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Original Article

Physical activity and metabolism of girls with different somatotypes

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Abstract:
The study of human physical activity, taking into account metabolism and somatotype, seems relevant due to the insufficient knowledge of this issue. *Research aim:* is to determine the relationship of physical activity with metabolism level in the body of girls of different somatotypes. *Research materials and methods***.** 376 female university students aged 17-19 without medical health restrictions were under observation to perform physical activities. Their somatotypes (M.V. Chernorutsky's scheme) and weekly physical activity volume (IPAQ-SF physical activity questionnaire) were determined, the metabolic rate was calculated, and physical qualities were tested. *Research results*. Girls with normosthenic somatotype have the largest number of days of intense and moderate physical activity per week and its duration per day among all the surveyed project participants. They have high indicators of energy potential, metabolic equivalent and physical fitness when performing various types of physical activity. Girls-normosthenics have higher physical fitness level. As for asthenic girls, all the studied indicators occupy a medial position. Girls of the hypersthenic type of constitution have insufficient weekly physical activity. They have low levels of metabolism and physical qualities. *Conclusions.* Our research project results confirm the existence of correlation between physical activity, metabolism and somatotype of female students. The results obtained can be used in educational institutions to plan training sessions taking into account the individual characteristics of the body of those involved.
Key Words*:* **somatotype, physical activity, metabolism, physical qualities**

Introduction

A person's state of health and quality of life depend on a number of the external and internal environmental factors (Ignatenko et al., 2021). Optimal physical activity plays a significant role in the process of forming the human health level (Bakiko et al., 2020). Hypokinesia increases in the modern younger generation (Pengpid et al., 2019; Chen et al., 2020; Dominski, & Brandt, 2020), physical, somatic (Zhang et.al., 2019) and mental health levels decrease (Tabacco, 2018). In such a situation, a negative change in metabolism and body weight occurs in the human body (Jordan et al., 2020), the immune status and life expectancy decrease (Ruegsegger, & Booth, 2018), especially during the COVID-19 pandemic (Sunda et al., 2021).

The literature sources present data from scientists' research works on the positive effects of physical activity over human health (De la Camara et al., 2021), his\her physical qualities (Yıldız, 2018), psychoemotional status and cognitive functions (Grajek, & Sobczyk, 2021).

Therefore, there is a need for a comprehensive study of the relationship of a person's regular physical activity with factors that can influence it.

To preserve the health of people aged 18-64 and older, WHO offers a weekly physical activity standard in the amount of 150 minutes (5 days a week x 30 minutes a day) with moderate aerobic loads or at least 75 minutes (3 days a week x 25 minutes a day) with high intensity loads (WHO. Global recommendations on physical activity for health, 2010). Increasing the optimal weekly physical activity program brings additional benefits for human health. The use of the unified protocol of WHO recommendations in scientific research

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makes it possible to obtain comparable results of physical activity of the population. The design of the global recommendations does not exclude the possibility of determining the metabolic equivalent of physical activity in different population groups, which increases the value of the research results.

The doctrine of people's constitutional difference makes it possible to use the method of somatotyping a person in sports and medical practice, especially in the field of physical education of young people (Miroshnichenko et al., 2019). There is an opinion on the principle of individualization introduction in the students' educational process of physical education, based on motor qualities and human somatotype connection (Kolokoltsev et al., 2021). The authors found that girls of the normosthenic somatotype are more tolerant to aerobic exercise and have high functional indicators of the cardiorespiratory system, compared with girls of other types of constitution.

The individual educational routes choice, taking into account the type of athletes' constitution, allows increasing the effectiveness of training sessions in the annual macrocycle (Ramos-Jiménez et al., 2018; Rybakova et al., 2020) of any sport, especially in fitness (Chwalczynska et al., 2017). The relationship of human somatotypes with various sports is reported by Martínez-Cervantes et al. (2018).

In the field of world sports science, the processes of new views emergence, updating and correction of methodological approaches to human physical activity study are constantly taking place. It still seems relevant to study the issues of improving human motor activity efficiency as a marker of preserving and improving the quality of human life (Drachuk et al., 2018). It is of interest to study the influence of physical activity over the metabolic rate of people with different somatotypes.

Research aim. Determination the relationship of physical activity with metabolism level in the body of girls with different somatotypes.

Material & methods

In 2021-2022 academic year, the body types, the volume of weekly physical activity, the level of metabolism and physical qualities of 376 girls aged 17-19 (18.2±0.3), students of the Technical University of Irkutsk (Russia) without medical health restrictions for physical activity were determined.

To determine the types of the girls' constitution, anthropometry was performed, according to International Standards for Anthropometric Assessment (2001). The assessment of the girls' body types (somatotype) was carried out using the scheme of M.V. Chernorutsky (Kolokoltsev et al., 2021), based on the calculation of the Pinier index value by the formula:

$$\mathbf{I = L - (P + T)}$$

where **L** is body length (cm), **P** is body weight (kg), **T** is chest circumference on exhalation (cm).

In hypersthenic somatotype (H) girls, the Pinier index value was <10. In girls of normosthenic somatotype (N), the index value was in the range from 10 to 30. In the asthenic somatotype (A) girls, the Pinier index value was > 30. The girls' weekly physical activity (PA) was studied and evaluated using the IPAQ-SF physical activity questionnaire (Kreid et al., 2003). The metabolic equivalent of the task (MET) of the girls' body was calculated using the formula: MET = K × PA × n (Guidelines for Data Processing and Analysis of the International Questionnaire on Physical Activity (IPAQ) - short and long forms, 2005), Table 1.

Table 1. MET level determination scheme (min/week)

PA	n	K	MET level
High	3 и >	8.0	High
Moderate	не < 3	4.0	Moderate
Low (walking)	< 3	3.3	Low

Note: PA – physical activity (minutes); n – number of PA days per week; K – correction coefficient.

High-intensity physical activity characterizes motor actions lasting at least 10 minutes, which lead to a strong increase in breathing, an increase in heart rate > 20%. Physical activity of moderate intensity includes motor actions that slightly increase breathing compared to rest and last for at least 10 minutes. Walking is classified as a low-intensive physical activity.

All girls of asthenic, normosthenic and hypersthenic physique were divided into 3 groups, according to PA intensity and MET level, Table 2.

Table 2. The scheme of the relationship between the PA intensity and the MET level

Group №	PA intrensity	Number of PA days per week	MET criteria (minutes/week)
I	High	3 and >	No < 1500 (No less than 1500)
		Daily PA of any intensity	No < 3000 (No less than 3000)
II	Moderate	3 and > duration of at least 20 minutes	No < 1500 (No less than 1500)
		No < 5 days (No less than 5 days)	Walking no < 30 minutes (Walking no less than 30 minutes)
		No < 5 days (No less than 5 days)	No < 600 (No less than 600)
III	Low	Below the specified time	Below the specified criteria

The amount of energy expenditure in girls is represented as the sum of all levels of metabolic equivalents of their physical activity per week according to the formula: $MET_{total} = MET_{High} + MET_{Moderate} + MET_{Low}$ (min/week). All the examined girls' motor qualities were determined according to the requirements of motor testing (Schmidt, & Lee, 2013). High-speed endurance and agility, trunk flexor muscles speed and strength endurance, shoulder girdle muscles strength and strength endurance, hand strength, lower limbs muscles dynamic strength, spine and thigh joints active flexibility and overall endurance were determined. The statistics of the results were carried out using the application programs «Microsoft Excel» and «Statistica 6.1». Taking into account the normal distribution of the studied features, parametric methods of processing indicators were used.

Results

The analysis of the 376 project participants' somatotyping results showed that among the girls there were asthenics 27.4%, normosthenics 53.7% and hypersthenics 18.9%. The ratio between somatotypes was as 1.4 A : 2.8 N: 1.0 H. The results of girls' with different types of constitution weekly physical activity (Table 3) confirmed the relationship of the weekly physical activity level with the constitution type, as may be evidenced by the difference in the results in the respondents' responses.

Table 3. Weekly physical activity of girls with different somatotypes according to the IPAQ-SF (M±m).

Somatotype	Questions				
	Number of days with intense physical activity per week	Duration of intensive physical activity per day (min)	Number of days with moderate physical activity per week	Duration of moderate physical activity per day (min)	How many days a week do you walk?
Asthenic (n =103)	3.12±0.11*	36.63±1.75*	2.42±0.11*	33.67±1.34*	5.47±0.29*
Normosthenic (n =202)	4.0±0.14	42.45±2.16	3.0±0.18	46.5±2.82	7.0±0.45
Hypersthenic (n = 71)	3.0±0.08*	21.6±1.23*	1.63±0.12*	28.8±1.98*	5.12±0.27*

Note: * - the significance of differences in the values of the respondents' with asthenic somatotype and hypersthenic somatotype response comparing with normosthenic somatotype ones, $p<0.05$.

Among all the surveyed participants of the project, normosthenic girls have the largest number of days of intense and moderate physical activity per week and its longest duration per day, $p<0.05$. They have more walking days per week than girls with asthenic and hypersthenic somatotypes, $p<0.05$. In girls of all types of constitution, the number of minutes of walking per day practically did not differ and amounted to about 62 minutes. Figure 1 shows the design of girls' with different somatotypes weekly physical activity.

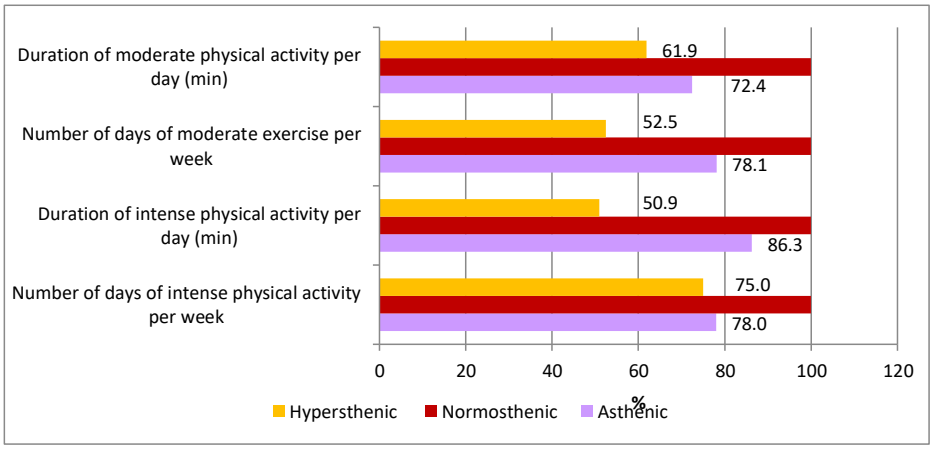

Fig. 1. Asthenics' and hypersthenics' weekly physical activity in % of the volume of normosthenics' physical activity

In asthenic girls, the number of intense physical activity days per week is 78.0%, in hypersthenics it is 75.0% of the number of days of intense physical activity in normosthenics (100%). The time of intensive physical activity for 1 day in asthenic girls is 86.3%, in hypersthenics 50.9% of the duration of intensive physical activity in normosthenics. The number of days of moderate physical activity in asthenic girls is 78.1%, in hypersthenics 52.5% of the number of days of intense physical activity in normosthenics. The time of moderate

physical activity per day in asthenic girls is 72.4%, in hypersthenics 61.9% of the duration of intense physical activity in normosthenics. Figure 2 shows graphical values of MET levels in girls with different somatotypes, depending on the type of their physical activity (PA) per week.

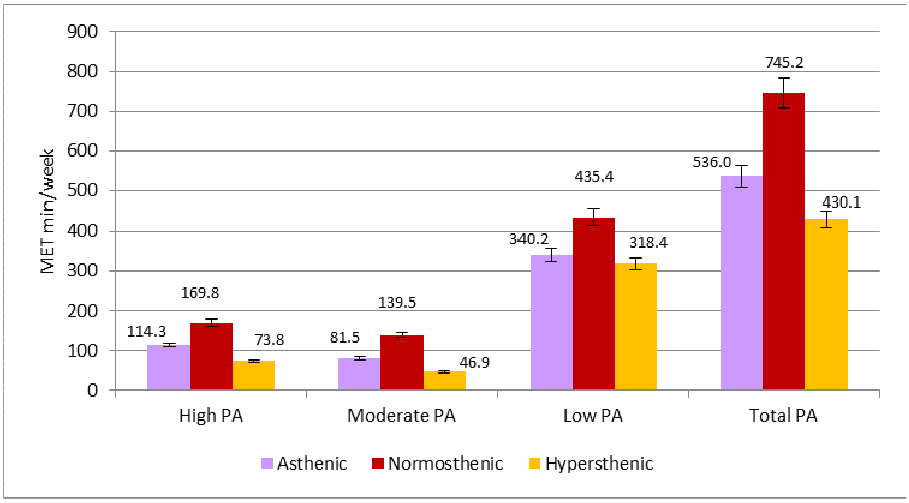

Fig. 2. The project participants' metabolism (minutes/week)

Normosthenic girls have the highest value of the total weekly MET level indicator (745.2±32.3 minutes/week), which is 39.0% higher than that of asthenic girls and 73.3% higher than that of hypersthenics (Figure 2). In the I group of girls with high weekly physical activity, the highest MET level was registered in normosthenics, which is 48.6% more than in asthenics and 130.1% more than in hypersthenics. In the II group of girls with moderate weekly physical activity, normosthenics had a MET level value 71.2% higher than asthenics and 197.4% higher than hypersthenics. In the III group of girls with low weekly physical activity, the value of the MET level in normosthenics is 27.9% higher than in asthenics and 36.7% higher than in hypersthenics. Table 4 shows the number of girls with different types of constitution and different weekly metabolism levels.

Table 4. Number of girls with different somatotypes and MET levels (%)

Constitution type	MET level (minutes/week)		
	High	Moderate	Low
Asthenic (n=103)	27.2	53.4	19.4
Normosthenic (n=202)	63.7	23.6	12.7
Hypersthenic (n=71)	14.1	28.2	57.7

Among the participants of the project with a high level of MET (minutes/week), the most were girls with the normosthenic type of constitution (63.7%). Among girls with moderate MET (minutes/week), the largest number of girls has an asthenic type of constitution (53.4%). The largest number of girls with low MET levels was found among hypersthenics (57.7%). It is of scientific and practical interest to study the issue of girls' with different somatotypes motor qualities (Table 5).

Table 5. Results of the girls' with different somatotypes motor abilities testing (M±m)

Tests	Somatotype			$p < 0.05$
	H (n=71, p_1)	N (n=202, p_2)	A (n=103, p_3)	
Speed and strength endurance and agility				
Shuttle run 5 m x 10, s	23.68±1.18	16.8±1.19	19.56±1.29	p_1-p_2, p_1-p_3
General endurance				
Run 1000 m, m/s	8.2±0.85	5.4±0.05	6.2±0.03	p_1-p_2, p_1-p_3
Upper limb muscle strength				
Bent suspension, s	6.35±1.72	10.64±1.55	8.44±1.83	p_1-p_2, p_1-p_3, p_2-p_3
Crunch, number of times	21.85±1.34	29.56±1.05	26.16±1.32	p_1-p_2, p_2-p_3, p_2-p_3
Push-ups, number of times	25.65±2.35	41.15±2.45	39.55±2.22	p_1-p_2, p_1-p_3
Flexibility				
Sit and reach, cm	12.45±1.67	16.43±1.45	14.24±1.16	p_1-p_2, p_2-p_3
Dynamic strength of the lower extremities muscles				
Standing long jump, cm	157.±5.24	172.9±6.93	170.7±6.18	p_1-p_2, p_1-p_3

Note: H – hypersthenic, N- normosthenic, A- asthenic somatotype

According to the results of testing the project participants' physical condition, it was found that girls with normosthenic somatotype have the best indicators of motor qualities, $p < 0.05$. The motor qualities of hypersthenic girls are the worst developed. The physical fitness of girls with asthenic somatotype was lower than that of normosthenic girls, but surpassed hypersthenic girls in upper limb muscles strength and flexibility.

Dicussion

A person's physical activity is a trigger for a healthy lifestyle, which is especially important during the lockdown and restrictive measures associated with the pandemic (Sunda et al., 2021). Therefore, the study of issues on the use and popularization of physical activity among various population groups is important and timely (Bakiko et al., 2020). The creation of methodological materials and recommendations based on the results of scientific research on human physical activity, especially at a young age, taking into account the type of physique and energy metabolism characteristics is an urgent action to improve the quality of life and conduct recreational activities of a physical orientation (Chwalczynska et al., 2017; Miroshnichenko et al., 2019).

Our research project results have shown that the metabolic processes in the body of girls with different somatotypes depend on the volume and intensity of physical activity. Weekly intensive physical activity in girls with asthenic physique exceeded the recommended WHO (25 minutes x 3 times a week) by 39.3 minutes (52.3%), in girls with normosthenic somatotype by 94.8 minutes (126.4%). This is higher than the physical activity rates of Swedish youth (23 minutes) reported by Hagstromer et al. (2010). In the hypersthenic girls we examined, the weekly rate of intense physical activity is 10.2 minutes lower (13.6%) than recommended by WHO.

The total amount of the girls' weekly physical activity (intensive + moderate + walking) has differences between different somatotypes. The most physically active were normosthenic girls, in whom this volume was 745.2±32.3 min/week and exceeded by 39% the PA values in asthenic girls and by > 70% in hypersthenics.

There are works in the world scientific literature devoted to the study of insufficient motor activity causes of the population (Pengpid et. al., 2019; Chen et al., 2020; Dominski, Brandt, 2020). It is known that human hypokinesia reduces energy costs and metabolic metabolism of the body. Low MET levels lead to severe non-communicable human diseases, such as diabetes, coronary heart disease, stroke, obesity, hypertension, and other severe diseases (Ruegsegger, & Booth, 2018; Zhang et al., 2019; Jordan et al., 2020). In our research it was found that girls with hypersthenic somatotype have the lowest level of metabolic equivalent among girls of all somatotypes. Therefore, we believe that such a somatotype should be attributed to the risk group of severe somatic diseases. The distribution of students according to the types of constitution (Kolokoltsev et al., 2021), physical activity levels and MET values allows PE teachers conducting activities to increase motivation for motor activity in students.

Our analysis of the project participants' motor qualities development assessment indicates that the physical condition of girls with asthenic and normosthenic types of constitution is expressed better than that of hypersthenics. We believe that the reasons for it is the high level of weekly physical activity in asthenic and normosthenic girls. In such somatotypes, the reserve capabilities of the body increase, tolerance to aerobic exercise is formed, the resting heart rate decreases, hemodynamics and systolic heart function improve, as we reported earlier (Kolokoltsev et al., 2021). The materials of this research complement our previous statements that physical activity is interrelated with the constitutional and metabolic characteristics of the body.

Conclusions

Among all the students with different body types, surveyed by us, girls of the normosthenic somatotype have the largest number of days of intense and moderate physical activity per week and their duration per day. They have a high energy potential, a metabolic equivalent when performing different types of physical activity. Normosthenics girls have higher physical fitness, as a result of performing the required optimal amount of weekly physical activity, according to WHO recommendations.

All indicators of the asthenic girls study have average values relative to other somatotypes. The examined girls with hypersthenic somatotype had insufficient weekly physical activity. They have low levels of metabolism and motor qualities. These indicators are predictors of future somatic diseases occurrence. Such girls require special attention from representatives of the sports and medical community.

The results of our research project confirm the existence of a relationship between female students' physical activity, metabolism and somatotype. We offer coaches and educational institutions teachers to plan training sessions taking into account the individual characteristics of the body of those involved.

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

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