PHYSICAL EDUCATION OF STUDENTS

Comparative characteristics of morphological features, somatotypes and motor qualities of female students from different generations (Irkutsk region, Russia)

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The purpose of the study is to give a comparative description of the somatotypes, anatomical components of the body, and motor qualities of female students studied at the university (Irkutsk, Russia) in 2009 and 2019.

Material: It was conducted the survey and somatotypological diagnosis of 1226 female students (in 2009 – n = 762; in 2019 – n = 464) on 27 anthropometric parameters. It was measured: Pinier index; the average value of the absolute and percentage of the bone component of the body (BC), the fat component of the body (FC), and muscle component of the body (MC). The following indicators were evaluated by motor tests: speed endurance and agility; speed; speed and strength endurance of the trunk flexor muscles; strength and endurance of the shoulder girdle muscles; dynamic strength of the lower limb muscles; active flexibility of the spine; overall endurance.

Results: In 2019, compared to 2009, there was observed: a decrease (by 19.6%) in the number of normosthenic females; an increase in the number of hypersthenics (by 70.9%), and asthenics (by 27.4%); body weight gain; decrease in body length. The values of the following indicators significantly decreased in 2019: the trunk length, upper and lower limbs; chest circumference. There was a decrease in the average values of body circumference; shoulder width. It was observed an increase in pelvic width. In 2019, compared to 2009, the following indicators were determined in females of all somatotypes: a significant increase in body fat content and a decrease in muscle mass ($p < 0.05$). As a result, the strength of the hands' dynamometry decreased. After 10 years, the bone component in the females' body has not changed.

Conclusions: The obtained data indicate a deterioration in all motor skills of females surveyed in 2019, compared to 2009. This is a consequence of the growing hypodynamics of modern youth. The obtained results of surveys expand the database of anthropometric and motor parameters of the young generation of Russia. This data can be used in planning training and coaching activities in educational and sports organizations.

Keywords: physical culture, female students, anthropometric body components, somatotypes, motor qualities.

Introduction

Somatotype is an integral indicator of an individual's physical development [1]. The somatotype reflects the morphofunctional condition of a certain population [2]. Therefore, individual-typological properties and features of a person could be criteria for metabolic, hormonal, and other body processes [3-5]. It is determined the correlation between some human diseases and somatotype. Somatotype to some extent can be a marker of a particular human nosology [6, 7].

The problem of human health-preserving and strengthening is associated with the impact of negative environmental, social, and economic factors, with low efficiency of the physical education system [8, 9]. This fact is often associated with an underestimation of human body features [10]. Therefore, research work aimed at studying the integration of physical culture and sports with the somatotype typology has intensified [11-13]. It is proved the close interrelation of somatotypes with motor qualities features of the person [14-17].

The studies have been conducted in Russia to identify the characteristics of motor qualities in young people with different somatotypes: in Perm region (Russia) [18]; in St. Petersburg (Russia) [19]. It is shown that representatives of the microsomal type of somatotype have advantages over the macrosomic type in the following motor qualities: speed; muscle strength of the upper limbs; coordination abilities; overall endurance.

The WHO is concerned about the level decrease of physical activity in youth [20]. WHO recommends at least 60 minutes of physical activity per day for 5-17 years old children. The WHO recommends 150 minutes of moderate-intensity physical activity per week for people 18 years old and older.

Basset et al. found out that most American teenagers do not follow the 60-minute-per-day recommendation for moderate or high-intensity physical activity [21]. Fernandez et al. studied differences in the anthropometric profile, quality of nutrition, and the nature of the physical activity of overweight schoolchildren in the Arica and Parinacota region (Chile) [22]. Participants of middle socioeconomic status were found to have a higher weight,

doi:10.15561/20755279.2020.0407

clothing size, and waist circumference than those of low-middle status.

Podstawski et al. identified the correlation between various forms of physical activity, anthropometric parameters, and motor abilities of first-year students (Poland) [23]. The authors conducted thirteen motor tests to evaluate the motor abilities of female students. The authors found that physical activity had the most profound effect on the level of physical fitness in female students.

Belanger et al. studied the type of physical activity in teenagers with body content in late teenagers or early adulthood [23]. The authors found out that participation in running in teenagers was associated with a lower body mass index, waist circumference, and skinfold thickness in later teenagers and early adulthood ($p < 0.01$).

Studies by several authors reflect the correlation between somatotypes and sports activities [24-27]. It was determined the effectiveness of basketball in wheelchair users from the length of the upper limbs [28, 29].

The important role in human life plays the condition of body component content [30]. There is evidence of a 2-fold decrease in hand muscle strength in students with a body mass deficit [31]. It is observed the dependence of the training process effectiveness and competitive activities on the condition of the body component content in some sports: ski jumping [32]; basketball [33, 34]; mountain biking [35].

Some researchers have defined the possibility of using data on the component body content and anthropometric indicators: in sports selection and training process [36, 37]; in planning fitness programs to correct a person's somatotype [38]; in industrial mountaineering [39]. Some scientists suggest considering the students' somatotype to increase the effectiveness of physical education and improve physical health and quality parameters of physical training [16, 40].

Rapid changes in the political, economic, social, and everyday life of modern people can affect human health, affect the physique and anatomical body components [41, 42]. This fact is especially noted in the initial periods of ontogenesis. In the previous studies, we evaluated the motor qualities of young males with different somatotypes from different generations [43]. The important socio-demographic significance has the study of the somatotypes peculiarities and anatomical components of female students (as future mothers). Their health influences the gene pool condition of subsequent generations of the country [44]. This issue has not been profoundly studied in the Irkutsk region (Russia).

Therefore, it is important to conduct a comparative analysis of the somatotypes and anatomical body components in females from different generations with a significant time interval. At this age, the morphofunctional development of the body is completed and the final somatotype is formed. Therefore, at this stage of human development, it is important to study and draw up specific morphological criteria for the diagnosis of the norm. Such studies are necessary to create standards of anatomical and somatotype features of the population. Such features of the population are stipulated by the changes in motor activity, acceleration and retardation, migration, and other processes in the human population [45, 46]. This allows estimating the change vector of these parameters. It also allows for making changes in the organization and implementation of health promotion technologies in certain groups of the population.

Irkutsk region is a region of Russia with severe climatic and geographical conditions and a significant anthropogenic load. From the medical anthropology points of view, this demand higher standards of the physical body status of the local population [47, 48].

In recent years, there appeared studies devoted to somatotypes' evaluating of young people in this region [13]. However, the comparative assessment of the somatotypes and anatomical components of teenage females from different generations and their correlation with motor skills are insufficiently studied.

The purpose of the article is to give a comparative description of the somatotypes, anatomical body components, and motor skills of female students who studied at Irkutsk University (Russia) in 2009 and 2019.

Material and methods.

Participants. The study involved 1226 female students aged 17-20 born and living in the Irkutsk region (Irkutsk National Research Technical University, Russia). Among them, 762 female students were surveyed in 2009, and 464 female students were surveyed in 2019. All female students belonged to the main medical group due to their health condition. The study does not infringe on the rights and does not endanger their health [49].

Design of the research

The following parameters were evaluated according to the standard method [50, 51]: body weight – on the medical scales; body length – with the help of height meter; diameters of the limbs were measured using a caliper; the length of particular body parts and circumferences were measured with a centimeter tape; skin and fat folds were measured with a caliper. The following parameters were measured in females:

- body mass (kg);
- length (cm): body (standing position); upper limbs; lower limbs; trunk;
- chest circumference at rest (cm);
- diameter (cm): chest - transverse at rest; shoulder; forearms; thigh; the lower part of the leg;
- width (cm): shoulder; pelvis;
- circumference (cm): shoulder; hip; chest on exhalation; 1/3 of the upper part of the shoulder; 1/3 of the lower part of the shoulder; 1/3 of the upper thigh circumference; 1/3 of the lower thigh circumference;
- skin and fat folds (cm): shoulders in front and behind; 1/3 of the upper thigh circumference; 1/3 of the lower thigh circumference; crus; back; belly.

The following functional parameters were measured: the strength of both hands (kg) with a dynamometer.

Somatotypological diagnosis of female students was performed according to the Chernorutsky scheme [52]

with the calculation of the Pinier index according to the formula:

$$I = L - (P + T),$$

where L- is body length standing (cm), P- is body mass (kg), T – is chest circumference on the exhalation (cm).

When the value of the Pinier index is <10, the somatotype was evaluated as hypersthenic (H), in the range of the index from 10 to 30 – as normosthenic (N), the index is> 30 – as asthenic (A) [52].

The average value of the absolute and percentage content of body components such as bone (BC), fat (FC) and muscle (MC) was measured according to Matiegka formula [53].

The main motor qualities of female students were evaluated according to motor tests [54, 55]:

- high-speed endurance and agility (shuttle run 10 x 5 m, s);
- speed (100 m run, s);
- speed and strength endurance of the trunk flexor muscles (sit-up, the number of times in 30 s);
- strength and strength endurance of the shoulder girdle muscles (hanging on the crossbar, s);
- dynamic strength of the lower limbs muscles (standing long jump, cm);
- active flexibility of the spine and thigh joints (seated forward bend, cm);
- overall endurance (1000 m run, m, s).

Statistical analysis. We used "Microsoft Excel" and "StatSoft Statistica 6.1". The arithmetic mean value of the indicators (M), the standard deviation (s), and the standard error (m) were measured. The significance of differences in the mean values of the independent samples was evaluated by parametric methods using Student's t-test. Differences between the indicators' values at the level of $p < 0.05$ were considered statistically significant. The χ^2 was used to measure the statistical significance of qualitative differences (at $p < 0.05$, the critical value $\chi^2 = 5.99$); statistically significant differences at $\chi^2 > \chi^2_{critical}$.

Results

Distribution of the number of females by somatotypes in 2009 and 2019 (Fig. 1).

In 2019, compared to 2009, there is ($p < 0.05$): a decrease (by 19.6%) in the number of females with normosthenic somatotype; increase in the number of hypersthenic females (by 70.9%) and asthenic females (by 27.4%).

Characteristics of the anatomical body components of females from different generations are presented in table 1.

In 2019, compared to 2009, there is ($p < 0.05$):

- increase in body mass of females (by 3.6%);
- decrease of body length (by 0.4%);
- decrease of trunk length, upper and lower limbs and chest circumference;
- increase in diameters of the upper and lower limbs;
- increase in diameters of forearms and thighs. This led to a slight increase in bone mass in the body component content of female students;
- the decrease in shoulder width and increase in pelvic width.

It is known that the anatomical body components are used to measure muscle mass content. In 2019, the average values of females' circumference indicators were differing from the 2009 results. It was determined the decrease in the value of all circumference indicators of females' body. The exception is a pelvic circumference. This value in 2019 was higher by 1.28%.

In 2019, compared to 2009, it is observed at all measurement points ($p < 0.05$): an increase in skin and fat folds (by 8.8%). Exceptions are indicators on the back and crus.

Somatotypological characteristics of different populations provide an assessment of the body component content. Table 2. shows the content of the main female's components content surveyed in 2009 and 2019.

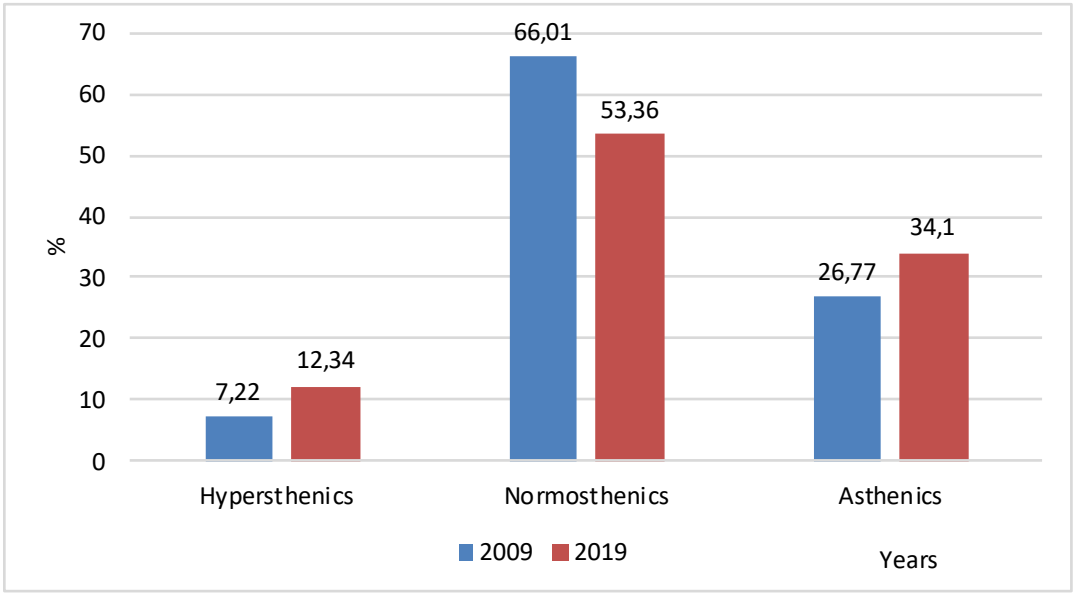

Fig.1. Types of female somatotypes in different years of the survey.

In 2019, compared to 2009, there is ($p < 0.05$): an increase in fat mass (by 45.5%) and a decrease in muscle mass (by 12.1%). After 10 years, the bone component in females' body did not change ($p \geq 0.05$).

The scientific and practical interest is a comparative study of the body mass components content in females with different somatotypes, surveyed at ten-year intervals (Fig. 2).

It was determined that hypersthenic females have the highest bone component content. The females with asthenic somatotype have the lowest bone component content. The females with the normosthenic somatotype occupy an intermediate position between the two somatotypes. After 10 years, females of all somatotypes have no significant difference in the bone component content in body mass.

The maximum amount of fat component was found in females with hypersthenic somatotype (the increase was 27.6%). The females with asthenic somatotype have had the fat content 6.3 ± 0.1 kg (2009) and 7.6 ± 0.16 kg (2019) (an increase of 20.6%). The females with the normosthenic somatotype on the body fat content occupied an intermediate position between these somatotypes. These females have the lowest value of FC

Table 1. The anatomical characteristics of 17-20 years old different populations females (M ± m)

Indicators		Years of study	
		2009 (n=762)	2019 (n=506)
Body mass, kg		55.59±0.25	57,27±0,37*
Length, cm	body (standing position)	165,2±0,19	164,5±0,25*
	lower limbs	85,8±0,16	82,6±0,22*
	upper limbs	74,44±0,16	73,88±0,13*
	trunk	54,50±0,15	53,98±0,17*
Chest circumference (at rest), cm		85.39±0.16	83,89±0,28*
Diameter, cm	chest transverse (at rest)	25,76±0,05	25,84±0,48
	shoulder	7,25±0,01	7,49±0,02
	forearm	5,41±0,01	5,50±0,02*
	thigh	10,05±0,02	10,30±0,03*
	crus	6,96±0,01	7,00±0,08
Width, cm	shoulders	36,74±0,06	35,83±0,08*
	pelvis	94,68±0,21	95,91±0,38*
Circumference, cm	chest (exhale)	83,37±0,18	82,18±0,33*
	1/3 upper shoulder	27,70±0,09	26,20±0,12*
	1/3 lower shoulder	24,31±0,06	23,51±0,1
	1/3 upper thigh	55,13±0,22	54,16±0,16
	1/3 lower thigh	39,86±0,16	38,12±0,11*
	shoulders	100,8±0,21	99,78±0,36*
	pelvis	94,68±0,21	95,9±0,38*
Fat folds, cm	shoulder front	0,44±0,02	0,54±0,01*
	shoulder back	1,20±0,02	1,34±0,02*
	1/3 upper thigh	2,35±0,04	2,48±0,04*
	1/3 lower thigh	1,73±0,03	1,82±0,02*
	crus	0,87±0,02	0,98±0,03
	back	1,34±0,02	1,40±0,03
	belly	1,63±0,02	1,82±0,03*

Note: * - significant differences between the females' indicators values ($p < 0.05$)

Table 2. The content of bone, fat and muscle components of females' body mass surveyed in 2009 and 2019

Body mass components	2009 year		2019 year	
	Absolute content (kg)	% of body mass	Absolute content (kg)	% of body mass
bone (BC)	10.89±0.23	18.8	11.29±0.05	19.8
fat (FC)	10.24±0.21	17.3	14.9±0.11*	26.5
muscle (MC)	23.67±0.14	42.55	20.8±0.14*	36.47

Note:* - Significant differences between females' indicators ($p < 0.05$)

growth rate. The maximum muscle component content in females with hypersthenic somatotype was 28.8 ± 0.67 kg (2009) and 24.8 ± 0.55 kg (2019). The decrease in MC was: hypersthenic - 13.8%; asthenics - 13.5%; normosthenics - 12.7%.

The decrease in muscle mass was reflected in the strength of the hands' dynamometry. In 2019, there is a decrease in hand strength ($p < 0.05$): right hand - by 4.3%; a left hand - by 6.5%.

Changes in the main motor qualities of female students are presented in table 3.

In 2019, compared to 2009, there is ($p < 0.05$):

- in the motor quality "speed endurance and agility" the highest decrease in the indicator value is observed in females with hypersthenic somatotype (5.8%);
- the least decrease was in asthenics (3.4%);
- in females with normosthenic somatotype decrease was 4.5%.

A decrease in motor test indicators in females with hypersthenic somatotype (compared with asthenics)

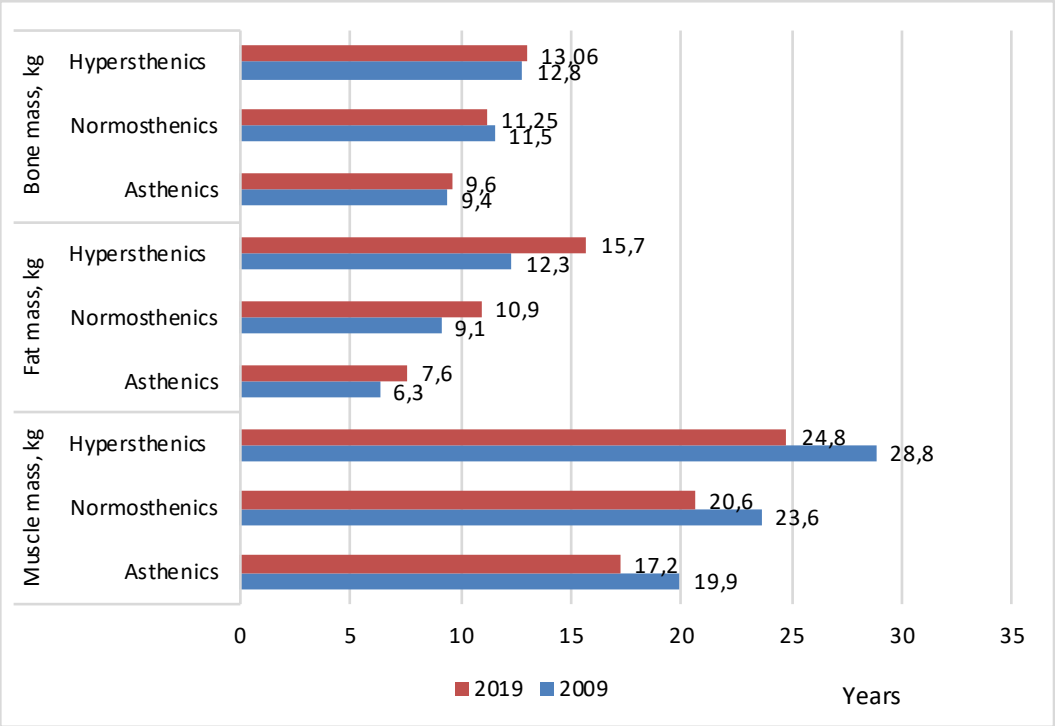

Fig.2. The content of bone, fat, and muscle components of the body mass in females with different somatotypes in 2009 and 2019.

Table 3. Indicators of motor qualities of females (%)

Motor qualities	Test	Decrease in values of indicators in 2019 compared to 2009 (in %)		
		Somatotype		
		Hypersthenic	Normosthenic	Asthenic
Speed endurance and agility	Shuttle run (s)	5.8	4.5*	3.4*
Speed	100 m run (s)	22.5	17.3*	9.2*
Strength and strength endurance of the muscles of the shoulder girdle	Handing (s)	36.4	32.3*	27.6*
Speed-strength endurance of the trunk flexor muscles	Sit-up (number of times)	61.2	37.3*	41.4*
Flexibility	Seated forward bend (cm)	21.5	11,8*	16,9*
Dynamic strength of the muscles of the lower limbs	Standing long jump (cm)	7.6	11,2*	11,4*
Overall endurance	1000 m run (m / s)	5.6	5,2*	4,8*

Note. * - significant differences between the indicators of females with asthenic and normosthenic somatotypes in comparison with the hypersthenic somatotype ($p < 0.05$)

is significantly observed in the other 4 motor qualities. Exceptions are the results of "flexibility" and "dynamic strength of the lower limbs" tests. In the test "Seated forward bend" (motor quality "flexibility") the highest decrease in indicators was observed in hypersthenics, the lowest – in normosthenics. Asthenics occupy an intermediate position between these somatotypes.

In the motor test (dynamic strength of the lower limbs muscles) the highest decrease was observed in asthenics (11.4%), the lowest in hypersthenics - 7.6% ($p < 0.05$). In females with normosthenic somatotype, the decrease in this indicator is almost no different from the results of asthenics (11.2%).

Discussion

It is known that asthenic somatotype is characterized by a reduced level of metabolic processes in the body, hypersthenic by accelerated levels of metabolic processes, organ differentiation, and puberty [56]. Compared with the normosthenic somatotype, females with an asthenic somatotype have the highest number of cases of disharmonious sexual development. This is presented by later menarche, their painfulness, delayed development of secondary sexual characteristics [57]. According to researchers, asthenia is a presentation of the retardation processes of physical development [58]. Retardation is considered as one of the forms of the organism's adaptation to the negative factors of the external environment [58]. According to our data, the increase in the number of asthenic females in recent years (Irkutsk region, Russia) correlates with the results of other researchers (St. Petersburg, Russia) [42].

Thus, asthenic somatotype can be considered as a predictor of negative characteristics of the somatic health condition. The increase in 2019 by almost 1/3 of the number of asthenic females in Irkutsk region indicates a complication of the situation with females' health in the region.

Our data on the quantitative body fat content depending on the somatotype are confirmed by the results of other authors' studies [41]. The authors found that the lowest fat content in the body is found in females with leptosomal (asthenic) somatotype. We identified the dynamics of increase (in 2019 compared to 2009) in the body fat content and decrease in muscle mass ($p < 0.05$) in females of all somatotypes. This affected the decrease in the values of strength tests of female students in 2019 (there is a decrease in the strength of the right and left hands).

A similar correlation between an increase in body fat and a decrease in the muscular component content of the body (in the early 2000s) was observed in children and teenagers 8-15 years old (Moscow, Russia). The authors compared survey data of young people of this age in the second half of the last century [59]. The thickness of skin and fat folds in females in the 2000s was 1.1-2.5 times higher than in females in the 1980s. The authors found a significant decrease in the strength of the right hand in teenagers of the 2000s, compared with children and teenagers of the 60s of the last century. For example, the strength of the right hand in 9-year-old boys and girls decreased more than 2 times in 2003 compared to 1960. The authors explain the decrease in functional body parameters by hypodynamics of youth, eating disorders, unfavorable environmental conditions, and other reasons.

Our data on the characteristics of motor qualities in females with different somatotypes are coinciding with other authors' studies [60]. The authors determined an improvement in motor tests of hypersthenics and asthenics. Previously, we found higher results in motor tests in females with asthenic and normosthenic somatotypes [43] compared with hypersthenic females. It has been shown that the reserves of the cardiovascular system (relative strength of the hands' muscles; respectively, physical performance) are higher in normosthenic and asthenic females compared with hypersthenics.

The obtained data indicate a deterioration in all motor skills in females in 2019 compared to 2009. This affects negatively on today's youth health. A lot of authors consider low physical activity as one of the reasons for the physical condition deterioration of modern youth. The growth of hypodynamics is observed in Europe [14, 61, 62], in Australia [63], in China [64], in the USA [21], in Russia [65], Chile [22]. There is a lack of efficiency of the existing system of physical education of the younger generation. This is due to the underestimation of knowledge about the somatotypes and anatomical components of the human body [10]. We believe that the social, reproductive, and professional functions of female students depend on their somatotype and morphofunctional features of the body. Therefore, further study of this problem is a promising area for studying the vector of changes in the physical health of modern youth.

Conclusions

1. One of the reasons for the physical fitness deterioration of modern females is the decrease in muscle mass with an increase in body fat. This is observed in females of all somatotypes. The reason for this is the growing hypokinesia, healthy lifestyle violation, bad habits.

2. The obtained results of screening observations for the development of morphofunctional, somatotypological, and motor qualities expand the predictive database on anthropometric and motor parameters of modern youth. The presented data can be used in educational institutions in planning educational and training classes in physical education and sports and the implementation of health activities in the youth environment.

Conflict of interest.

The authors declare that there is no conflict of interest.

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Cite this article as:
Kolokoltsev M, Kuznetsova L, Jagiello W, Romanova E. Comparative characteristics of morphological features, somatotypes and motor qualities of female students from different generations (Irkutsk region, Russia). *Physical Education of Students,* 2020;24(4):242–250.
https://doi.org/10.15561/20755279.2020.0407

Received: 02.07.2020
Accepted: 08.08.2020; Published: 30.08.2020