

Comparative screening of sexual dimorphism inversion of girls from different populations

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Abstract:

Research aim is to conduct a comparative screening study of the constitution types, anatomical parameters, body components, and motor qualities of adolescent female students of different studying years to establish the nature of sexual dimorphism population inversion. *Research materials and methods.* 1263 girls, aged 20.3 ± 0.3 , students of the Irkutsk Technical University (Russia) enrolled in 2009 ($n=759$) and 2019 ($n=504$), respectively, participated in the survey. Anthropometric measurements were performed, index sexual dimorphism (ISD), body mass index (BMI), body component composition of the girls were calculated, motor qualities, weekly physical activity and strength of the girls' hand muscles were evaluated. The Tanner sexual dimorphism index was used to determine all girls' sexual somatotype. *Research results.* In 2019 population, a reduction in the number of girls with gynaecaner sexual somatotype, increasing the number of girls with andromorphous type, compared to the population in 2009. The number of girls with mesomorphic somatotype is approximately the same and exceeded 60%. Girls with mesomorphic and gynaecaner sexual somatotype muscle strength and power indices of both hands were significantly lower in 2019 compared to these parameters of girls having same sexual somatotype in 2009. Students of 2019 population with andromorphous sexual somatotype showed less fat component in the body and more muscular one in comparison with the results of a survey of girls in 2009. In the girls' body of 2019 population with mesomorphic and gynaecaner types of sexual dimorphism less muscle component and more fat one, compared with the results obtained from the examination of girls in 2009. In girls with andromorphous sexual dimorphism, all motor tests results (with the exception of active flexibility test) are significantly higher than the results of girls in 2009. Girl with mesomorphic somatotype and gynaecaner somatotypes, surveyed in 2019, did not have an optimal weekly motor mode in the amount of 150 minutes and have significantly low indicators values in four motor tests than girls with the same sexual somatotype in the population 2009. *Conclusions.* The results of the girls from different populations survey showed differences in sexual dimorphism inversion. The trend for muscularization is greater in the girls of the 2019 population. Between the girls' populations, there are differences in the component composition of the body, motor qualities and physical activity of girls with different somatotypes. The research results expand the knowledge about the population changes in sexual dimorphism in girls from different generations and its integration with physical education. Our research materials can be used in the pedagogical practice of young students' physical education, which will increase the effectiveness of students' development of PE discipline.

Key Words: girls, sexual dimorphism, inversion, physical education

Introduction

Currently there is interest in scientific research aimed at studying the relationship between human body constitution types and its physical health (Tunnenmann, 2013), with the biomechanical peculiarities of individual movements (Druz et al., 2017), with the organization of the population's physical education and sports training (Martínez-Cervantes et al., 2018). Underestimation of the importance of the types of constitution reduces the effectiveness of physical education lessons. At the same time, the integration of physical culture and human typology significantly optimizes students' physical education process (Miroshnichenko et al., 2019). Knowledge

of body types is widely used in sports selection and training (Kutseryb et al., 2017), in fitness programs for correcting human body weight (Kashuba et al., 2017; Ivanchykova et al., 2018).

One of the methods is to determine the index of sexual dimorphism (J. Tanner index), which allows one to give an individual assessment of somatic sexual differentiation and to trace the dynamics of its possible change in several generations of young people. Research is underway to study the index of sexual dimorphism in athletes in men's and women's sports (Tkachuk et al., 2019; Oleynik, & Bugaevsky, 2020; Borysova et al., 2020).

Researchers have shown that in order to achieve high athletic performance in women, an important role is assigned to their somatotype, body mass and sexual dimorphism indices. As a result of intense and strenuous physical activity, the content of endogenous fat and adipose tissue, which are involved in estrogens synthesis, decreases in female athletes. It leads to a change not only in the women's sexual dimorphism index in the direction of androgenicity (masculinization), but also seriously disrupts their reproductive function (Kandel et al., 2014).

The world's population urbanization and society globalization, modern youth's rhythm and lifestyle can affect the morphofunctional changes in their body and affect their constitutional variability (inversion) vector. In addition to these factors, the anatomical, functional parameters and component composition of students' body may be influenced by factors related to university studies (Eksterowicz, Jerzy, & Napierała, Marek, 2020). The process of professional training at the university is characterized by high academic and neuropsychiatric loads, «digital» learning, lifestyle changes and hypokinesia (Gerber et al., 2017), negative habits appearance (Pengpid, & Peltzer, 2019). A comparative study of the morphofunctional indicators of the organism, the main components of the body structure and conditioning abilities in different generations of young people is important for determining the vector of sexual inversion.

Determining the relationship of motor qualities, component composition and body functional characteristics with sexual somatotype is an important scientific research direction in the field of human physical health (Yıldız, 2018).

Such studies are particularly important in girls of reproductive age. Sexual constitution peculiarities identification in modern youth is allowed to make adjustments to the educational process of physical education (Kolokoltsev et al., 2020). The sexual differentiation inversion in young female students of different generations with a ten-year observation interval is not fully reflected in the literature, which explains the choice of our research topic.

Research aim. Research aim is to conduct a comparative screening study of the constitution types, anatomical parameters, body components, and motor qualities of adolescent female students of different studying years to establish the nature of sexual dimorphism population inversion.

Material & methods

The survey involved 1263 female students of a technical university (Irkutsk, Russia), of the same chronological age (20.3 ± 0.3 years), studying at the university in 2009 ($n = 759$) and 2019 ($n = 504$).

To calculate the index sexual dimorphism (ISD), body mass index (BMI) and body component composition of the girls, 22 anthropometric measurements were performed, and the hands muscles strength was evaluated taking into account the requirements of the International Standards for Anthropometric Assessment (2001).

The female students' weekly physical activity was determined by the International Questionnaire on Physical Activity, IPAQ-Short Form (Craib, et al., 2003). The sexual dimorphism index of Tanner (1986) was used to determine the sexual somatotype of all girls.

According to the WHO Global Database on Body Mass Index (BMI), the body mass index was calculated. The BMI was evaluated according to the WHO: Memorial of the meeting arranged by USAID, WHO, PAHO and Mother Care Organization («Mother Care»), 1991.

The Ruffier Strength Index (RI) was calculated using the formula: $RI = \text{hand muscle strength} / \text{body weight} \times 100\%$ (Nikitina et al., 2016). According to the formulas of J. Matiegka (1921), the component composition of the body of all girls was found.

The girls' motor qualities study was carried out according to the requirements for testing (Schmidt, Lee, 2013; Fitness Testing Requirements, 2017). For this purpose, a battery of motor tests to assess speed and agility, overall endurance, muscle strength of the upper shoulder girdle, muscle strength of the trunk, joint flexibility, and dynamic strength of the muscles of the lower extremities were used.

This study was conducted 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). In connection with the normal distribution of the studied features, parametric methods were used to calculate the reliability of the Student's t-test.

Results

The number of girls with different sexual dimorphism types in different years of observation is shown in Figure 1.

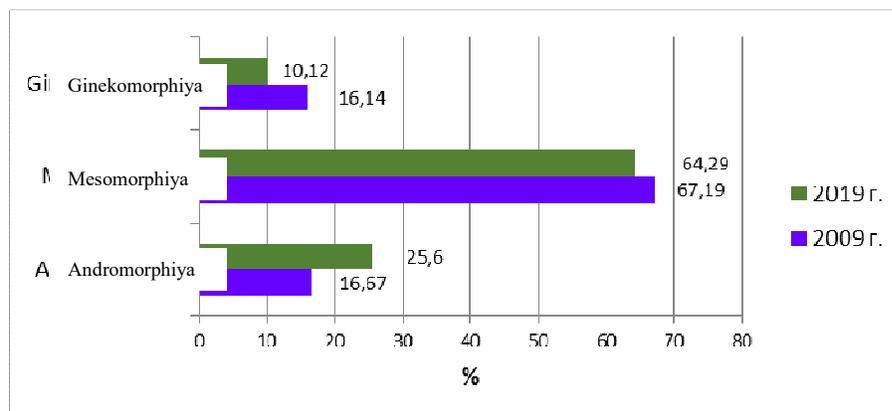


Fig. 1. The number of girls of different populations and sexual dimorphism types (%)

Compared with the population of girls in 2009, in 2019 the number of girls with gynaecaner sexual somatotype decreased 37.2%, the number of girls with andromorphous type has increased 53.6 %. We regard these results as an unfavorable prognostic sign indicating gender dysplasia in a significant portion of the female population in 2019. The number of girls with mesomorphic type in both years was approximately the same and exceeded 60%.

It is of scientific and practical interest to assess the examined girls' of different sexual somatotypes anatomical and functional parameters, because a person's physical fitness is largely related to the morphofunctional characteristics of the body (Table 1).

Table 1. The girls' morphofunctional characteristics (M±m)

Indicators	2009			2019		
	Andromorphiya (n=126)	Mesomorphiya (n=511)	Ginekomorphiya (n=122)	Andromorphiya (n=129)	Mesomorphiya (n=324)	Ginekomorphiya (n=51)
Body length	168,5±0,41	165,5±0,23	162,6±0,47	167,4±0,47	163,7±0,30*	162,0±0,75
Body mass	59,1±0,63	56,8±0,29	53,7±0,51	60,1±0,86	56,3±0,41	54,3±1,03
Chest circumference at rest	88,7±0,47	87,3±0,21	83,9±0,38	85,9±0,62*	83,2±0,32*	82,5±0,92
Lower limbs length	90,0±0,39	88,2±0,18	85,5±0,40	84,8±0,34*	82,1±0,21*	79,9±1,33*
Shoulder width	37,2±0,08	34,9±0,04	31,9±0,16	37,8±0,10*	35,5±0,05*	32,4±0,25
Pelvis width	26,7±0,18	26,6±0,07	27,9±0,82	28,6±0,24*	28,4±0,10*	32,0±1,87*
ISD	85,0±0,19	78,2±0,02	67,8±1,18	84,8±0,21	78,2±0,13	65,3±2,1
BMI	20,96±0,005	20,45±0,02	19,71±0,02	21,8±0,12*	21,01±0,07*	20,31±0,23*
Hand muscles strength (left hand)	24,4±0,31	23,2±0,23	22,0±0,53	26,6±0,43*	21,7±0,26*	20,4±0,57*
Hand muscles strength (right hand)	25,7±0,52	24,1±0,25	22,9±0,40	27,8±0,38*	21,9±0,26*	21,3±0,23*
RI left hand	41,3±0,17	40,8±0,19	40,9±0,22	44,2±0,16*	38,5±0,12*	37,5±0,21*
RI right hand	43,5±0,18	42,4±0,21	42,6±0,27	46,2±0,19*	38,8±0,14*	39,2±0,23*

Note * - differences between the values of indicators in 2009 and 2019 reliable (p < 0.05)

The girls of 2019 population with all sex somatotypes, values of body length, chest circumference at rest and lower limbs length were less than the shoulders width, pelvis width values and BMI more than the girls with the same sexual somatotype, 2009 population have.

In 2019 girls with andromorphous somatotype showed indicators values of left and right hands muscle strength significantly higher by 9.0 and 8.6 %, respectively (Fig.2), RI respectively is above by 5.8 and 5.5%, (Fig.3), in comparison with the values of the parameters in girls with the same somatotype in 2009 (p < 0.05). This is a confirmation of the trend towards masculinization of andromorphous type girls in 2019.

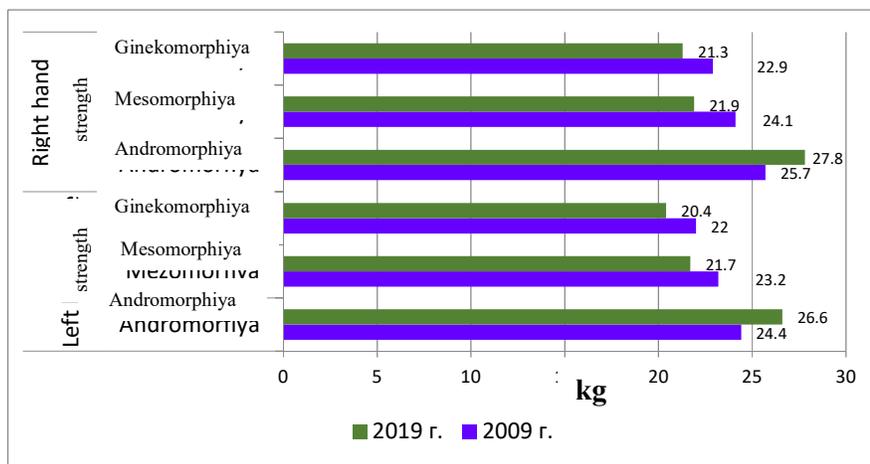


Fig. 2. The girls' of different populations hands muscles strength indicators value (kg)

Girls with mesomorphic and gynaecaner sexual somatotype hands muscle strength values and power indices of both hands was significantly lower in 2019 compared to the indicators of the girls' with the same sexual somatotype hands strength in 2009.

Muscle strength values of the left and right hands of girls with mesomorphic sexual somatotype in 2019 were below 6.4 and 9.8%, respectively, those of girls with gynaecaner somatotype were below 7.2 and 6.6 %, respectively, compared to 2009 ($p < 0.05$). In 2019, lower were the power index values of the left and right hands of girls with mesomorphic type of constitution by 7.0 and 9.2%, respectively, and by 9.5% and 7.4 %, respectively, in girls with gynaecaner type of sexual dimorphism in comparison with the results of the girls' population in 2009 ($p < 0.05$).

A person's strength abilities are his/her physical health criterion. A comparative analysis of our screening study results showed a difference in the strength abilities of girls with different types of sexual dimorphism after 10 years (Fig. 3).

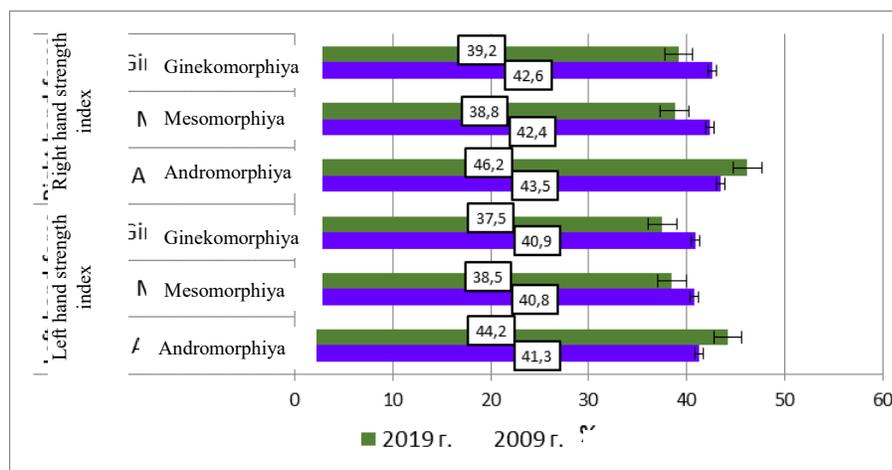


Fig. 3. The girls' power index indicators value (%)

Our research results show that there is deterioration in the physical health of girls with mesomorphic and gynecomorphic (gynaecaner) somatotypes. One of the reasons for the decrease RI of the muscles of the hands of girls, may be a decrease in the content of the amount of the muscle component in the body of girls due to hypokinesia of the modern younger generation.

Therefore, a comparative population assessment of the body component composition and motor qualities of girls of different sexual somatotypes is of interest.

All the examined girls' body component composition is presented in Table 2.

Table 2. The girls' basic body components (kg, M±m)

Sexual dimorphism somatotype	2009 (n=762)			2019 (n=504)		
	Fat component	Muscle component	Bone component	Fat component	Muscle component	Bone component
Andromorphiya	14,5±0,15	23,8±0,27	8,2±0,14	13,3±0,11*	26,7±0,25*	8,3±0,16
Mesomorphiya	15,8±0,17	22,4±0,32	8,2±0,15	16,3±0,15*	20,2±0,42*	7,8±0,19
Ginekomorphiya	15,7±0,23	22,5±0,46	7,6±0,45	17,2±0,18*	19,1±0,23*	7,7±0,14

Note * - differences between the values of indicators in 2009 and 2019 reliable (p < 0.05)

The difference between the body components content of girls with the same somatotypes in different years of the survey was established. For students with andromorphous sexual somatotype values of the fat component content index in the body was lower by 8.3%, the coefficients of the muscle content component in the body was more by 12.2% in 2019 compared to girls of the population 2009 (p < 0.05). The increase in muscular component content in the andromorphous type girls' body in 2019 explains the higher growth parameters of their power capabilities, compared with girls in 2009. When comparing the results of girls' with mesomorphic and gynaecaner sexual dimorphism types survey it was found that the coefficients of muscular component contents in the body of girls is below by 9.8% and 15.1%, respectively, and the fat mass indicator values in the body of the female students is higher by 3.2% and 9.5% respectively in 2019, compared with the results obtained from the girls' of 2009 population screening (p < 0.05). The bone component content in the body of girls from different populations does not differ significantly (p > 0.05).

Body mass index indicators in both girls' of all somatotypes populations do not exceed the normal limits. In 2019, the values of BMI indicators in girls of all somatotypes are higher than in girls in 2009 (p < 0.05).

Significant differences between the main components values in the body of girls of different populations and different somatotypes allowed to assume that there are also population differences in the students' motor qualities and physical activity. Therefore, we conducted tests of the girls' motor qualities (Table.3) and a questionnaire about their weekly physical activity amount.

Table 3. Girls' with different types of sexual dimorphism motor qualities (M±m)

Тесты	2009			2019		
	Andromorphiya (n=126)	Mesomorphiya (n=511)	Ginekomorphiya (n=122)	Andromorphiya (n=129)	Mesomorphiya (n=324)	Ginekomorphiya (n=51)
20 m run, standing start, sec	4,29±0,12	4,42±0,13	4,68±0,14	3,41±0,05*	4,73±0,05*	5,15±0,15*
1000 m run, m/sec	6,34±0,03	7,23±0,05	7,57±0,07	5,12±0,02*	8,25±0,03*	9,13±0,09*
Shuttle run 3 x 10, m/sec	20,33±0,21	21,18±0,06	21,38±0,21	19,18±0,15*	22,55±0,11*	23,46±0,16*
Hanging on a low bar, sec	11,8±0,42	10,3±0,23	8,8±0,34	13,8±0,71*	10,1±0,57	9,2±1,36
Abdominal crunch for 30 sec, number of times	23,4±0,52	22,3±0,12	23,6±0,23	26,7±0,55*	21,3±0,56*	21,1±0,65*
Bend forward from a sitting position, cm	15,7±0,35	14,6±0,16	13,7±0,63	15,5±0,48	14,08±0,24	13,2±0,73
Standing long jump, cm	162,1±1,78	162,0±0,82	158,3±1,52	175,2±2,0*	162,6±2,7	160,8±1,11

Note * - differences between the values of indicators in 2009 and 2019 reliable (p < 0.05)

The results of a survey in 2019 showed that girls with andromorphous sexual dimorphism type almost all engaged in various sports, their motor mode significantly exceeds 150 minutes a week and have higher performance indicators in all motor tests than that of girls of the population in 2009.

Girls with andromorphous type of sexual dimorphism in 2019 showed a increase in the indicators values in all motor tests (with the exception of the test for active flexibility), compared to the test scores of girls in 2009 (p < 0.05), in which the amount of physical activity was not high. Girls with mesomorphic and gynecomorphic (gynaecaner) somatotypes, examined in 2019, did not perform the optimal weekly motor mode in the amount of 150 minutes. Their values in the four motor tests were lower than in girls with the same somatotypes in the 2009 population (p < 0.05).

Dicussion

The female body with the andromorphous somatotype is characterized by an increased content of male sex steroids and is considered as a predictor of their somatic health negative characteristic (Kandel et al., 2014; Tkachuk et al., 2019). In comparison with our data from the study of girls in 2009, after 10 years, there was an increase by 53.6% in female students' of fertile age number with an andromorphous body type and a tendency to decrease reproductive function. There are reports that an increase in the volume and intensity of physical activity

in sports leads to a decrease in the fat content in the component composition of athletes' body, this content is the basis for the synthesis of estrogens in the female body (Oleynik, Bugaevsky, 2020).

Masculinization signs in women are manifested by the results of the ratio of the shoulder width and pelvic width values in the direction of androgenization, a decrease in the amount of fat in the body. The girls of different populations examined by us have such signs; this fact is consistent with other researchers' in the field of sexual somatotypology data (Oleynik and Bugaevsky, 2020). Some authors report that the process of girls' androgenization depends on a number of factors, including dietary conditions, lifestyle, bad habits, environmental conditions, physical activity, and other factors (Eksterowicz, Jerzy, Napierała, Marek, 2020).

In recent years, we have noted that more than half of senior students do not reduce their optimal physical activity after completing mandatory PE classes at the university (Mikhail Kolokoltsev, Wladyslaw Jagiello, 2020). Many female students pay attention to their body weight and control their diet. In their body, the amount of fat decreases, so there is a slow androgenesis of modern girls' body, which is confirmed by the results of our research of sexual dimorphism population inversion. In our research, girls with an andromorphous somatotype and an increased muscle tissue content in the body have an advantage in motor qualities, compared to girls with other types of sexual dimorphism. They have higher values of motor test scores. According to our testing in 2019, there has been a decrease in motor qualities, an increase in hypokinesia in girls with mesomorphic and gynaecaner types of sexual dimorphism. We believe that the reason for this is the lack of mandatory PE classes in senior studying years. It can negatively affect modern youth's health. Report by Craid et al. (2003) confirms the importance of exercising a motor regime of at least 150 minutes per week for a young body. This is consistent with the results of our survey of all female students, where girls with andromorphous type of sexual dimorphism report performing the weekly motor regime in full.

Conclusions

There has been an increase in the trend towards masculinization of the body of girls of fertile age in the last ten years. An analysis of our observation comparative results of the sexual dimorphism inversion in adolescent girls showed an increase in the number of girls with signs of andromorphism (masculinization) by more than 50% in the 2019 population. In such girls, there was a decrease in fat component index value and an increase in muscle component index value in the body, muscle strength and hands strength indices. They have the highest performance in motor tests, both in their population and in comparison with the results of the female population in 2009 survey. Girls of the population 2019 with mesomorphic and gynaecaner sexual dimorphism types noted significant decrease in the muscular component content, muscle strength and hands strength indices against the background of fat mass increase in the body, compared with the results of girls' with the same types of sexual dimorphism in 2009 survey. The bone component content in the body of girls with different types of sexual dimorphism in both populations does not differ significantly.

We believe that in educational institutions, it is necessary to conduct a comparative assessment of young people's of different generations' physical activity separately for each sexual dimorphism type. This will allow adjusting health-improving programs to improve the quality of life and the ability to the future human potential work. The materials of our research on population changes in sexual dimorphism in girls of different generations and its integration with physical education can be used in the pedagogical practice of young students' physical education, which will increase the effectiveness of students' mastering the discipline «Physical culture».

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