13,38± 1,13*	12,34± 1,22	-
Standing long jump, (cm)	156,7± 4,6	172,9±0 ,9	170,4± 0,78	p ₁ -p ₂ p ₁ -p ₃ p ₂ -p ₃	152,6± 1,2	162,1± 2,2*	164,4± 2,6*	p ₁ -p ₂ p ₁ -p ₃

Note. G – hypersthenic, N- normosthenic, A- asthenic constitution type.

* - statistically significant differences (p < 0,05)

According to Table 2, the motor tests values in girls of functional groups I and III significantly differ, p < 0,05.

In Ist functional group girls with normosthenic somatotype have an advantage in all motor tests, compared to girls of other constitution types in this group. Asthenic girls have an advantage over hypersthenics in all tests, except for test #. 6.

A slightly different picture is observed in girls of IIIrd group of health. In girls of normosthenic physique, the best indicators' values were established in three tests # 2, 3, 6, $p < 0.05$. Asthenic girls have an advantage over other somatotypes in four tests # 1, 3, 4 and 7, $p < 0.05$. In hypersthenic girls, the low values of motor test scores # 1, 2, 3, 5, and 7 were lower than in girls of other somatotypes.

A comparative analysis of the girls' from Ist and IIIrd groups physical fitness did not establish a significant difference between the indicators values of hypersthenic girls in tests # 4, 6, 7, $p > 0.05$. Also, there was no significant difference between the indicators values of the asthenic girls' from groups Ist and IIIrd in tests # 4 and 6, $p > 0.05$. The indicators values of all motor tests in girls - normosthenics of the Ist functional group are significantly higher than in girls of the IIIrd functional group of the same types of constitution, $p < 0.05$.

The girls' of different functional groups of health body composition is presented in Table 3.

Table 3. The girls' of groups I and III body weight composition (M±m)

Body weight composition	I st group		III rd group	
	Absolute count (kg)	% of body mass	Absolute count (kg)	% of body mass
Bone	11,15±0,10	19,76	11,39±0,45	18,8
Fat	10,68±0,39	15,24	18,29±0,49*	24,93
Muscle	21,47±0,23	36,13	15,57±0,30 *	28,63

Note - *statistically significant differences ($p < 0,05$)

It was found that in group I girls, the muscle component content of body weight was 37.8% higher, and the fat component content was 71.2% lower, compared to group III girls, $p < 0.05$. The bone component content in the body of girls is practically the same.

The girls with different types of body constitution component composition is shown in Fig. 2.

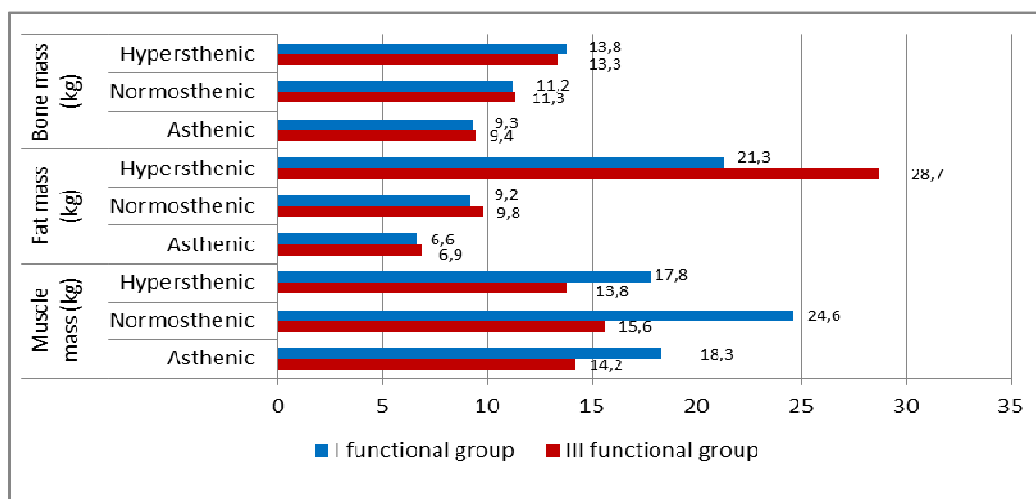


Fig. 2. The girls' of different constitution types and functional groups body composition component (kg)

The muscle component content in asthenic girls of group I body weight was greater by 28.8%, in normosthenics by 57.6% and in hypersthenics by 28.9 %, compared with students of the IIIrd functional group with the same somatotypes, $p < 0.05$. This explains the difference in power abilities between them.

Hypersthenic girls from both observed groups differ in the fat component content in body weight, $p < 0.05$. In the hypersthenic girls' body of the Ist functional group, the fat mass was 25.8% less than in the same girls of the IIIrd functional group, $p < 0.05$.

In both functional groups, girls of the hypersthenic type of constitution lead in the bone component content in body weight, $p < 0.05$.

Dicussion

As a result of our research, more than 30% of asthenic girls were identified in each of the observed groups, which is consistent with the results of other authors (Komissarova, et.al., 2017). Asthenization of the physique and a decrease in metabolic processes in the human body leads to a delay in its physical development

and a decrease in its motor qualities (Nikityuk, Khapalyuk, 1997). The negative impact of asthenization in women is reflected in the sexual functions of the female body (Egorova et.al., 2010)

Presence of more than a third of asthenics in the young girls' population surveyed by us indicates a complication of the medical and demographic situation in this territory and requires health-saving preventive measures adoption. Asthenic girls should be allocated to the risk group for non-communicable diseases.

The results of a body component composition comparative analysis indicate a low content of muscle and a high content of fat mass in the body of girls from group III of all types of constitution, compared with the results of girls from group I with the same somatotypes, which affects the strength abilities. The highest content of fat mass (28.7%) was found in hypersthenic girls from the third group.

This is confirmed by our research of female students' motor qualities results. In both groups, the indicators values of strength and strength qualities in hypersthenic girls are lower, compared with the indicators values in normosthenic and asthenic girls. Our data are consistent with the results of monitoring the motor qualities and body composition of female students in Krakow (Karol Görner, Alexa Reineke, 2020) and are an indirect confirmation of inactivity presence among modern youth. This is also reported by other researchers (Potop et.al., 2017; Zhang et.al., 2019; Savco, Hojempo, 2018; Golovin, Romanova, 2017).

The dependence of the body functional system on human constitution type is established in the work of Moi et. al. (2016). The indicators values of the cardiovascular system in the examined girls of all types of constitution in I functional group of health were significantly lower than in the girls in the III functional group with the same somatotypes ($p < 0.05$). Comparative results of the female students' cardiovascular system reserve capabilities analysis indicate a better adaptation of the girls of I functional group to physical exertion of an aerobic orientation.

Previously, we found that girls with normosthenic and asthenic body types have more reserve capabilities of the cardioresperator system when performing physical loadings, compared with girls of the hypersthenic somatotype (Kolokoltsev et.al., 2020). The research results supplement the previous statement that in different functional health groups, the heart rate at rest indicators values, after a load of 20 squats, the Robinson index in normosthenics and asthenics girls is lower than in hypersthenics ($p < 0.05$).

Our research on the female students' of normosthenic, asthenic and hypersthenic body types and different functional health groups morphofunctional capabilities should be taken into account when organizing PE classes in educational institutions. Teachers should pay special attention to girls with a hypersthenic body type in the classroom, as to people having a low functional potential to perform physical activity. For hypersthenic girls, we recommend an additional independent program for normalizing body weight using low-calorie diets and performing exercises for general endurance, swimming, long-term walking and CrossFit. Asthenic girls need strong physical activity aimed at increasing muscle mass and including foods with a high content of animal proteins in the diet.

Conclusions

In each of the examined female students' functional groups, more than a third of the adolescent girls had an asthenic body type.

Between girls of different functional groups and somatotypes, there were significantly distinctive signs in the cardiovascular and muscular system indicators, motor qualities and body component composition.

All girls of I functional group had significantly higher functional parameters of the cardiovascular and muscular systems, higher content of the muscle component and lower content of fat mass in the body, compared with the indicators of all girls of similar somatotypes in III functional group.

Girls with normosthenic and asthenic body types in both groups had more reserve capabilities of the cardiovascular system when performing aerobic exercise and higher motor qualities compared to girls of the hypersthenic type of constitution. The muscle component content in girls' of all types of constitution of I functional group body was higher compared to girls of the III group with the same somatotypes. Therefore, girls of I functional group of all types of constitution had an advantage in power abilities.

In both observation groups, the highest content of fat and bone components in body weight was found in hypersthenic girls, which reduces their physical condition.

In comparison with hypersthenic girls in both functional groups, normosthenic and asthenic ones have the best results in speed, strength, agility, flexibility and overall endurance.

The results obtained on the state of the cardiovascular and muscular systems, motor qualities and body composition of girls of different health groups and types of constitution expand the range of information about the functional capabilities of modern youth's body and help to adjust the curriculum for students' physical education.

Conflicts of interest. The authors declare no conflict of interest.

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