PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

The level of students' physical development depending on the ethno-territorial variability of morpho-functional features

Iryna Ivanyshyn[1ABCDE], Ihor Vypasniak[1ABDE], Sergii Iermakov[2,3ABDE], Wladyslaw Jagiello[2CDE], Tetiana Yermakova[3BD], Vasyl Lutskii[1BDE], Oleh Vintoniak[4BDE], Irina Kriventsova[5BD]

[1]*Department of Theory and Methods of Physical Culture and Sports, Vasyl Stefanyk Precarpathian National University, Ukraine*
[2] *Department of Sport, Gdansk University of Physical Education and Sport, Poland*
[3]*Department of Pedagogy, Kharkiv State Academy of Design and Arts, Ukraine*
[4]*Department of Physical Training and Sports, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine*
[5] *Department of Martial Arts, Fencing and Endurance Sports, H.S. Skovoroda Kharkiv National Pedagogical University, Ukraine*

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

Abstract

Background and Study Aim The variability of interpopulation morphofunctional traits in humans is closely related to various environmental factors. However, body composition has a significant relationship with indicators of physical fitness, human performance, with its adaptation to environmental conditions. The aim of the work is to investigate ethno-territorial variability of morphological characteristics of students studying at Ukrainian universities.

Material and Methods Datum were from cross-sectional surveys since 2014 through 2019. Male students aged 18–25 years old (n = 488) of Ivano-Frankivsk National Medical University from different countries were recruited. Anthropometric methods included body length (BH), body weight (BW), chest girth in three states: at maximum, maximum inspiration and rest; skinfolds thicknesses and epiphysis measurements. Somatometric physical development indicators (body mass index - BMI), Kettle', Pignet', Livi' and Erisman' indexes) were calculated on the basis of these parameters. Body composition (absolute and relative amounts of skeletal, fat and muscle components) were determined using Matiegka formula.

Results It was found that the average growth of students in European countries is higher compared to students from Asia (9-10%) and Africa (3-5%). Reliably significant differences ($p < .05$) in body weight indicators between all ethnic groups were found. Students from India are characterized by very low levels of relative body fat. Most representatives of Egypt (61.4%) and Jordan (50.9%) are characterized by moderately high fat content. For representatives of all other countries, this figure is within the optimal ratio.

Conclusions The obtained results showed that anthropometric and morphometric indicators of students aged 18-25 change statistically significantly depending on the ethno-territorial factor. Thus, the study of ethnic variability of morphological characteristics is of great importance for the individualization of physical training of students from other countries in higher education institutions of Ukraine.

Keywords: population, morphological, ethnicity, anthropometric, motor abilities.

Introduction

The study of the variability of interpopulation morphofunctional traits in humans under the influence of various environmental factors (climatic-geographical, socio-economic, anthropogenic) is a topical issue today [1]. Analysis of the variability of the results of ethno-territorial features of anthropometric features has always attracted the attention of researchers from different countries [2, 3, 4, 5]. Bodicoat et al. [2] postulated significant differences between the ethnic groups for body mass index and waist circumference in multi-ethnic populations from the UK (local people and immigrants from South Asia) and India. Heymsfield et al. [3] in sum concluded that when BMI and height are held constant, however, regional mass and body composition proportions differ across the race/ethnic groups. Tinsley et al. [4] found that fat-free mass characteristics vary based on sex, race, and weight status in US adults.

The same results were received by Carpenter et al. [5] among 940 college students – Asians (49%), Caucasians (23%), Hispanics (7%) and Other (21%) – for body fat and body-mass index.

Fundamental research has been conducted by Frongillo and Hanson (USA) [6]. The authors examined human body weight (122 studies in 40

doi:10.15561/20755279.2022.0306

countries) and human body length (123 studies in 44 countries). A significant interethnic difference was found.

Lear et al. [7] analyzed the longitudinal and circumferential dimensions of people. It is established that the relationships between anthropometric indicators differ in different regions of the world.

Data on the variability of length and body weight in people of different nationalities were given by Eveleth and Tanner [8]. The authors compared data from a multicenter WHO reference study with data from studies in 55 countries or ethnic groups. However, these studies date mainly to the period 1964–1990, although earlier data were also included in the report.

Studies of different populations were conducted mainly for the contingent under 18 years of age [9]. The studies concerned either individual indicators of physical development [10, 11] or were conducted within one country [12, 13, 14, 15].

Many researchers [16, 17, 18] believe that indicators of physical development and body constitution are the most important criteria for individualization of physical training and differentiation of assessment of physical condition of pupils and students. Thus, Serhiienko [19] proved that finding out the levels of motor skills in students with different physical development is necessary to select the optimal physical activity. This approach will improve the results of motor tests. Ivanyshyn et al. [20] have established the intercorrelation between adolescent's physical status and aerobic capacity level. Price et al. [21] found significant differences in physical fitness profiles between non-Hispanic White (White) and African American students. Furthermore, weight status was significantly associated with cardiovascular fitness.

Dogra et al. [22] studied the types of physical activity among 400,055 people and identified the benefits of physical activity by ethnicity (whites, South Asians, Southeast Asians, West Asians, blacks, Latinos, and others). The benefits of physical activity were divided into eight categories: walking, endurance, recreation, sports, regular exercise, active travel to work and lack of physical activity. Logistic regression models were used to estimate the chances of participating in each motor activity by ethnicity.

It is likely that the construction of physical education curricula and differentiated standards of physical fitness should take into account the indicators of physical development of students. This will allow to individualize the process of physical training, which will contribute to more effective learning and rehabilitation of students [23, 24].

The aim of the work. Investigate ethno-territorial variability of morphological characteristics of students studying at Ukrainian universities

Material and Methods

Participants

The study involved students (n = 488, age - 18-25 years; male only) from 9 countries (Table 1). All students agreed to participate in the experiment. The study protocol was approved by the Commission of Biomedical Ethics of Ivano-Frankivsk National Medical University (protocols №85177 from 24.10.2014, №89198 from 22.10.2015, №92850 from 23.11.2016, № 96311 from 24.10.2017 and № 112/19 dated 24.12.2019).

Table 1. Distribution of study participants

Country	n
Poland	45
Bulgaria	62
Malaysia	34
India	41
Jordan	68
China	38
Egypt	26
Tunisia	35
Ukraine	49
Totals	488

Research Design.

Datum was from cross-sectional surveys since 2014 through 2019 on the basis of Ivano-Frankivsk National Medical University (Ukraine) during 2014–2019.

Anthropometric examination of students was performed with standard tools according to the generally accepted unified method [25]. Anthropometric methods included body length measurement (BH) using a height meter precision ±0.5 cm in two states: standing and sitting, body weight (BW) – electronic scales with a precision ±0.05 kg, chest girth was performed using an anthropometric ruler with a precision ±0.5 mm in three states: at maximum inspiration, at maximum exhalation and at rest; skinfolds were measured using Lange adipometer (Fat Control, USA) with a precision of 0.2 mm and a constant pressure of 10 g/mm^2, epiphysis were determined *using digital caliper* (OMNI-TECH, SHA120).

Somatometric physical development indicators were studied on the basis of body height (BH), body weight (BW), body circumferences and physical development indices measurement: body mass index (BMI), Kettle, Pignet, Hirata and Rohrer indexes [26]. Body composition was determined on the basis of a three-component model [27]. For this purpose, the absolute and relative amounts of skeletal, fat and muscle components were determined using Matiegka formula [28].

The comparative analysis was conducted on the basis of the generally accepted classification of relative fat content for students aged 18-34 who are not athletes [29]: not ideal (<8%), low (8%), middle (13%), middle (13%), upper (22%) and obesity (> 22%).

We also calculated such components of the constitution as endomorphy, mesomorphy and ectomorphy according to the somatotyping scheme, which is recommended for persons of both sexes aged from 14 to 70 years [30].

Statistical analysis

The experimental data were processed using SPSS Statistics 17.0 program. Checked the data series for compliance with the normal distribution law. Arithmetic mean (), standard deviation (SD), standard error (SE) and variation coefficient (CV) were determined. Determining the statistical significance of obtained research results required Fisher's *F*-test and Chi-squared test (-test). Statistical significance was set at $p \leqslant .05$.

Results

Comparative analysis of body length indicators of male students revealed that it is possible to combine all countries into 3 groups, with significantly different ($p < .05$) values of body length: European countries (Poland, Bulgaria, Ukraine), Asian countries (Malaysia, India, China, Jordan) and African countries (Egypt, Tunisia). It was found that the average growth of students in European countries is higher compared to students from Asia (by 9–10%; $t = 3.39–5.05$; $p < .05 – .01$) and Africa (by 3–5%; $t = 2.05– 3.06$; $p < .05$) (Table 2).

Regarding the indicators of body weight, mass-growth index Kettle, there were statistically significant differences ($p < .05 – .001$) of this indicator between all ethnic groups.

The frequency distribution (%) of study participants by body mass index for different ethnic groups is presented in Fig. 1.

From fig. 1 shows that the largest share (41.06%) of the total contingent of European countries are students with BMI, which corresponds to the norm. However, these countries also tend to be overweight (BMI > 25 kg·m^{-2}), the part of which varies between 22 - 28%, on average 11.79% of students from these countries were obese I-II degree.

Analysis of the BMI of the Asian continent showed that for the majority of students (45.31%) of these countries have the BMI within the norm. However, the tendency to be underweight (24.31%) is very pronounced (except for Jordan). The number of people with overweight BMI is lower than in European and African countries.

An analysis of the BMI of African countries' representatives showed that a fairly large percentage of students have overweight and obese - 31.15% and 14.75%, respectively. These indicators can be explained by the economic and social living standards of the people in these countries. This fact is also confirmed by WHO statistical reports [31].

Measurements of longitudinal and circumferential dimensions of body parts are given in table 3.

According to these values the indicators of physical development were calculated – Pignet index, which characterizes the strength of the physique (Fig. 2).

As can be seen from Fig. 2, students from Egypt and Jordan are characterized by a hypertensive body type, students from Bulgaria, Poland and Ukraine - normosthenic, students from African-Asian countries - normosthenic with a high proportion of asthenic.

These indicators are in good agreement with

Table 2. Anthropometric indicators of students, x̄ (SD)

Country	BHstand (cm)	BHsit (cm)	BW (kg)	BMI (kg·m-2)
Poland	176.3(17.2)	94.9(15.1)	70.2(14.2)	22.6(3.2)
Bulgaria	178.2(15.8)	90.1(14.5)1	75.1(14.8)	23.6(3.8)
Ukraine	174.4(16.0)	93.1(13.2)	63.6(13.1)1.2	21.6(3.1)1,2
Malaysia	164.3(15.6)1,2,3	89.8(12.3)	57.4(11.2)1,2,3	21.3(1.2)1,2
India	165.2(16.3)1,2,3	88.2(13.1)	52.2(13.2)1,2,3	19.1(1.3)1,2,3,4
Jordan	172.8(16.7)4,5	92.3(15.2)1	73.1(14.4)3,4,5	24.5(2.5)1,3,4,5
China	160.1(15.3)1,2,3,6	88.0(13.8)3	52.1(12.8)1,2,3,6	20.3(1.3)1,2,3,4,5,6
Egypt	170.2(19.7)2,7	89.7(20.2)	74.7(21.8)3,4,5,7	25.8(3.0)1,2,3,4,5,7
Tunisia	170.8(15.8)2,7	88.8(16.7)	61.8(19.4)1,2,5,6,7,8	21.2(3.4)2,5,6,8

Note: statistically significant difference ($p < .05$) between data of students from: 1 – Poland and others; 2 – Bulgaria and others; 3 – Ukraine and others; 4 – Malaysia and others; 5 – India and others; 6 – Jordan and others; 7 – China and others; 8 – Egypt and others (based on F-test)

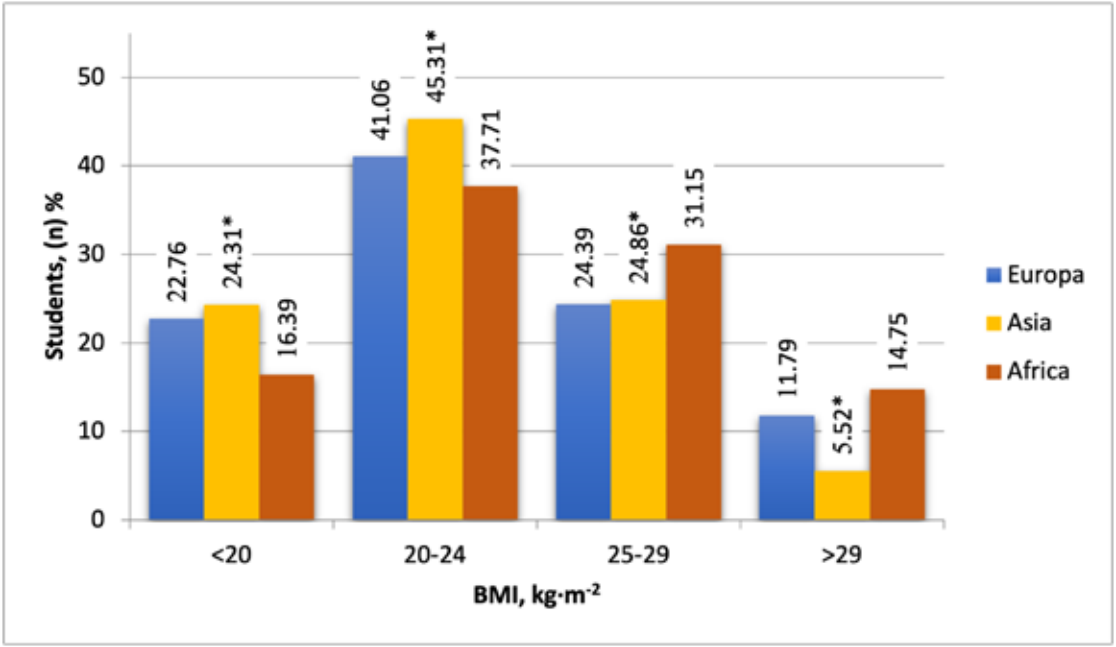

Figure 1. Frequency of distribution of students according to BMI (kg·m^{-2}): * - differences between representatives of Asia and Africa at the level of p <.1 (based on -test)

Table 3. Longitudinal and circumferential dimensions of the body of students, x̄ (SE)

Indicators	Country								
	Poland	Bulgaria	Malaysia	India	Jordan	China	Egypt	Tunisia	Ukraine
Epiphysis (mm)									
Humerus	9.4(0.4)	10.0(1.1)	8.7(1.1)	8.2(1.3)	9.7(1.0)	9.4(1.2)	9.8(1.3)	9.6(0.8)	9.5(1.2)
Ulna	6.1(0.5)	7.6(0.8)	6.8(1.0)	6.8(0.9)	7.7(1.1)	7.7(1.0)	9.0(1.8)	7.4(1.2)	8.2(1.3)
Femur	10.2(1.0)	11.2(1.2)	10.1(1.4)	9.7(1.1)	10.9(1.1)	9.9(1.3)	11.1(1.2)	10.0(1.4)	9.8(1.0)
Tibia	7.9(0.7)	8.7(1.0)	7.9(1.2)	7.8(1.6)	8.5(1.1)	7.6(1.0)	9.1(1.5)	8.4(1.6)	8.0(1.1)
Circumferences (mm)									
Biceps	28.8(1.4)	31.4(2.2)	26.2(1.7)	25.7(1.5)	28.2(1.2)	27.4(2.1)	30.7(1.6)	29.2(2.1)	29.4(1.8)
Forearm	26.0(2.5)	27.2(3.0)	23.2(2.1)	23.8(3.2)	26.1(3.0)	23.4(2.2)	28.9(2.9)	24.8 (2.0)	27.4(2.7)
Chestmax	98.6(4.4)	102.1(6.2)	88.3(6.3)	87.2(5.2)	99.1(6.8)	86.1(6.9)	102.4(7.2)	89.2(4.5)	98.3(6.4)
Chestmin	90.6(4.3)	93.7(5.6)	81.3(3.1)	81.5(3.8)	91.6(5.2)	76.1(9.1)	92.9(9.3)	78.7(8.9)	89.2(9.9)
Chestpausa	92.1(5.4)	96.9(4.8)	83.0(2.9)	83.4(3.6)	93.3(4.5)	82.8(9.3)	94.6(9.8)	83.3(12.6)	93.7(6.5)
Thigh	55.3(4.6)	58.2(4.7)	49.4(3.6)	48.2(3.3)	57.9(4.1)	46.7(3.4)	60.1(2.5)	50.7(2.8)	55.7(3.2)
Calfmax	37.5(2.9)	37.2(2.3)	34.5(1.7)	35.6(1.9)	38(1.5)	34.2(1.9)	38.9(2.0)	35.2(1.7)	37.2(2.0)

the body build (Erisman) index and ponderal (Livi) index (Fig. 3).

Erisman index values for students from Egypt, Jordan and Bulgaria are higher than 5.8 cm. This indicates a wide chest. However, the values of the Left index (within the norm - 50-55%) for students of all ethnic groups (Fig. 3) and BMI (Table 1) indicate a high level of chest and height index. For students from Jordan and Egypt, this fact is due not so much to athleticism as to the tendency to be overweight.

Indicators of body composition are BMI, as well as the thickness of skin and fat folds in different parts of the human body [32]. The results of measuring the thickness of the skin and fat folds of students are presented in table 4. Table 5 shows the calculated component body composition.

Calculations show that students from India are characterized by very low levels of relative body fat. Most representatives of Egypt (61.4%) and Jordan (50.9%) are characterized by moderately high fat content. This confirms the high importance of BMI for students from these countries. For the vast majority of students in all other countries, the value of % BF is within the optimal ratio. Skeletal muscle mass values are in the range of 20.3-38.8%. This corresponds to the values of the average person. The

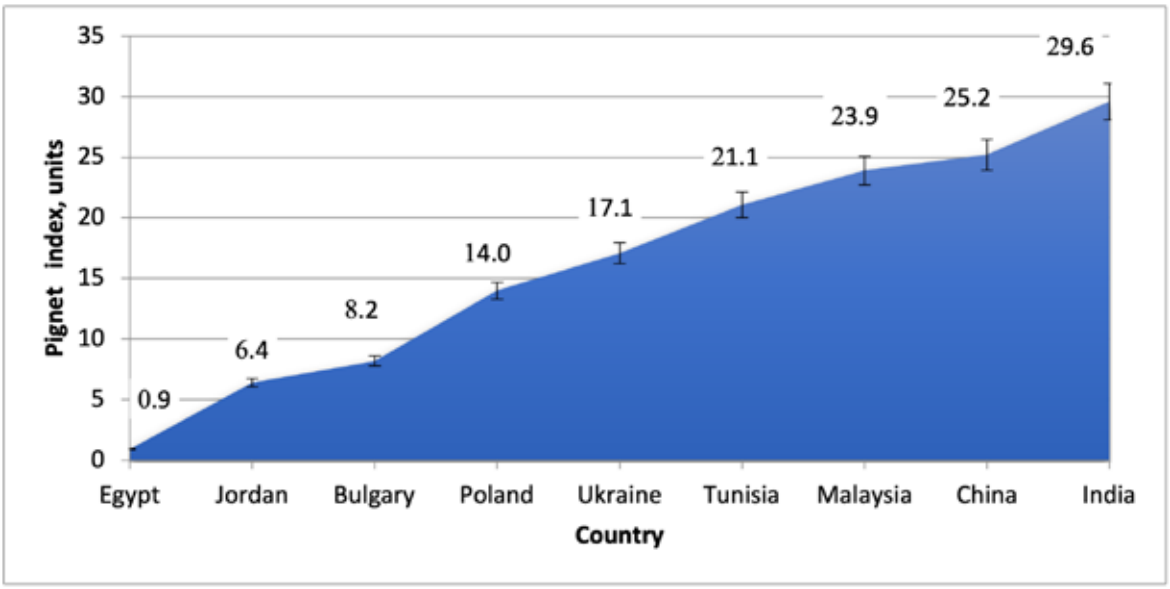

Figure 2. Pignet value of student index, units

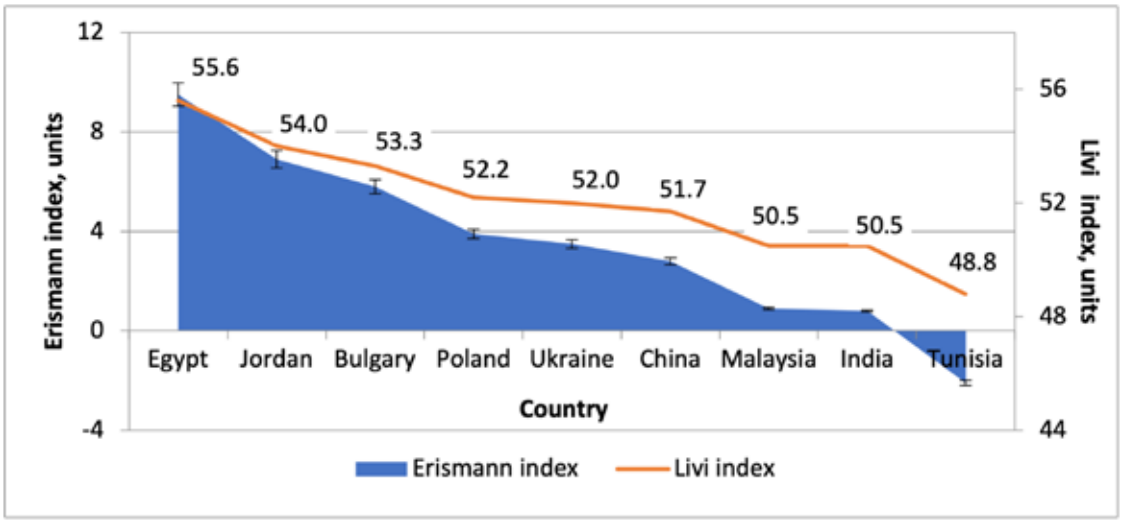

Figure 3. Erismann and Livi index values for students depending on ethnicity

ratios of fat, bone and muscle tissue in the body of students are shown in Fig. 4.

Thus, there are significant differences in skeletal muscle mass ($F = 3.69$, $p < .05$) and adipose tissue mass ($F = 6.99$, $p < .005$) among body components for students from Europe and Asia and Africa. No significant difference for the mass of the bone component was found ($F = 1.44$, $p > .05$).

Slightly higher mean muscle tissue mass scores of African students were compared to Asian students (3.54%) and correspondingly lower adipose tissue mass rates (1.2%). However, these differences are not significant ($F = 1.50$ and $F = 0.93$, respectively, $p > .05$).

To verify the results, we calculated such components of the constitution as endomorphy, mesomorphy and ectomorphy. The calculation data are presented in table 6.

As we can see, the highest indices of endomorphy and mesomorphy are characterized by students from Bulgaria (4.09 and 8.96), Egypt (5.06 and 9.32) and Jordan (5.48 and 8.16). Students from Poland (3.22 and 8.10) and Tunisia (3.29 and 7.53) have slightly lower rates. Students from Malaysia (2.02 and 6.99) and India (2.17 and 6.29) have the lowest indicators of endo- and mesomorphic components. Chinese students with a low value of endomorphy (2.06) have a high value of mesomorphy (8.20). Ecto-mesomorphic type of constitution is characteristic of the representatives of these countries. Students from Ukraine are marked by the most proportional indices of endo-, ecto- and mesomorphy (3.48, 3.50 and 7.21). The correlation coefficient between %BF and endomorphism is 0.87 ($p < .01$), between BMM and mesomorphy - -0.63 ($p < .05$).

Table 4. Thickness of fat folds of students, x̄ (SE)

Indicators	Country								
	Poland	Bulgaria	Malaysia	India	Jordan	China	Egypt	Tunisia	Ukraine
subscapula	13.1 (3.2)	12.6 (2.4)	7.8 (1.9)	8.4 (2.2)	17.6 (6.4)	8.02 (1.6)	16.2 (7.5)	10.9 (2.8)	10.3 (2.7)
triceps	11.4 (3.5)	10.9 (1.8)	5.8 (1.3)2	6.2 (1.8)2,	15.1 (4.3)	6.3 (1.6)2,	14.1 (4.9)	8.0 (2.2)	9.4 (2.1)
biceps	10.0 (2.2)	10.7 (2.1)	4.4 (1.2)1,2	4.1 (1.4)1,	14.8 (4.7)3,4	5.1 (1.1)1,4	13.8 (3.6)3,4,	9.1 (3.1)	8.9 (2.4)
forearm	9.9 (3.1)	10.0 (3.6)	3.5 (1.4)	3.2 (1.2)1,	13.7 (3.8)3,4	4.0 (1.3)4	13.0 (4.1)3,4,	8.9 (4.1)	7.9 (3.8)
suprailiac	13.4 (5.1)	16.5 (5.2)	7.2 (2.6)	7.5 (2.8)	22.8 (8.0)	6.8 (3.0)	20.3 (6.2)6	13.2 (5.6)	11.3 (3.1)
abdominal	18.8 (4.9)	18.3 (4.7)	9.0 (2.1)	9.1 (2.5)	20.4 (5.7)	6.6 (3.1)1,2,4	20.1 (6.0)6	12.1 (3.4)	13.2 (2.8)
medial calf	18.2 (5.1)	17.5 (3.9)	7.6 (2.9)2	7.8 (2.1)2,	19.9 (6.0)4	6.5 (2.8)1,2,4	19.8 (5.4)3,4,	11.9 (4.2)	10.6 (3.8)

Note: statistically significant difference (p <.05) between data of students from: 1 – Poland and others; 2 – Bulgaria and others; 3 – Malaysia and others; 4 – India and others; 5 – Jordan and others; 6 – China and others (based on F-test)

Table 5. Values of indexes % BF, BFM, %MM, BMM, %BM, BBM of students

Indicators	Country								
	Poland	Bulgaria	Malaysia	India	Jordan	China	Egypt	Tunisia	Ukraine
S (m^2)	1.9(0.3)	1.9(0.3)	1.6(0.4)	1.6(0.4)	1.9(0.2)	1.5(0.3)	1.9(0.1)	1.8(0.1)	1.8(0.3)
% BF	15.5(1.1)	17.1(1.0)	13.3(1.2)2	9.0(1.0)1,2,3	18.3(1.3)3,4	11.5(0.8)1,2,4,5	20.0(1.4)1,3,4,6	13.2(1.1)2,4,5,7	13.9(1.0)2,4,5,7
BFM (kg)	15.3(1.2)	16.5(1.2)	11.3 (1.0)1,2	10.1(1.4)1,2	17.6(1.2)	11.1(1.1)1,2	18.4(1.4)3,4,6	11.5(1.4)1,2,7	13.2(1.2)7
%MM	25.9(1.3)	27.1(1.5)	34.7(1.2)1,2	37.9(1.2)1,2	19.3(2.3)1,2,3,4	38.8(1.0)1,2,3,5	25.4(1.2)3,4,5,6	36.2(0.9)1,2,5,7	35.4(1.2)1,2,5,6,7
BMM (kg)	18.2(2.1)	20.4(2.0)	19.9(1.9)	19.8(2.2)	14.1(1.8)2,3,4	20.2(1.4)5	19.0(2.1)	22.4(2.0)5	22.5(2.2)5
%BM	13.8(1.1)	12.9(0.8)	16.9(0.9)1,2	18.6(0.8)1,2	13.3(0.8)3,4	18.6(1.1)1,2,5	13.0(0.9)3,4,6	15.7(1.1)2,4	15.3(1.0)4,6
BBM (kg)	9.7(1.1)	12.3(1.3)	7.9(1.2)2	7.8(1.5)2	10.4(2.1)	8.0(0.4)2	10.7(2.1)	8.7(1.3)2	9.1(1.4)

Note: 1) S – body surface area; % BF – percentage body fat; BFM – body fat mass; %MM – percentage *muscle mass*; BMM – body *muscle mass*; %BM – percentage *bone mass*; BBM – body *bone mass; 2)* statistically significant difference (p <.05) between data of students from: 1 – Poland and others; 2 – Bulgaria and others; 3 – Malaysia and others; 4 – India and others; 5 – Jordan and others; 6 – China and others; 7 – Egypt and others (based on F-test)

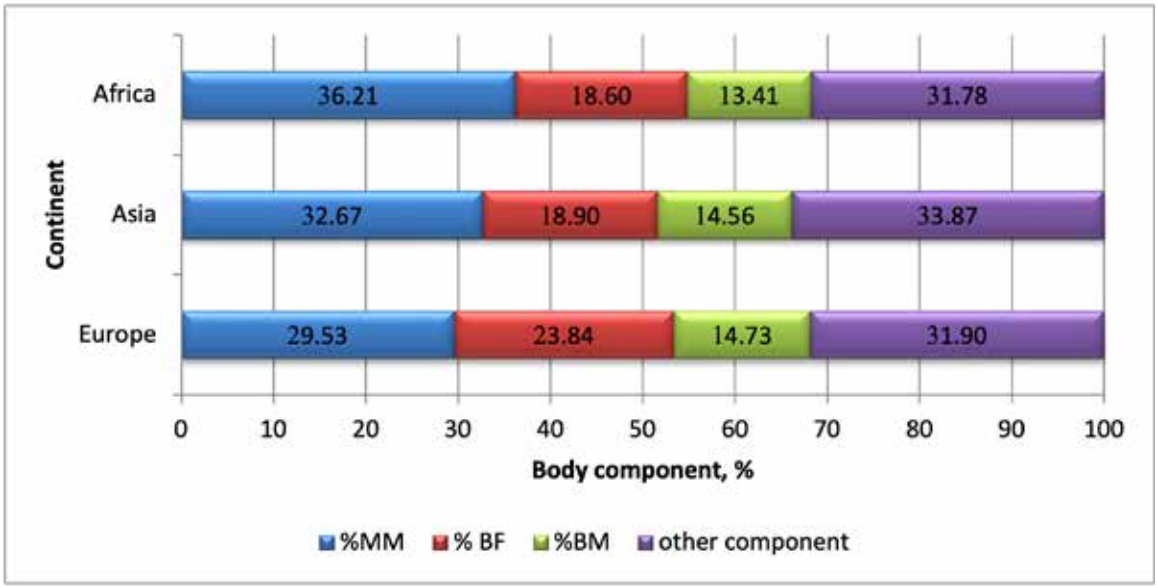

Figure 4. The ratio between the body components of students of different races: %BF - percentage body fat; %MM - percentage muscle mass; %BM - percentage bone mass

Discussion

Studies of the composition of human body weight have become increasingly important in recent years. Our results found that 33.8–39.8% of male students from European countries participating in the study were overweight/obese. This finding was lower than the average overweight/obese rate found by Gallus et al. [33]. Almost 54.5% the interviewed European male adults were overweight or obese and 14.0% were obese. In particular, in Poland the overweight/

Table 6. Components of the constitution of the body of students

Body type	Poland	Tunisia	Bulgaria	Egypt	Jordan	India	China	Malaysia	Ukraine
Endomorph	3.22	3.29	4.09	5.06	5.48	2.17	2.06	2.02	3.48
Mesomorph	8.10	7.53	8.96	9.32	8.16	6.29	8.20	6.99	7.21
Ectomorph	2.5	3.0	2.5	1.0	1.5	4.0	3.0	2.5	3.5
X-coordinate	-0.72	-0.29	-1.59	-4.06	-3.98	1.83	0.94	0.48	0.02
Y-coordinate	10.47	8.77	11.33	12.57	9.33	6.40	11.34	9.46	7.44
	endo-mesomorphic					ecto-mesomorphic			

obese rate for men aged > 18 years was found 53.6 %, in Bulgaria – 54.9 %. Such difference can be explained by the level of education of our sample. It's approved that prevalence of obesity significantly decreased with level of education [34, 35].

Our study results found that 30.38 % of students from Asian countries participating in the study were overweight/obese. Moreover, the rate of overweight/obese among students from Malaysia, India, China was in average 22.12 % and 42.65 % were from Jordan. These are similar results to Gopalakrishnan et al. [36] where pre-obese male students accounted for 18.3 % and 9.2 % were found to be obese. Jingya et al. [37] found that 2.9 %–14.3 % of Chinese students, depends on province, have overweight and obesity. Similar results were obtained by Jiang et al. [38]. Results got by Peltzer et al. [39] indicated that the median BMI was 20.2 kg·m^{-2} and 20.8% were overweight/obese (7.8 % overweight and 13.0 % obese).

The BMI results of African countries showed that a fairly large percentage of students were overweight and obese - 31.15% and 14.75%, respectively, which was confirmed by Okati-Aliabad et al. [40] who found the range of prevalence of obesity was between (15.09–30.20%) and the range of prevalence of overweight was between (28.94–32.63%).

Our results confirmed the data of a number of foreign researchers [4, 5, 6, 41, 42]. The authors noted that BMI and obesity differ significantly between ethnic groups and these differences change throughout adulthood. The authors explain such differences both by genetic mechanisms and by different patterns of nutrition, economic and social impact on populations.

Carpenter CL [5] estimated the percentage of body fat (% BF) and BMI. The authors determined the level of BMI, %BF in different races of college students (n = 940, age - 21.4 years). Among the students were Asians (49%), Caucasians (23%), Latinos (7%) and others (21%). Almost all anthropometric indicators differed significantly depending on race, which was confirmed in our study.

In our opinion, it is not advisable to use the standards of physical development formed on the basis of averages. Even if the data are the result of mass research and provided a significant number of overweight people. This statement is due to the fact that such data do not take into account the degree of development of the components of body weight. This approach is confirmed by the results of studies by Kamarudin et al. [43]. After all, it is known that the greater the number of signs put into the assessment of physical development, the more accurate will be the assessment itself.

It is known that the percentage of body fat is characterized by a nonlinear dependence on body mass index. Different values of BMI may correspond to the same value of % BMD in different individuals (depending on gender, age and ethnicity). For example, at the same values of % BMD, the value of BMI in black Americans is on average 1.3 units less, and in Polynesian peoples - 4.5 units more than in Caucasians [44, 45].

Our considerations about the influence of constitutional features on motor skills and functional parameters of students have been confirmed in the studies of Kolokol'tsev [46, 47], Mishechkin [48]. The authors noted that taking into account the somatotype will specify the provisions of the methodology of planning individual differentiated learning in the discipline "Physical Education".

The results of numerous studies [49, 50] show that body composition has a significant relationship with indicators of physical performance, with its adaptation to environmental conditions, as well as with professional and sports activities. In addition, body shape is different both among sports and between categories and positions within a sport; each sport requires morphological peculiarities [49]. Lee et al. [51] postulated that different levels of performance in muscular strength, endurance, and flexibility effectively predicted abdominal obesity in both genders, whereas cardiorespiratory fitness predicted abdominal obesity only in men.

Sirard et al. [52] found that compared with White girls, African-American girls had higher fitness scores when measured in absolute terms but similar relative fitness scores. The higher BMI values for the African-American girls might be responsible for their greater absolute fitness which, in turn, may reflect a greater fat-free mass because additional

fat mass would not be expected to result in greater levels of fitness.

Kuk et al. [53] also been reported that black individuals may have a lower cardiorespiratory fitness (CRF) than white and Hispanic individuals.

Chaouachi et al. [54] found that aerobic capacity variables demonstrated significant interaction effects with somatotype over a period of aerobic training. The mesomorph and the mesomorph-ectomorph demonstrated greater improvements in aerobic capacity than endomorphs-mesomorphs and ectomorphs.

Ryan-Stewart et al. [55] indicated that mesomorphs with higher endomorphic components were likely to have lower strength and physical fitness index scores than those with lower endomorphic components.

Çinarli et al. [56] study highlighted the fact that the subgroups of somatotype have an effect on performance parameters. In particular, the statistically significant differences were found between 9 somatotype subgroups in terms of explosive force, aerobic and anaerobic power output and they found no significant between groups in terms of flexibility, relative anaerobic peak and mean power output.

López-Sánchez et al. [57] also studied differences in body composition, physical fitness and lifestyle between students (age 21.5 ± 1.9 years) from universities in different countries. The authors have developed recommendations for improving the health of students from certain countries who come to the university, based on body morphology.

McEligot et al. [58] also showed that such fitness parameters as relative VO2 max, %BF and total fitness scores are associated with obesity in all three ethnic groups (non-Hispanic whites; Hispanics and Asians). Therefore, for all three ethnic groups, university programs should consider promoting physical fitness, including increased aerobic activity and strength training, which may reduce overall obesity in these respective groups, and that special attention may be needed to reduce excess weight in Hispanic college students.

Saffer et al. [59] used the results of the 2007 National Health Survey (NHIS) [60]. The authors pointed out significant differences in motor activity between racial groups. According to them, 33.8% of whites, 23.8% of Hispanics and 23.2% of blacks engage in regular physical activity at leisure.

Saint Onge [61] used data from the 1998 National Health Survey (n = 17,455) and information on exercise in 15 types of physical activity. The authors studied the educational differences in the exercises among students of different races. The authors came to the conclusion: Europeans are disproportionately engaged in fitness and exercise; blacks are prone to team and fitness classes; Mexican Americans tend to team sports; Asians tend to yoga, stretching, gymnastics. According to the authors, this may help to develop better health programs in educational institutions.

Conclusions

The obtained results showed that anthropometric and morphometric indicators of students aged 18-25 change statistically significantly depending on the ethno-territorial factor. From the other side, the significant role of anthropometric and morphometric characteristics in sport (fitness) performance besides other factors is well known. Thus, the study of ethnic variability of morphological characteristics is of great importance for the individualization of physical training of students from other countries in higher education institutions of Ukraine.

Further work is required to determine the peculiarities of functional state versus ethnicity as a prescription of training programmes for university male students.

Conflict of interest

The authors state that there is no conflict of interest.

References

1. Doak C. Auxology: studying human growth and development. *Eur J Clin Nutr*. 2014;68:534. https://doi.org/10.1038/ejcn.2014.4
2. Bodicoat DH, Gray LJ, Henson J, Webb D, Guru A, Misra A, et al. Body Mass Index and Waist Circumference Cut-Points in Multi-Ethnic Populations from the UK and India: The ADDITION-Leicester, Jaipur Heart Watch and New Delhi Cross-Sectional Studies. *PLoS ONE,* 2014; 9(3): e90813. https://doi.org/10.1371/journal.pone.0090813
3. Heymsfield SB, Peterson CM, Thomas DM, Heo M, Schuna JM Jr. Why are there race/ethnic differences in adult body mass index-adiposity relationships? A quantitative critical review. *Obes Rev*. 2016;17(3):262–275. https://doi.org/10.1111/obr.12358
4. Tinsley GM, Smith-Ryan AE, Kim Y, Blue MNM, Nickerson BS, Stratton MT, et al. Fat-free mass characteristics vary based on sex, race, and weight status in US adults. *Nutrition Research*. 2020;81:58–70. https://doi.org/10.1016/j.nutres.2020.07.002
5. Carpenter CL, Yan E, Chen S, Hong K, Arechiga A, Kim WS, et al. Body Fat and Body-Mass Index among a Multiethnic Sample of College-Age Men and Women. *Journal of Obesity*. 2013;2013: 1–7. https://doi.org/10.1155/2013/790654
6. Frongillo EA, Hanson KMP. Determinants of variability among nations in child growth. *Annals of Human Biology*. 1995;22(5):395-411. https://doi.org/10.1080/03014469500004082

7. Lear SA, James PT, Ko GT, Kumanyika S. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *European Journal of Clinical Nutrition*. 2010;64(1): 42–61. https://doi.org/10.1038/ejcn.2009.70
8. Eveleth PB, Tanner JM. *World-wide variation in human growth*. 2nd ed. Cambridge: Cambridge University Press; 1990.
9. World Health Organization. *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development*. Geneva: World Health Organization, 2006:312.
10. Max R, Cameron A, Hannah R. *Human height*. OurWorldInData.org; 2020.
11. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *The Lancet*. 2016;387(10026): 1377–1396. https://doi.org/10.1016/S0140-6736(16)30054-X
12. Asiki G, Mohamed SF, Wambui D, Wainana C, Muthuri S, Ramsay M, et al. Sociodemographic and behavioural factors associated with body mass index among men and women in Nairobi slums: AWI-Gen Project. *Global Health Action*. 2018;11(sup2):1470738. https://doi.org/10.1080/16549716.2018.1470738
13. He W, Li Q, Yang M, et al. Lower BMI cutoffs to define overweight and obesity in China. *Obesity (Silver Spring),* 2015;23:684– 691. https://doi.org/10.1002/oby.20995
14. Liu B, Du Y, Wu Y, Snetselaar LG, Wallace RB, Bao W, et al. Trends in obesity and adiposity measures by race or ethnicity among adults in the United States 2011-18: population based study *BMJ* 2021;372:n365. https://doi.org/10.1136/bmj.n365
15. Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. *Br J Nutr.* 2009;102:632–641. https://doi.org/10.1017/S0007114508207221
16. Arabmokhtari R, Khazani A, Bayati M, Barmaki S, Fallah E. Relationship between Body Composition and Cardiorespiratory Fitness in Students at Postgraduate Level. *Zahedan J Res Med Sci*. 2018;20(2):e12109. https://doi.org/10.5812/zjrms.12109
17. Zaccagni L, Barbieri D, Gualdi-Russo E. Body composition and physical activity in Italian university students. *J Transl Med.* 2014;12:120. https://doi.org/10.1186/1479-5876-12-120
18. Pribis P, Burtnack CA, McKenzie SO, Thayer J. Trends in body fat, body mass index and physical fitness among male and female college students. *Nutrients*. 2010;2(10):1075–1085. https://doi.org/10.3390/nu2101075
19. Serhiienko VM. *System of control of motor abilities of student youth: theory and methodology of physical education*. SDPU named A. S. Makarenko. Sumy; 2015. (in Ukrainian).
20. Ivanyshyn I, Lemak O, Vypasniak I, Sultanova I, Vintoniak O, Salatenko I, Huzak O. Intercorrelation between adolescent' physical status and aerobic capacity level. *Journal of Physical Education and Sport,* 2021; 21 (5)384: 2890–2900. https://doi.org/10.7752/jpes.2021.s5384
21. Price AA, Whitt-Glover MC, Kraus CL, McKenzie MJ. Body Composition, Fitness Status, and Health Behaviors Upon Entering College: An Examination of Female College Students From Diverse Populations. *Clin Med Insights Womens Health*. 2016;9(Suppl 1):23–29. https://doi.org/10.4137/CMWH.S34697
22. Dogra S, Meisner BA, Ardern CI. Variation in mode of physical activity by ethnicity and time since immigration: a cross-sectional analysis. *Int J Behav Nutr Phys Act*. 2010;7:75. https://doi.org/10.1186/1479-5868-7-75
23. Matiichuk V, Vypasniak I, Ivanyshyn I, Aloshyna A, Ivanyshyn Y, Rymyk R, Bychuk I. Morpho-biomechanical characteristics of female students as a basis for the development of differentiated health-related programs. *Journal of Physical Education and Sport,* 2021; 21(5)383:2880–2889. https://doi.org/10.7752/jpes.2021.s5383
24. Meshcheryakov AV. Optimization of physical education of young students on the basis of physiologically grounded methodology of physical training taking into account students' individual typological characteristics. *Moscow University Anthropology Bulletin. Seria 23 Anthropology*. 2016;2: 72–84. (in Russian).
25. Lohman TJ, Roache AF, Martorell R. Anthropometric Standardization Reference Manual: *Medicine & Science in Sports & Exercise*. 1992;24(8): 952. https://doi.org/10.1249/00005768-199208000-00020
26. Makarova GA. *Practical guide for sports therapists*. Rostov-on-Don: BARO-PRESS; 2002. (in Russian).
27. Martirosov E, Nikolaev D, Rudnev S. *Technologies and methods of human body composition assessment*. Moscow: Science; *2006.* (in Russian).
28. Matiegka J. The testing of physical efficiency. *American Journal of Physiology and Anthropology*, 1921;4: 223–330. https://doi.org/10.1002/ajpa.1330040302
29. Heyward VH, Wagner D. *Applied body composition assessment*. Champaign, IL: Human Kinetics; 2004.
30. Carter JL, Heath BH. *Somatotyping – development and applications*. Cambridge University Press; 1990.
31. National Department of Health. *Statistics South Africa, South African Medical Research Council, ICF. South Africa Demographic and Health Survey 2016*. [Internet]. Rockville: ICF International Inc; 2018 [cited 2022 Jan 15]. Available from: https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf
32. Reilly JJ, Wilson J, Durnin JV. Determination of body composition from skinfold thickness: a validation study. *Arch Dis Child*. 1995;73(4):305–310. https://doi.org/10.1136/adc.73.4.305
33. Gallus S, Lugo A, Murisic B, Bosetti C, Boffetta P, La Vecchia C. Overweight and obesity in 16 European countries. *Eur J Nutr.* 2015;54(5):679–89. https://doi.org/10.1007/s00394-014-0746-4
34. Cohen AK, Rai M, Rehkopf DH, Abrams B.

Educational attainment and obesity: a systematic review. *Obes Rev*. 2013;14(12):989–1005. https://doi.org/10.1111/obr.12062
35. Witkam R, Gwinnutt JM, Humphreys J, Gandrup J, Cooper R, Verstappen SMM. Do associations between education and obesity vary depending on the measure of obesity used? A systematic literature review and meta-analysis. *SSM - Population Health*. 2021;15: 100884. https://doi.org/10.1016/j.ssmph.2021.100884
36. Gopalakrishnan S, Ganeshkumar P, Prakash MVS, Christopher null, Amalraj V. Prevalence of overweight/obesity among the medical students, Malaysia. *The Medical Journal of Malaysia*. 2012;67(4): 442–444.
37. Jingya B, Ye H, Jing W, Xi H, Tao H. Quantitative analysis and comparison of BMI among Han, Tibetan, and Uygur university students in Northwest China. *Scientific World Journal*. 2013;2013:180863. https://doi.org/10.1155/2013/180863
38. Jiang S, Peng S, Yang T, Cottrell RR, Li L. Overweight and Obesity Among Chinese College Students: An Exploration of Gender as Related to External Environmental Influences. *Am J Mens Health*. 2018;12(4):926–934. https://doi.org/10.1177/1557988317750990
39. Peltzer K, Pengpid S, Samuels TA, Özcan NK, Mantilla C, Rahamefy OH, Wong ML, Gasparishvili A. Prevalence of overweight/obesity and its associated factors among university students from 22 countries. *Int J Environ Res Public Health*. 2014;11(7):7425–7441. https://doi.org/10.3390/ijerph110707425
40. Okati-Aliabad H, Ansari-Moghaddam A, Kargar S, Jabbari N. Prevalence of Obesity and Overweight among Adults in the Middle East Countries from 2000 to 2020: A Systematic Review and Meta-Analysis. *J Obes*. 2022;2022:8074837. https://doi.org/10.1155/2022/8074837
41. Schuna JM, Peterson CM, Thomas DM, Heo M, Hong S, Choi W, et al. Scaling of adult regional body mass and body composition as a whole to height: Relevance to body shape and body mass index: Bmi Scaling Relations. *American Journal of Human Biology*. 2015;27(3): 372–379. https://doi.org/10.1002/ajhb.22653
42. Broyles ST, Bouchard C, Bray GA, Greenway FL, Johnson WD, Newton RL, et al. Consistency of fat mass–fat-free mass relationship across ethnicity and sex groups. *British Journal of Nutrition*. 2011;105(8): 1272–1276. https://doi.org/10.1017/S0007114510004794
43. Kamarudin A, Tengah RY, Rasyid NY, Jusoh N. Relationship between Body Mass Index, Waist Circumference, Fat Mass and Fat Percentage as a Measurement of Obesity among Universiti Pendidikan Sultan Idris Students. *J. Fundam. Appl. Sci.* 2017; 9(6S):1161–1172. https://doi.org/10.4314/jfas.v9i6s.86
44. Deurenberg P, Deurenberg-Yap M. Differences in body-composition assumptions across ethnic groups: practical consequences. *Curr Opin Clin Nutr Metab Care*. 2001 Sep;4(5):377–383. https://doi.org/10.1097/00075197-200109000-00007
45. Deurenberg P, Deurenberg-Yap M. Validity of body composition methods across ethnic population groups. *Forum of Nutrition*. 2003;56: 299–301. https://doi.org/10.1007/s00592-003-0077-z
46. Kolokol'tsev MM, Lebedinskiy VYu. Comparative characteristics of the level of physical development of youth students of the Irkutsk region. *Bulletin of East Siberian Scientific Center, Siberian Branch of the Russian Academy of Medical Sciences*. 2012;(6):47–54. (in Russian).
47. Kolokoltsev MM. Characteristic of male students physical development with regard to the typological features of their somatotypes. *Vestnik Irkutskogo gosudarstvennogo tekhnicheskogo universiteta,* 2015;10:309-314. (in Russian).
48. Mishechkin MM, Chairkin IN, Yurtaykina MN, et al. Anatomofunctional and somatotypological features of female adolescent students in the Republic of Mordovia with regard to their ethnic origin. *University proceedings. Volga region. Medical sciences*. 2021;(3). https://doi.org/10.21685/2072-3032-2021-3-10
49. Ramos-Jiménez A, Chávez-Herrera R, Castro-Sosa AS, Pérez-Hernández LC, Hernández Torres RP, Olivas-Dávila D. Body Shape, Image, and Composition as Predictors of Athlete's Performance. In: Sozen H (ed.) *Fitness Medicine*. InTech; 2016. https://doi.org/10.5772/65034
50. Nikbakht M. Relationships between somatotype, anthropometry and physical fitness variables in untrained university students. *Journal of Physical Education and Sport*. 2011;11(2):101–104.
51. Lee PF, Ho CC, Kan NW, Yeh DP, Chang YC, Li YJ, Tseng CY, Hsieh XY, Chiu CH. The Association between Physical Fitness Performance and Abdominal Obesity Risk among Taiwanese Adults: A Cross-Sectional Study. *Int J Environ Res Public Health*. 2020;17(5):1722. https://doi.org/10.3390/ijerph17051722
52. Sirard JR, Pfeiffer KA, Dowda M, Pate RR. Race differences in activity, fitness, and BMI in female eighth graders categorized by sports participation status. *Pediatr Exerc Sci*. 2008 May;20(2):198–210. https://doi.org/10.1123/pes.20.2.198
53. Kuk JL, Ardern CI. The influence of ethnicity and gender on the association between measured obesity and cardiorespiratory fitness with self-rated overweight, physical activity and health. *Perspectives in Public Health*. 2014;134(1):38–43. https://doi.org/10.1177/1757913913480751
54. Chaouachi M, Chaouachi A, Chamari K, Chtara M, Feki Y, Amri M, Trudeau F. Effects of dominant somatotype on aerobic capacity trainability. *Br J Sports Med*. 2005 Dec;39(12):954–959. https://doi.org/10.1136/bjsm.2005.019943
55. Ryan-Stewart H, Faulkner J, Jobson S. The influence of somatotype on anaerobic performance. *PLoS One*. 2018;13(5):e0197761. https://doi.org/10.1371/journal.pone.0197761
56. Çinarli F, Kafkas M. The effect of somatotype characters on selected

physical performance parameters. *Physical Education of Students*. 2019;23(6):279–287. https://doi.org/10.15561/20755279.2019.0602
57. López-Sánchez GF, Radzimiński Ł, Skalska M, Jastrzębska J, Smith L, Wakuluk D, Jastrzębski Z. Body Composition, Physical Fitness, Physical Activity and Nutrition in Polish and Spanish Male Students of Sports Sciences: Differences and Correlations. *Int J Environ Res Public Health*. 2019;16(7):1148. https://doi.org/10.3390/ijerph16071148
58. McEligot AJ, Mitra S, Beam W. The association between fitness and obesity in diverse multi-ethnic college students. *J Am Coll Health*. 2021;69(3):290–297. https://doi.org/10.1080/07448481.2019.1665054
59. Saffer H, Dave D, Grossman M, Leung LA. Racial, Ethnic, and Gender Differences in Physical Activity. *J Hum Cap*. 2013;7(4):378–410. https://doi.org/10.1086/671200
60. National Center for Health Statistics. *National Health and Nutrition Examination Survey (NHANES)*. Centers for Disease Control and Prevention; 2021.
61. Saint Onge JM, Krueger PM. Education and racial-ethnic differences in types of exercise in the United States. *J Health Soc Behav*. 2011;52(2):197–211. https://doi.org/10.1177/0022146510394862

Information about the authors:

Iryna Ivanyshyn; https://orcid.org/0000-0003-1765-8311; iryna.ivanyshyn@pnu.edu.ua; Department of Theory and Methods of Physical Culture; Vasyl Stefanyk Precarpathian National University; Ivano-Frankivsk, Ukraine.

Igor Vypasniak; (Corresponding author); https://orcid.org/0000-0002-4192-1880; ihor.vypasniak@pnu.edu.ua; Department of Theory and Methods of Physical Culture; Vasyl Stefanyk Precarpathian National University; Ivano-Frankivsk, Ukraine.

Sergii Iermakov; http://orcid.org/0000-0002-5039-4517; sportart@gmail.com; Department of Sport, Gdansk University of Physical Education and Sport; Gdansk, Poland.

Wladyslaw Jagiello; http://orcid.org/0000-0001-7417-4749**;** wjagiello1@wp.pl; Department of Sport, Gdansk University of Physical Education and Sport; Gdansk, Poland.

Tetiana Yermakova; https://orcid.org/0000-0002-3081-0229**;** yermakova2015@gmail.com; Department of Pedagogy, Kharkiv State Academy of Design and Arts; Kharkov, Ukraine.

Vasyl Lutskyi; https://orcid.org/0000-0003-3940-1349; luckij55@gmail.com; Department of Theory and Methods of Physical Culture; Vasyl Stefanyk Precarpathian National University; Ivano-Frankivsk, Ukraine.

Oleh Vintoniak; https://orcid.org/0000-0003-4940-1238; oleg.v@ukr.net; Department of Physical Training and Sports; Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine.

Irina Kriventsova; http://orcid.org/0000-0001-6931-3978**;** kriventsova.ira@ukr.net; Department of Martial Arts, Fencing and Endurance Sports, H.S. Skovoroda Kharkiv National Pedagogical University; Kharkiv, Ukraine.

Cite this article as:
Ivanyshyn I, Vypasniak I, Iermakov S, Jagiello W, Yermakova T, Lutskii V, Vintoniak O, Kriventsova I. The level of students' physical development depending on the ethno-territorial variability of morpho-functional features. *Physical Education of Students,* 2022;26(3):154–164.
https://doi.org/10.15561/20755279.2022.0306

Received: 03.05.2022

Accepted: 12.06.2021; **Published**: 30.06.2022