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Interethnic Differences in the Main Anthropometric Indicators and Indices for Assessing Physical Development

Zhanar Suyundikova¹, Damilya Konysbaeva², Gaukhar Baubekova¹, Ainur Yermekova², Kadyrzhan Makangali³ and Gulzhan Tokysheva³

¹Department of Natural Sciences, Natural-Mathematical Faculty, Kostanay State Pedagogical University, Kostanay, **Kazakhstan**

²Department of Plant Protection and Quarantine, Faculty of Agriculture, S.Seifullin Kazakh Agrotechnical University, Astana, **Kazakhstan**

³Department of Food Technology and Processing Products, Technical Faculty, S.Seifullin Kazakh Agrotechnical University, Astana, **Kazakhstan**

*Correspondence: kadr_90.taz@mail.ru Accepted: 09 April, 2019 Published online: 07 May, 2019

Interethnic features of the main anthropometric indicators and indices for assessing the physical development of female students of indigenous (Kazakh) (n=191) and alien (n=145) population of Slavic ethnicities in northern Kazakhstan are considered in terms of anthropometric research. In determining the physical development, anthropometric indices (body length and weight, chest circumference in pause) were used, which were obtained during examination of subjects using the unified method of V.V. Bunak. Additionally, the assessment was made of the harmony of physical development using computational methods: the Quetelet index, the Pignet index, the Livibody-weight index, the Manouvrier's index. These methods for assessing the physical development of the subjects are easy to use, do not require special centile tables, do not depend on gender, age, and height of the subjects, and are recommended for widespread use during screening examinations. Mathematical and statistical processing of the research results was performed in Microsoft Excel 2007 and Statistica v.6.0. Statistical analysis was performed based on the calculation of arithmetic means (M) and their errors ($\pm m$). The significance of differences in the studied parameters corresponding to the normal distribution was determined using the Student's t-test other than the normal distribution, the Mann-Whitney U-test. The results were considered statistically significant at $p \leq 0.05$. The obtained results indicate the completion of the ontogenetic development of the examined group of female students. The predominance of the mean values of the expression of quantitative anthropometric characteristics reflects the satisfactory aspects of the somatic health of the majority of the examined female students as part of their educational and professional activities.

Keywords: students, indigenous and alien populations, anthropometry, somatic health, health-saving education

INTRODUCTION

One of the most important strategic tasks of any state is to preserve and promote the health of young people as the potential of the nation.

Health is not just a desirable quality of a future specialist but also a necessary element of his or her personal structure, a necessary condition for highly effective training. In this regard, the use of

only medical methods to influence the preservation of the health of students is ineffective. The priority is the formation of a healthy lifestyle, conducting non-pharmacological disease prevention and correction of risk factors based on monitoring studies of students' health. A methodological approach is important to allow adequate analysis of various aspects of the health of participants in the educational process (Negasheva and Mishkova, 2005; Menshikh, 2013; Klimov et al., 2016).

The age of students in the aspect of the individual development of the organism coincides with the completion of the human biological development, and all the functional parameters reach their final values. In this regard, the level of development in this period can be a criterion of the effectiveness of the whole system of health-saving procedures that were carried out at the previous stages of individual development, and indicate further adjustments and work on youth health improvement (Kirsanov and Shibkova, 2012; Gerasevich et al., 2013).

It is known that the basis of the morphofunctional status of a person is formed depending on the specifics of hereditary traits, which have not been studied sufficiently so far. According to modern concepts, a significant part of the morphological and functional characteristics of the body is characterised by polygenicity and a multifactorial basis. The parameters of physical development, which reflect the specificity of the metabolic processes of the whole body, the enzymatic and hormonal status, etc., have a pronounced hereditary dependence.

Physical development, as a basic health indicator (Kazin, 2010), is determined by the influence of such factors as ecology, adequate and balanced nutrition, perinatal factors, climate, geographical conditions, physical activity, heredity. Natural and social factors are one of the main conditions that determine the level and shifts in the health status of the population and its individual age and sex, urban, rural groups, etc. (Latyshevskaja et al., 2003). It is known that the adverse effects of the negative factors of the natural and social environment on physical development can be manifested in a decrease in physical development indicators (Kajumov, 2000). Thus, physical development allows assessing the level of health, general morbidity, predicting the further development of the individual, performing rational planning of educational and training loads during physical education and sports.

The importance of studying the morphological,

physiological, and constitutional peculiarities of people belonging to different ethnic groups is due to the need to evaluate and develop criteria for the individual norm of morpho functional parameters taking into account ethnic characteristics (Budukool, 2007; Negasheva et al., 2007; Budukool and Aizman, 2009).

These prerequisites determined the purpose and direction of this study. The objective of this article is to study interethnic differences in the main anthropometric indicators and indices of the student-age population of the Kazakh and Slavic ethnicities in Northern Kazakhstan.

MATERIALS AND METHODS

The study was conducted on the basis of the research laboratory Adaptation of biological systems to natural and extreme environmental factors of the Chelyabinsk State Pedagogical University and the Natural and Mathematical Faculty of the Kostanay State Pedagogical Institute from 2009 to 2014.

The study included female students of full-time education of the 1st- 4th years of study of biology, chemistry, geography majors of 17 to 21 years of age. The sample size was 336 people.

The sampling was differentiated into two groups according to the criterion of ethnicity: the first group (group I) consisted of female students of Kazakh ethnicity of the indigenous population; the second group (group II) consisted of female students of Slavic ethnicities of the alien population (Table 1).

The study presents two major ethnic groups living in Kazakhstan: the indigenous Kazakh population and the alien Slavic population, who arrived on the border area as a result of historical processes: the Stolypin agrarian reform of Russia, the establishment of Soviet power, the development of virgin and fallow lands. Studies were conducted on a voluntary basis in the first half of the day with the exclusion of physical activity during the previous day and in accordance with the basic bioethical rules. All examinations were conducted in the period between the exams. The assessment of the main anthropometric indicators of physical development (body length and weight, chest circumference in the pause) was carried out according to the unified method of V.V. Bunak (Bunak, 1941) widely used in screening examinations.

Measurement of body length was performed using a stadiometer. The measurement accuracy was 0.5 cm.

Measurement of body weight was performed using medical scales with an accuracy of 0.05 kg.

Table 1; Distribution of examined female students by years of study and departments depending on ethnicity

	1 st year of study	2 nd year of study	3 rd year of study	4 th year of study	Total sampling
Indigenous female students (group I)	60	40	42	48	190
Alien female students (group II)	41	30	38	37	146

Measurement of the chest *circumference* was performed as follows: in a standing position, the hands are lowered, with maximum inhalation, full exhalation, and quiet breathing. A centimetre tape was applied horizontally, behind the corners of the shoulder blades, from the front of the girls at the point of transition of the chest into the mammary glands.

Measuring the muscular strength of the hand. The muscular strength of the leading hand (kg) was measured using a hand-held dynamometer (DRP-90). The subject five times squeezed the fingers of the right or left hand with a maximum force, with an interval of 1-2 minutes; each time the position of the arrow was recorded. The greatest deviation of the dynamometer arrow was considered an indicator of the maximum strength of the hand muscles. Measurement accuracy is 0.5 kg.

An index method was also used to assess physical development.

Based on the data obtained, a dynamometric index (DI) was calculated: $DI = (\text{Leading hand strength (kg)} \times \text{body weight (kg)}) / 100$,

To assess the harmony and proportionality of physical development, the Quetelet, Pignet, Livi and Manouvrier's indices were used.

According to the weight and length of the body, the *body-weight index* was calculated:

Body-weight index = body weight (g) / body length (cm). The index shows how many grams of body weight accounts for 1 cm of body length. Average values for women are 325–375 g/cm.

Body mass index = $(BW \text{ (kg)}) / BL \text{ (m}^2)$

Pignet index (PI) is an indicator of physique strength.

$PI = BL - (BW + CC)$, where BL is the body length (cm), BW is the body weight (kg), CC is the chest circumference in the expiratory phase (cm). PI less than 10 conventional units shows a strong physique; 10-20 is the good physique; 21-25 is

the average; 26-35 is weak; over 36 is the very weak physique. According to the method, three types of constitution are distinguished: asthenic (index is 20 or more), normosthenic (index from 10 to 20), hypersthenic (index below 10).

Erismann index (EI), which determines the proportionality of the constitution, was calculated by the formula:

$$EI = CC_p \text{ (cm)} - BL \text{ (cm)} / 2$$

For girls, the norm is from -1.5 to +2.4; the results below the norm mean narrow chest, more than the norm is a broad chest.

Livi Index (LI): $LI = \sqrt[3]{BW \text{ (kg)}} / BL \text{ (cm)}$

Manouvrier's Skelia Index (MSI) is an indicator of the proportionality of physical development:

$MSI = (\text{length of legs/sitting height}) \times 100$, the value of up to 84.9 indicates brachyskelia; 85-89 indicates mesoskelia, 90 and higher indicates macroskelia.

RESULTS AND DISCUSSION

To study the characteristics of the physical development of the surveyed population, an anthropometric study of Kazakh and Slavic female students was conducted, the results of which are summarised in Table 2. The results of the evaluation of the anthropometric indicators of girls' physical development showed that during four years of study in the university, the total body sizes do not change significantly, regardless of the ethnicity of female students, which may indicate the end of an ontogenetic maturity of bodies of examined. The values of the coefficients of variation of the main indicators of the physical development of female students are within acceptable limits (up to 20%), which indicates the relative homogeneity of the average group parameters of both groups. It should be noted that the most variable feature in the structure of physical development in the examined groups of female students is the body mass index (CV from 11.7% to 18.3%), which does not contradict the

fundamental aspects of human physical development.

The data presented in Table 1 shows that the absolute values of the average anthropometric indicators of the physical development of the examined girls of Kazakh ethnicity are significantly lower ($p \leq 0.05$) than the indicators of students of Slavic ethnicities that make up the alien population group. In the sample of third-year female students, there was a pronounced tendency towards intergroup differences.

Girls of Kazakh ethnicity had a low body weight in all years of study compared with girls of the alien population. The average group values of the 2nd and 4th years of study and the total sample of Kazakh girls have significantly smaller values.

An analysis of the values of the chest circumference showed smaller values of the parameter to be diagnosed in indigenous female students in comparison with girls of the alien population. Significantly lower values for Kazakhs are recorded for students of the 2nd year of study. In general, the revealed fact of statistically significantly smaller total body size of Kazakhs gives evidence to the genetic determinism of the manifestation of the constitutional features of people of Kazakh ethnicity due to ecological adaptation to the specific climatic conditions of the region. The results obtained are consistent with the works of other authors (Burhanov et al., 1991; Aizman and Chanchaeva, 2012).

The absolute values of these anthropometric indicators do not fully reflect the national differences in the morphological status of female students. Therefore, calculation indices were used for an additional assessment of physical development.

The indices of physical development are the ratios of individual anthropometric characteristics, which make it possible to use them for an indicative assessment of physical development in the course of mass examinations of the population, as well as for analysing the influence of various environmental factors on the body. A qualitative assessment of anthropometric indices was given based on the Quetelet, Pignet, Livi, Manouvrier and Erisman indices.

The results of the quantitative assessment of somatotypological features based on the method of the indices are presented in Table 3.

Analysis of the qualitative assessment of the anthropometric data of the examined female students (Figure 1) using the Livi index showed that the group of indigenous female students is dominated by people of normal physical

development (41%), the frequency distribution of students in this group with high and low indicator values has a similar intensity (about 30%). In the group of alien female students, the distribution of the indicator values shows the prevalence of the number of subjects with high physical development (38%), which is 10% higher than the similar results of indigenous students. The frequency of cases with low values in the group of female students of the alien population corresponds to the distribution of Kazakh students.

Further analysis of the qualitative assessment of the level of physical development was aimed at studying the distribution of female students in terms of the Quetelet body-weight index, which reflects the characteristics of nutritional status and is a preliminary diagnosis of obesity. The generalised results of the percentage distribution of the examined female students by the Quetelet index (Figure 2) showed that the values of the indigenous and alien female students were normal (80% and 73%, respectively).

The data of Figure 5 shows that the incidence of overweight in the group of alien female students is twice as high as in the group the Kazakh female students (13% and 6%, respectively), which is reflected in the prevalence of the number of students with a strong physical development according to the Livi index (Figure 1). The deficit of body weight was found in 13% of the examined students of both groups. In the examined groups, isolated cases with signs of obesity were noted. For those examined with signs of deviation from the norm, it is necessary to implement the health-saving principles of education, based on objective methods of assessing somatic health and correcting maladaptive states of the body of female students.

Analysis of the percentage distribution of the values of the Quetelet index (QI) by years of education depending on the ethnicity showed that the values of the Quetelet index tend to increase on all years of study among female students of the alien population. Indicators of the Quetelet index, regardless of ethnicity, were within the 'norm' in 40–57% of girls.

When analysing the individual indicators of the Quetelet index (Table 4), it was noted that in all groups, the largest percentage was made up of girls with a body mass corresponding to the 'norm', and there were more Kazakh students with well-balanced physical development than alien female students. In all years of study, hypotrophy ranging from 11 to 24% was noted among

students of the indigenous and alien populations and largely (13% more) it was a characteristic of the alien population.

Table 2-Anthropometric indicators of the physical development of students of the Kazakh and Slavic ethnicities, (M±m)

Group I					
Indicator	Year 1 (n=60)	Year 2 (n=40)	Year 3 (n=42)	Year 4 (n=49)	Total sampling (n=191)
Body length, cm	161.3±0.7*	161.6±0.8	161.7±1.2	160.5±0.8	161.2±0.4
Body weight, kg	54.7±0.9	54.5±1.0	54.7±1.4	56.7±1.5	55.2±0.6
CC, cm	83.0±0.5	83.3±0.5	84.2±0.9	84.2±0.9	83.6±0.4
Group II					
Indicator	(n=41)	(n=30)	(n=38)	(n=37)	(n=145)
Body length, cm	165.0±0.9	165.8±1.2	164.2±0.8	163.7±1.0	164.6±0.5
Body weight, kg	57.2±1.3	59.1±1.7	56.6±1.2	61.5±1.8	58.2±0.7
CC, cm	84.6±1.0	86.0±1.2	84.9±0.8	86.4±1.0	85.3±0.5

Note: * significant differences of indicators between the studied groups (at $p \leq 0.05$).

Table 3-Relative indicators of the physical development of KSPI female students, (M±m)

Indicator	Group I (n=191)	Group II (n=145)	p-level
Pignet Index, cu	23.4±0.9	20.2±1.6	0.057
Livi Index, cu	23.6±0.1	24.0±0.4	0.164
Quetelet Index, cu	21.2±0.2	23.3±1.2	0.061
Manouvrier index, cu.	85.2±0.7	89.6±1.3*	0.001
Erismann Index	3.0±0.4	3.1±0.5	0.890

Note: * significant differences of average group indicators (at $p \leq 0.05$).

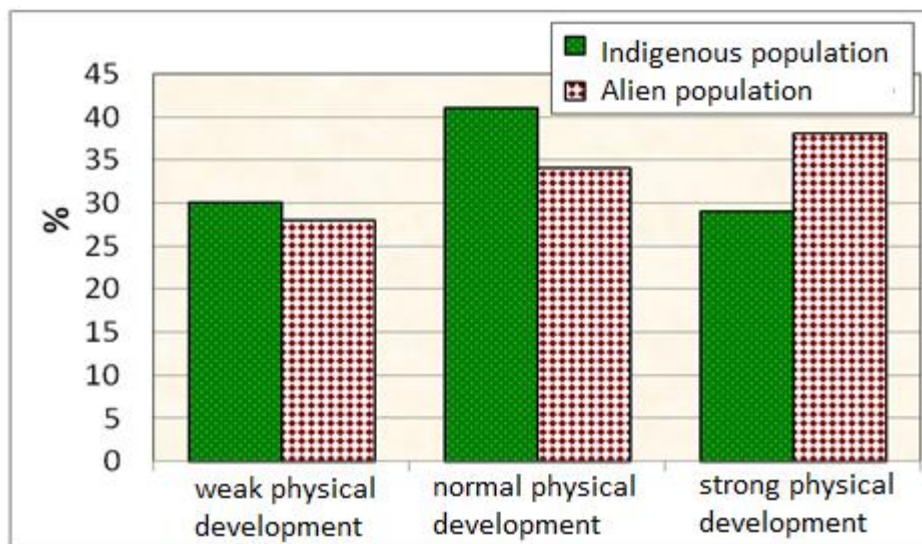


Figure. 1. Distribution of students of the indigenous and alien population by the level of physical development (Livi index)

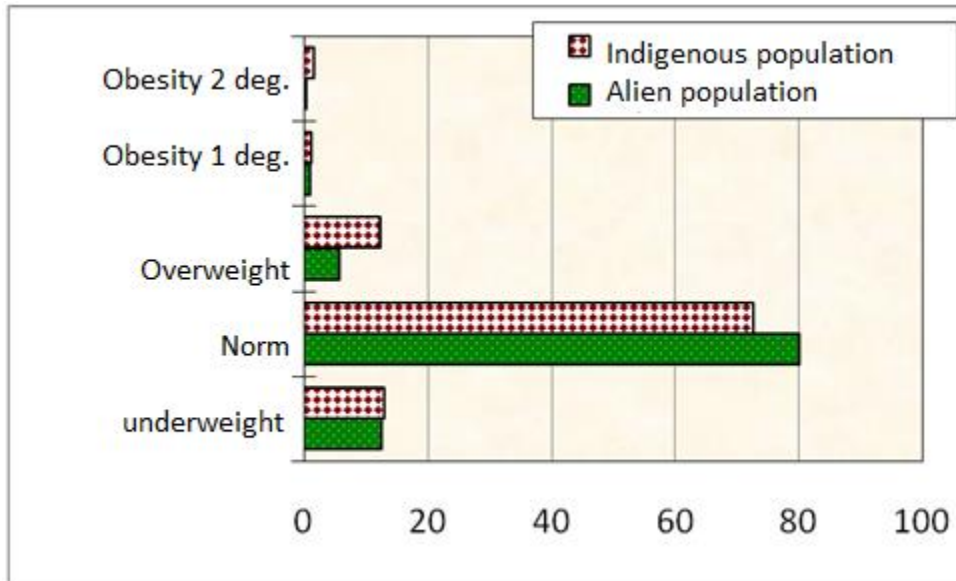


Figure. 2. Distribution of students of the indigenous and alien population by body mass index (BMI)

Table 4. Distribution of female students by Quetelet index, %

Group	Hypo troph.	Reduced nutrition.	Norm	Increased nutrition	Obesity 1 deg.	Obesity 2 deg.	Obesity 3 deg.
Year 1							
I	15	15	47	23	-	-	-
II	17	17	42	24	-	-	-
Year 2							
I	15	25	42.5	15	2.5	-	-
II	23	17	30	23	-	7	-
Year 3							
I	17	17	57	7	-	-	2
II	24	10	45	18	3	-	-
Year 4							
I	15	8	56	13	6	-	2
II	11	8	40	24	11	3	3

Table 5. Distribution of female students by Manouvrier's Skelia Index, %

Year	Group	Brachyskelia	Mesoskelia	Macroskelia
1	I	63.3	25.0	11.7
	II	22.0	43.9	34.1
2	I	60.0	27.5	12.5
	II	23.3	33.3	43.4
3	I	45.2	35.7	19.1
	II	23.7	50.0	26.3
4	I	39.6	35.4	25.0
	II	29.7	21.6	48.7

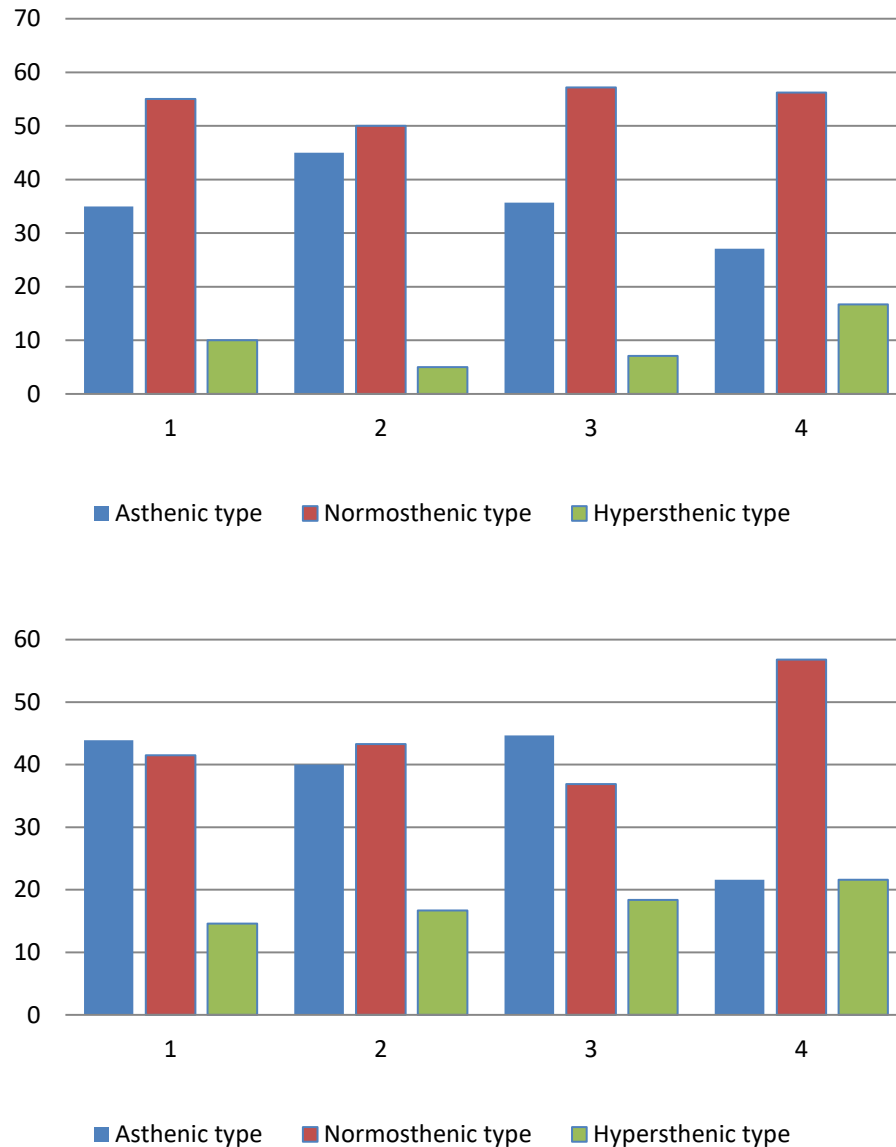


Figure 3. Distribution of female students of 1st-4th years of study of indigenous (A) and alien (B) population by type of physique

The least of female students with reduced nutritional status was observed in the 4th year of study in both groups of subjects (8%), and the most part of such students was noted in the 2nd year of study among the indigenous population; the rest varied from 10 to 17%. It should be noted that both students with a deficit of body weight and with increased nutritional status were observed in the group of female students of the alien population compared to female students of the indigenous population. In the first years of study, there were no female students with obesity

of various degrees. The obesity of the first degree was registered in 2.5% of the indigenous population, and the obesity of the second degree was registered in 7% of female students of the alien population in the second year of study. In the third year, 2% of female Kazakh students have the obesity of second degree; 3% of students of the alien population have the obesity of the first degree. A relatively larger percentage of obese girls of various degrees were observed among female students of the fourth year of study among the alien population: 11% with the obesity of

1st degree and 3% each for obesity of 2nd and 3rd degrees. These results can be explained by an unbalanced diet, low motor activity and, as a consequence, different levels of metabolic processes, as was shown previously (Litovchenko, 2009).

To determine the proportionality of the physique, we used the Manouvrier's Skelia Index, which allows calculating the ratio of the torso to the length of the legs and, accordingly, revealing the 'relative short-leggedness', 'average length of legs', 'relative long-leggedness'.

The data in Table 5 shows that the proportion of persons with brachyskelia in all years of study among Kazakh women is higher than that of alien female students.

Analysis of the percentage distribution of the Manouvrierskelia index among female students, depending on ethnicity, showed that Kazakh women are characterised by brachyskelia; among female students of the alien population, individuals with a proportional physique or with macroskelia dominated. The Pignet index was used to determine the type of physique, reflecting the constitutional features of female students. At present, many authors consider the constitution as the most fundamental and integral characteristic of the whole body. That is the reason why the concept of the constitution is the backbone of human science (Nikitjuk, 1991)

The constitution type is commonly understood as the unity of morphological and functional features, inherited and acquired, relatively stable in time, defining the characteristics of the body's reactivity and the profile of individual development (Nikitjuk, 1991).

The average group values for the Pignet index, depending on the year of study, showed that in both groups of ethnicities, the indicators corresponded to a normosthenic body type. No significant differences were found among the groups of different ethnicities.

The data shown in Figure 3 demonstrates the maximum number of persons with asthenic body type is noted in the second year of study among the indigenous students. The fewest people were with hypersthenic body type (from 5 to 16.7%). By the 4th year of study, a smooth increase in hypersthenics was observed.

In girls of the alien population, the distribution of persons with asthenic and normosthenic body types during the 1st–3rd years of study was practically at the same level, and at the 4th year, the number of people with normosthenic type prevailed. The least part of female students of the

alien population were girls with the hypersthenic type of physique, although when compared with Kazakh female students, the number of hypersthenic types was almost twice as high.

Thus, according to the Pignet index, no inter-ethnic differences of constitutional types have been identified.

The feature of proportionality of the body structure was estimated by the Erisman index. Comparison of the average group indicators by the Erisman index in the total sample of female students, depending on ethnicity, did not reveal any significant differences. Both national groups were characterised by a predominantly broad chest.

An analysis of the individual characteristics of the proportionality of the body structure showed that in all the studied groups the largest (42.1–54.1%) percentage of girls was characterised by 'broad chest'. The share of persons with 'narrow chest' in the groups examined was about a quarter of the female students, with the number of persons with a narrow chest among the female students of the alien population higher than in the group of Kazakh female students (Table 6).

Thus, according to the Erisman index, the girls of national groups did not differ significantly in their body types. Most girls, regardless of their ethnicity, were characterised by a 'broad chest'.

The functional state of the muscular system was assessed according to the strength of the hand muscles. The parameters of hand dynamometry reflect the degree of development of neuromotor functions, the musculoskeletal system, and the static resistance of an individual (Budukool, 2007).

Analysis of hand dynamometry indicators showed that indigenous students of the first and second years of study have significantly low indices of right-hand muscle strength; the left-hand muscle strength among the female students of the third year of study is less than that of girls of the alien population (Table 7).

The average group values of the muscle strength of the hands in groups of both ethnicities corresponded to the physiological norm characteristic of this age.

Indicators of hand muscle strength are higher in all years of study among female students of the alien population compared with student of the indigenous population, although female students of the first and the second years of study had significantly higher indicators of right-hand strength, while left-hand strength indicators were higher for female students of the third year.

Table 6. Distribution of female students by Erisman index, %

Group	Narrow chest	Norm	Broad chest
Year 1			
I	23.3	25.0	51.7
II	31.7	24.3	44.0
Year 2			
I	22.5	42.5	35.0
II	26.7	26.7	46.6
Year 3			
I	28.6	28.6	42.8
II	23.7	34.2	42.1
Year 4			
I	16.7	29.2	54.1
II	21.6	24.3	54.1

Table 7. Indicators of hand muscle strength and wrist index of female students, (M±m)

Years	Right-hand muscle strength	Left-hand muscle strength	Right-hand dynamometric index	Left-hand dynamometric index
Group I				
1	29.2±0.7*	28.5±0.6	53.5±1.2	52.2±1.2
2	28.0±0.6**	27.9±0.6	52.7±1.4	52.3±1.5
3	27.9±0.9	26.3±0.98	52.1±1.5	49.3±1.8
4	28.8±0.9	27.9±0.8	51.5±1.8	49.9±1.7
Group II				
1	31.9±0.9	30.4±0.9	56.6±1.7	53.6±1.5
2	31.6±1.1	30.1±1.0	54.2±1.8	52.1±2.0
3	29.8±1.0	29.0±0.9	52.8±1.6	51.6±1.7
4	31.1±0.8	30.1±0.9	52.0±1.9	50.4±2.1

Note: * p≤0.01 significance of differences between groups of ethnicities,
 ** p≤0.002, ■ p≤0.05

The average values of the right-hand muscle strength were greater than the values of the left-hand muscle strength, regardless of the year of study or ethnicity.

In order to obtain a full picture of functional differences, along with absolute values, relative calculated indicators (wrist index) were used (Table 7).

Calculated indicators reflecting the ratio of the hand strength to body mass did not reveal significant differences between the ethnicities. The average group values of the wrist index in both groups (52.51 ± 10.15; 53.97 ± 10.68) are rated as 'satisfactory'.

According to R.I. Aizman (2012), the interethnic differences in the morphofunctional parameters of groups of people living in the same ecological zone provide an opportunity to estimate the genotypic traits. The identified manifestations of the genotypic trait in female students of Slavic ethnicity are manifested mainly in terms of body length (Aizman and Chanchaeva, 2012). Our data are consistent with the data of a number of

authors (Burhanov et al., 1991; Dakenova, 1999; Dzhardemov, 2007; Berdygaliev, 2009), which shows that female students of alien populations, regardless of age and gender, surpass their peers of the indigenous population in basic physical development indicators.

In the racial classification system, the Kazakhs, like the Tuvinians, Altaians, Buryats, belong to the Mongoloids. They are characterised by certain features in the body structure, in particular, short stature, short legs (Batocyprenova, 2006; Gundjegmaa, 2009). Low anthropometric indices in combination with a broad chest indicate ethnic characteristics determined by genetic factors and the influence of the external environment that form a certain adaptive type (Budukool, 2011)

CONCLUSION

After analysing the relative anthropometric characteristics of female students of the alien population of Slavic ethnicities, it was found that the average group indicators of surveyed

quantitative anthropometric characteristics are in the range of normal values and do not have significant differences. The exception is the average proportionality ratio of the Kazakh women's constitution (Manouvrier index), which reflects significantly lower average group values of this indicator in comparison with female students of the alien population and represents the prevalence of people with brachyskelia (relatively short legs) in this group.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study. All authors read and approved the final version.

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