PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

The functional state of students depending on the ethno-territorial factor

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Abstract

Background and Study Aim Integration processes in education provide for increased mobility of students from different countries. The related change in environmental parameters, cultural and social standards require additional tension in the work of regulatory mechanisms. This can lead to exhaustion of the body's reserve capabilities, disruption of adaptation and loss of health. The purpose of the work is to investigate the ethno-territorial variability of the functional state and adaptation potential of foreign students studying at Ukrainian universities.

Material and Methods Students of the medical university (n = 488, age 18–25) who came to study in Ukraine from different countries took part in the study. Data were obtained from cross-sectional surveys from 2014 to 2019. Anthropometric measures included body length (LT), body mass (MT). Functional status was assessed by Robinson, Rufier, vital capacity and strength indices. Adaptation capabilities and the level of physical condition of students were also determined. Experimental data were processed using the SPSS program.

Results It was established that the vast majority of students had Robinson index values: low and below average (students from Poland, Bulgaria, Jordan, Egypt); below average level (students from Ukraine, Malaysia and Tunisia); medium (students from India and China). Students from Poland, Jordan and Egypt are characterized by the lowest vital capacity index (52.7 – 54.9 $ml \cdot kg^{-1}$). Among the residents of India and China there were the most students with above average and high levels of vital capacity index. Most of the students (with the exception of students from Malaysia and Egypt) had a power index at the level of average and above average. The Ruffier index for students was: weak level – students from Poland, Bulgaria, Egypt and Jordan; satisfactory level – students of Tunisia, Ukraine, India and Malaysia; moderate level – students from China. The majority (40–44%) of the examined contingent from Poland, Bulgaria and Jordan was in a pre-diagnostic state. There were14–27% of such students among students from Egypt, China, India and Tunisia. There were about 10% of such students among Ukrainian students. From 6% to 11% of all foreign students were in a pre-morbid state. This condition is characterized by a decrease in the functional reserves of the circulatory system. Among Ukrainian students, there were 2.04% of such students. From 2.44% to 7.69% of foreign students had asthenization of regulatory systems; such a state was not observed among Ukrainian students.

Conclusions The obtained results of the study expand the data on the peculiarities of the physiological state of students of foreign countries and their adaptation capabilities. It is important that students with strained adaptation mechanisms or an unsatisfactory level of adaptation are able to reveal high functional capabilities with individualized physical exercises. An unsatisfactory state of functional systems can stimulate students to increase the body's adaptive resources. This contributes to increasing the level of motor activity and improving physical education courses with training according to an individualized educational program.

Keywords: adaptation potential, ethnic group, population, functional state.

Introduction

Integration processes in education provide for increased mobility of students from different countries. This approach should help improve the employment system of university graduates and raise the status of these countries in the field of education [1, 2, 3]. It is known that the place of residence is closely related to the state of the

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environment. Characteristics of the environment significantly affect the type and dynamics of functional development of human vegetative organs. The current stage of the development of world society is characterized by tendencies towards the deterioration of physiological and psychofunctional characteristics in young people. This leads to an increase in dissatisfaction with the quality of life [4, 5, 6]. The educational process is accompanied by hypodynamia, educational and emotional stress, and informational stress. All these factors contribute to the emergence and development of various diseases in young people [4, 7, 8, 9, 10]. It is also known that complex determinants of the environment place increased demands on the adaptive capabilities of the human body [11].

Currently, it has been established the relationships between: environmental parameters and the state of human health [12, 13, 14, 15]; geographical latitude of residence and morbidity of the population [16, 17, 18]. Such relationships are due to the fact that any adaptation process requires homeostatic restructuring of the human body. This becomes possible as a result of additional stress in the work of regulatory mechanisms and can lead to exhaustion of the body's reserve capabilities, disruption of adaptation and loss of health [11, 14, 19, 20]. When living in the territory with a changed photoperiod, a change in daily and seasonal rhythms of physiological processes, deterioration of sleep quality was noted [21, 22, 23, 24].

It is typical for foreign students to move for study from one climatic zone to another. Therefore, adaptation to the educational process is combined with adaptation to new climate-geographical conditions. All this creates prerequisites for the emergence or exacerbation of various diseases [25, 26, 27] and disruption of the adaptation process [19, 20, 28, 29, 30, 31]. At the same time, changes on the part of the lungs to the greatest extent reflect the dynamics of adaptive changes in the body as a whole [32]. In this context, many studies [33, 34, 35] note that men are the most vulnerable. They are more prone to "restrictive emotionality" and tolerate chronic stress worse. Adaptation to the environment in men takes place in the energy-consuming way of ensuring homeostatic functions. Central nervous system occurs due to increased activity of the sympathetic division of the autonomic nervous system.

Thus, when studying at a university outside the territory of residence, the combined influence of natural factors and intensive educational activities puts additional demands on the life support systems of students. In turn, this leads to the tension of adaptation mechanisms, which is reflected in the change of objective and subjective indicators of the functioning of body systems [36, 37, 38].

The purpose of the work is to investigate the ethno-territorial variability of the functional state and adaptation potential of students studying at Ukrainian universities.

Materials and Methods

Participants

Students (n = 488, age - 18–25 years; only male) from 9 countries of the world participated in the study (Table 1). All students agreed to participate in the experiment. The research protocol was approved by the Biomedical Ethics Commission of Ivano-Frankivsk National Medical University (Ukraine, protocols No. 85177 dated 10.24.2014, No. 89198 dated 10.22.2015, No. 92850 dated November 23, 2016, No. 96311 dated October 24, 2017 and No. 112/19 dated 12.24.2019).

Table 1. Distribution of study participants

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

Research Design

Data were obtained from cross-sectional studies from 2014 to 2019 on the basis of Ivano-Frankivsk National Medical University (Ukraine). Somatometric physical development indicators were studied on the basis of body height (BH), body weight (BW). The functional state was estimated by using Robinson's index [39, 40], which indicates myocardial coronary reserve, vital capacity index (VCI), which reflects respiratory system reserves and strength indexes (SI). The Ruffier Test was carried out to measure the aerobic resistance to short-term effort and the cardiac recovery capacity, and therefore the level of physical fitness in students [41, 42]. Maximum hand grip strength was measured using a digital Takei Hand Grip Dynamometer (range 5–100 kg, precision of 100 g), through two attempts per every hand. Blood pressure (BP, mmHg) was measured by a mechanical tonometer Microlife BP AG 1–30, heart rate (HR) – using a Polar 800 RS heart rate monitor. The spirometry test is performed using spirometer in standing position (precision of 100 ml). After 2-3 measurements with 15-20 s pauses the highest result was fixed.

Physiological indicators were calculated by formulas [43]:

$$\text{Robinson index } IR = (HR_{rest} \cdot SBP)/\ 100,$$

where, HR_{rest} – resting heart rate (beats·min^{-1}); SBP – systolic blood pressure (mmHg);

$$\text{vital capacity index } VCI = [VC(ml)]/[BM(kg)],$$

where, VC – vital capacity (ml); BM – body mass (kg);

$$\text{strength index } SI = [\text{handgrip dynamometry}(kg) \cdot 100\%)]/[BM(kg)];$$

Baevsky adaptive capacity was also determined [39, 44*]*:

$$AD_B = 0.011 \cdot HR_{rest} + 0.014 \cdot SBP + 0.008 \cdot DBP + 0.014 \cdot age + 0.009 \cdot BM - 0.009 \cdot BH - 0.273,$$

where, DBP – diastolic blood pressure (mmHg); BH – body height (cm).

Level of physical condition (PCL, units) follows the formula [45]:

$$PCL = [700 - 3 \cdot HR_{rest} - 2.5\ ABP - 2.7 \cdot age + 0.28 \cdot BM]/[\ 350 + 21 \cdot BH - 2.6 \cdot age],$$

where, ABP – average of SBP and DBP.

Expert evaluation of all indices was carried out by comparing the obtained result with standard values.

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 ($\bar{x}$), standard deviation (SD), standard error (SE) and variation coefficient were determined. Determining the statistical significance of obtained research results required Student's *t*-test and Chi-squared test (χ^2-test). Statistical significance was set at $p \leqslant .05$.

Results

The results of the research are given in table 2. Functional reserves of the respiratory system (average value of VCI) are the lowest in students of the Asian continent (3600±500) ml. Representatives of Europe (3900 ± 600) ml and the African continent (4100 ± 500) ml are characterized by statistically significantly higher VCI values. Among the representatives of student youth of European countries (Poland, Bulgaria, Ukraine), Bulgarian students had statistically significantly higher VCI values ($t = 4.69–3.18$, $p < .05$). Among representatives of student youth from Asian countries (Malaysia, India, China, Jordan), representatives of Jordan differed statistically significantly in terms of the value of this indicator ($t = 2.98–8.59$, $p < .05$). There was no statistically significant difference in VCI values between students from African countries.

Indicators of hand dynamometry also show statistically significant differences in average values among students of Asian countries ($t = 5.87–13.60$, $p < .05$), with the exception of representatives of Jordan (tab. 2). It should be noted statistically significant differences in hand dynamometry indicators for right and left hands: in European students, it was on average 8.5–15.5%; among students of Asian countries (with the exception of representatives of China, 5.0%) – 13.7–21.5%; among students from

Table 2. Physiometric indicators of students, $\bar{x}$ (SD)

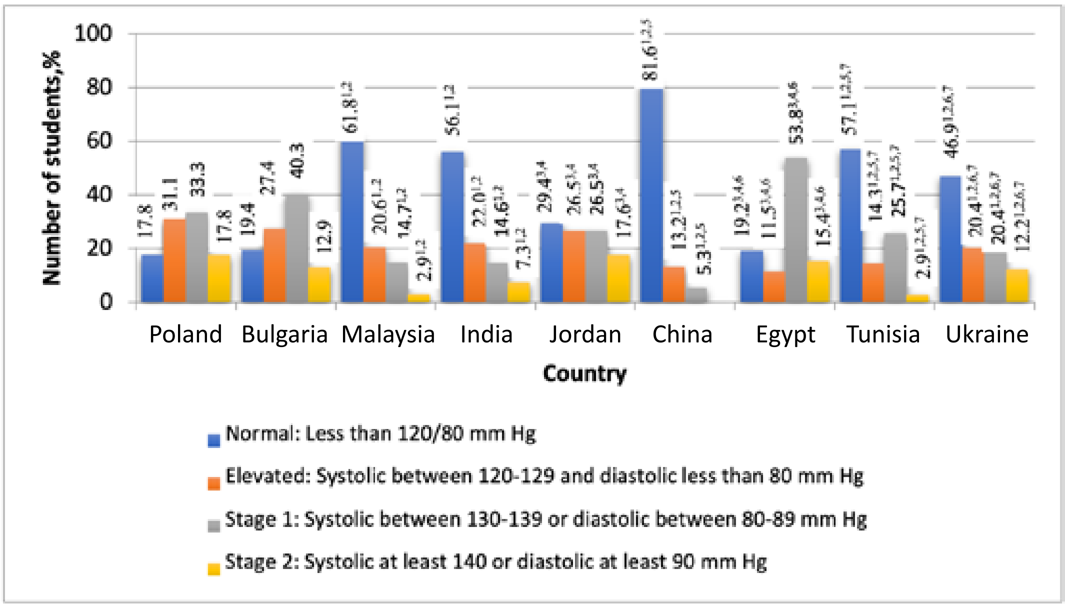
Indicators	Country								
	Poland	Bulgaria	Malaysia	India	Jordan	China	Egypt	Tunisia	Ukraine
VCI (l)	3.7(0.5)	4.2(0.6)^{1}	3.2(0.5)^{12}	3.7(0.6)^{23}	4.0(0.3)^{1234}	3.5(0.4)^{1235}	4.1(0.3)^{1346}	4.0(0.6)^{1346}	3.8(0.7)^{2367}
Right handgrip dynamometry (kg)	35.5(4.0)	38.8(5.6)^{1}	27.0(2.9)^{12}	29.8(4.0)^{123}	37.2(4.6)^{134}	30.1(4.1)^{1235}	36.7(4.7)^{346}	35.8(3.8)^{2346}	35.5(5.2)^{2346}
Left handgrip dynamometry (kg)	31.4(3.8)	35.5(4.8)^{1}	21.2(3.0)^{12}	25.6(4.6)^{123}	32.1(4.0)^{234}	28.6(4.2)^{12345}	29.9(4.5)^{2345}	29.2(4.1)^{12345}	30.0(4.3)^{2345}
HR_{rest} (beats·min^{-1})	79.7(5.2)	80.1(4.1)	72.6(9.1)^{12}	70.4(11.5)^{12}	78.7(9.1)^{34}	66.0(4.3)^{12345}	72.8(18.4)	70.6(7.2)^{1256}	75.4(5.2)^{124568}
SBP (mm Hg)	130.2(18.1)	130.5(15.6)	122.5(12.4)^{12}	120.8(14.4)^{12}	128.9(22.1)^{4}	119.8(21.8)^{125}	132.4(18.3)^{346}	124.6(16.5)	126.2(15.1)
DBP (mm Hg)	82.4(12.2)	82.6(10.6)	70.6(6.5)^{12}	75.8(8.2)^{123}	78.4(10.6)^{23}	70.8(5.2)^{1245}	74.8(6.6)^{1236}	72.2(5.8)^{1245}	79.1(9.6)^{3678}
Ruffier test HR_2 (beats·min^{-1})	40.5(4.1)	38.5(5.0)^{1}	31.1(3.2)^{12}	30.2(3.0)^{12}	36.8(7.5)^{134}	30.0(2.5)^{125}	39.5(3.4)^{3456}	34.3(8.0)^{123467}	33.0(5.5)^{124567}
Ruffier test HR_3 (beats·min^{-1})	30.6(4.0)	29.6(4.8)^{1}	20.5(2.8)^{12}	24.4(3.2)^{123}	30.8(6.7)^{34}	20.5(2.8)^{1245}	30.2(4.1)^{1346}	22.4(6.4)^{12357}	20.1(5.2)^{12357}

Note: HRrest (beats·min-1) – heart rate at rest; Ruffier test HR2 – second pulse measurement; Ruffier test HR3 – third pulse measurement; statistically significant difference ($p < .05$) between data of students from (shown in the form of upper index): 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; 8 – Tunisia and others (based on t-test)

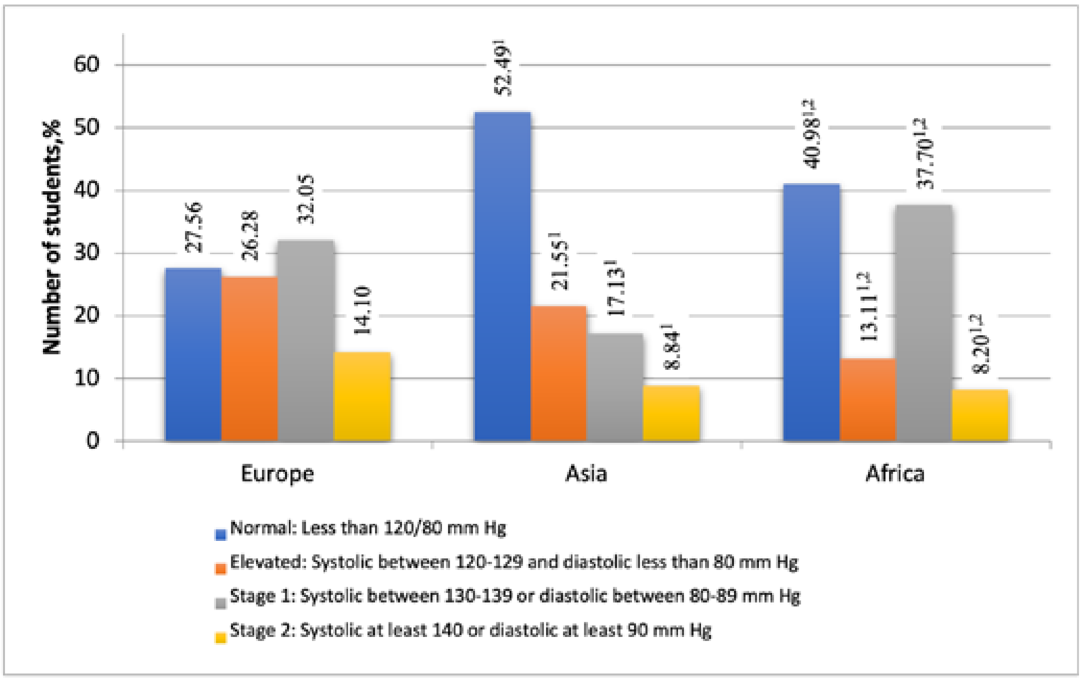
Egypt and Tunisia – 18.5%.

In addition, we determined such parameters as heart rate (HR_{rest}), arterial blood pressure (SBP and DBP) (Table 2). As can be seen from the given data (Table 2), the average heart rate at rest for representatives of European countries is (78.4 ± 4.8) beats·min^{-1}, for students from Asian and African countries, the value of (HR_{rest}) is slightly lower - (71.8 ± 5.8) beats·min^{-1}. The average arterial systolic pressure in students of European and African countries does not differ reliably and is (129.0 ± 16.3) mm Hg and (128.5 ± 17.4) mmHg, respectively. Representatives of Asian countries have significantly lower values of systolic pressure - (123.0 ± 14.7) mmHg. A similar pattern is observed for diastolic pressure values. Moreover, the largest difference between systolic and diastolic pressure (55 mmHg) is typical for representatives of Egypt and Tunisia.

In students of most countries, with the exception of Malaysia, India, China, blood pressure values exceed the generally accepted norm (fig. 1). It should be noted that from 40% to 54% of foreign students have the first and second stage of hypertension.



a)



b)

Figure 1. Frequency distribution of students by Blood pressure level (mm Hg): a) differences between representatives (shown in the form of upper index): 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 ($p < .05$) (based on χ^2-test); b) (shown in the form of a superscript): 1 – differences between representatives of the countries of Asia and Africa and Europe; 2 – differences between representatives of Asian and African countries ($p < .05$) (based on χ^2-test)

Among Ukrainian students, the percentage of such is 32.6%.

The indicators of the Robinson index (criterion of the reserve and economy of the functions of the cardiovascular system) are presented in table 3. As can be seen from table 3, the Robinson index was very weak for students from Poland, Bulgaria, Jordan and Egypt. Among the representatives of these countries, 73 to 93.5% of students had low and below average levels of Robinson index (Fig. 2). Students from Ukraine, Malaysia, and Tunisia had below Robinson index, while those from India and China had an average (fig. 2).

The distribution of students by VCI level is shown in Figure 3. The lowest VCI indicators (below the average) are characterized by students from Poland, Jordan and Egypt (52.7 – 54.9 ml·kg^{-1}).

Students from Malaysia (44.1%), Bulgaria (45.2%), China (57.9%), Ukraine (61.2%), Tunisia (62.9%) and India (64.3%) had VCI values that corresponded to average and above average levels (fig. 3). It should be noted that among the representatives of India and China there were the most students from above average (14.6% and 18.4% respectively) and high (9.8% and 13.2% respectively) levels.

As for the strength index, the majority of students (with the exception of students from Malaysia and Egypt) had values corresponding to the average and above average levels (Fig. 4). 58.8% of students from Malaysia and 65.4% of students from Egypt had strength index values that corresponded to low and below average levels.

As for the Ruffier index (characterizing the body's performance), for students from the following countries it was the following: Poland – 16.4 units (95% CI 15.32–17.48); Bulgaria – 15.3 units (95%

Table 3. Indicators of express assessment of students' somatic health,

Country	Indicators					
	Robinson index (c.u. units)	**Vital capacity index (ml·kg^{-1})**	**Strength index (%)**	**Ruffier test (units)**	**Baevsky adaptive capacity (units)**	**Level of physical condition (units)**
Poland	103.8(12.5)	52.7(5.6)	50.6(6.0)	16.4(3.6)	2.48(.32)	0.243(0.051)
Bulgaria	104.5(11.8)	55.9(6.0)[1]	51.7(5.4)	15.3(4.0)[1]	2.52(.21)	0.241(0.032)
Ukraine	95.1(18.2)[12]	59.7(4.1)[12]	55.8(5.0)[12]	8.9(2.9)[12]	2.02(.32)[12]	0.275(0.026)[2]
Malaysia	88.9(16.5)[12]	55.7(4.8)[13]	47.0(5.5)[123]	7.9(2.5)[12]	2.29(.25)[123]	0.319(0.045)[123]
India	85.0(17.1)[123]	70.9(5.1)[1234]	57.1(6.4)[124]	8.9(1.9)[12]	2.23(.41)[123]	0.319(0.031)[123]
China	79.1(16.9)[1234]	67.2(4.0)[12345]	57.8(7.2)[124]	6.8(1.4)[1235]	2.07(.38)[124]	0.377(0.047)[12345]
Jordan	101.4(22.4)[456]	54.7(3.8)[13456]	50.9(6.5)[3456]	14.9(4.2)[13456]	2.48(.50)[3456]	0.262(0.042)[456]
Egypt	96.4(17.5)[256]	54.9(4.9)[356]	49.1(6.1)[356]	15.2(4.8)[3456]	2.47(.47)[356]	0.292(0.031)[126]
Tunisia	87.9(18.0)[1267]	64.7(8.1)[1234578]	57.9(5.9)[12478]	9.7(3.5)[124678]	2.19(.46)[1278]	0.316(0.080)[12367]

Note: differences between representatives (shown in the form of upper index): 1 – Poland and others; 2 – Bulgaria and others; 3 – Ukraine and others; 4 – Malaysia and others; 5 – India and others; 6 – China and others; 7 – Jordan and others; 8 – Egypt and others ($p < .05$) (based on -test)

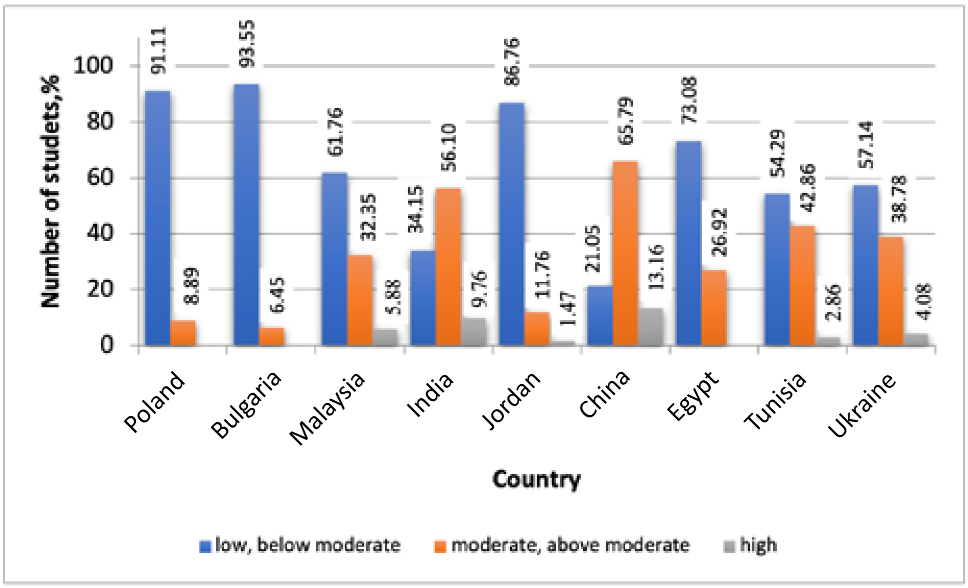


Figure 2. Distribution of students by Robinson index level (units)

CI 14.28–16.32); Egypt – 15.2 units (95% CI 13.26–17.14); Jordan – 14.9 units (95% CI 13.88–15.92). This corresponds to the weak (moderate heart failure) level (Fig. 5). For students from Tunisia, Ukraine, India, and Malaysia, the value of the Ruffier index was, respectively: 9.7 units (95% CI 8.50–10.90), 8.9 units (95% CI 8.07–9.73), 8.9 units (95% CI 8.30–9.50), 7.9 units (95% CI 7.03–8.77). This corresponds to the satisfactory level. For students from China, the value of the Ruffier index was 6.8 units (95% CI 6.34–7.26), which corresponds to the moderate level.

Only for representatives of Ukraine and China Baevsky adaptive capacity values corresponded

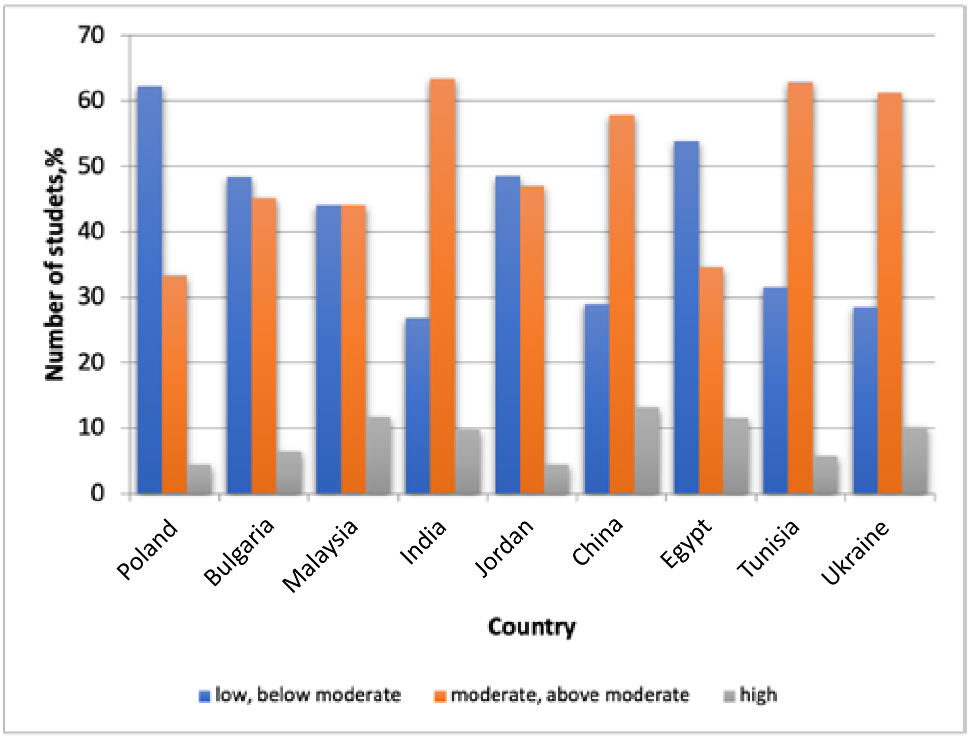


Figure 3. Distribution of students by Vital capacity index level (units)

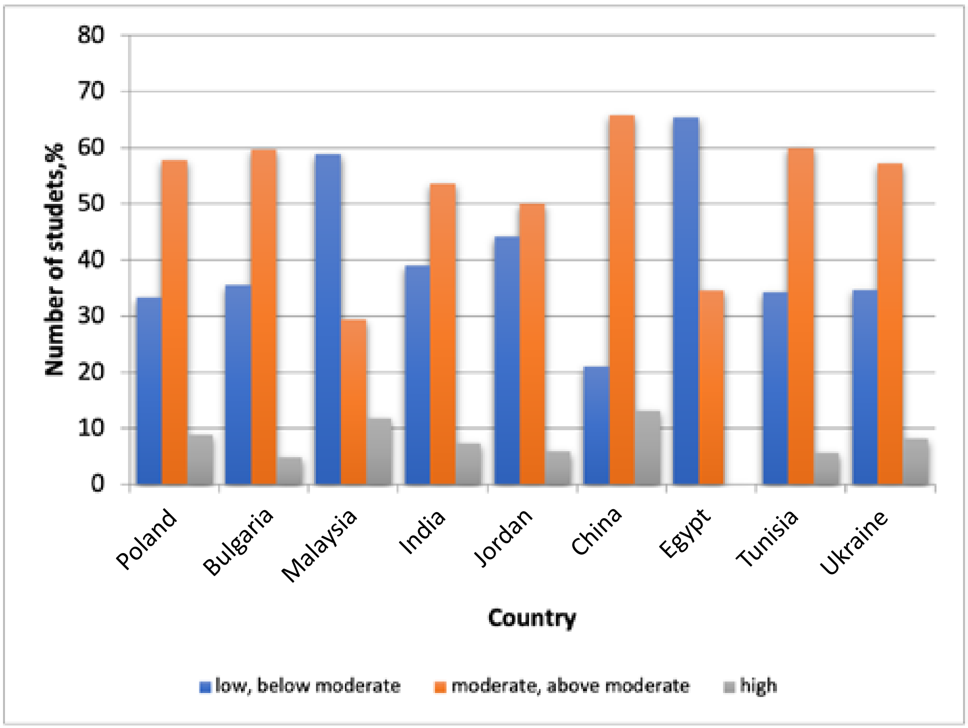


Figure 4. Distribution of students by handgrip strength index level (%)

to satisfactory adaptation, and the cardiovascular system of students of other countries was characterized by the tension of adaptation mechanisms (Fig. 6).

The majority (40–44%) of the examined contingent from Poland, Bulgaria, and Jordan was in a pre-diagnostic state (fig. 6). Among students from Egypt, China, India and Tunisia, the share of such was 14–27%. There were about 10% of such students among Ukrainian students. From 6% to 11% of all foreign students were in a premorbid state characterized by a decrease in the functional reserves of the circulatory system. Among Ukrainian students, the share of such was 2.04%. From 2.44% to 7.69% of foreign students had asthenization of regulatory systems (disruption of adaptation processes, inability of the body to maintain balance with the environment). Such a situation was not observed among Ukrainian students.

The research results obtained by us in the majority

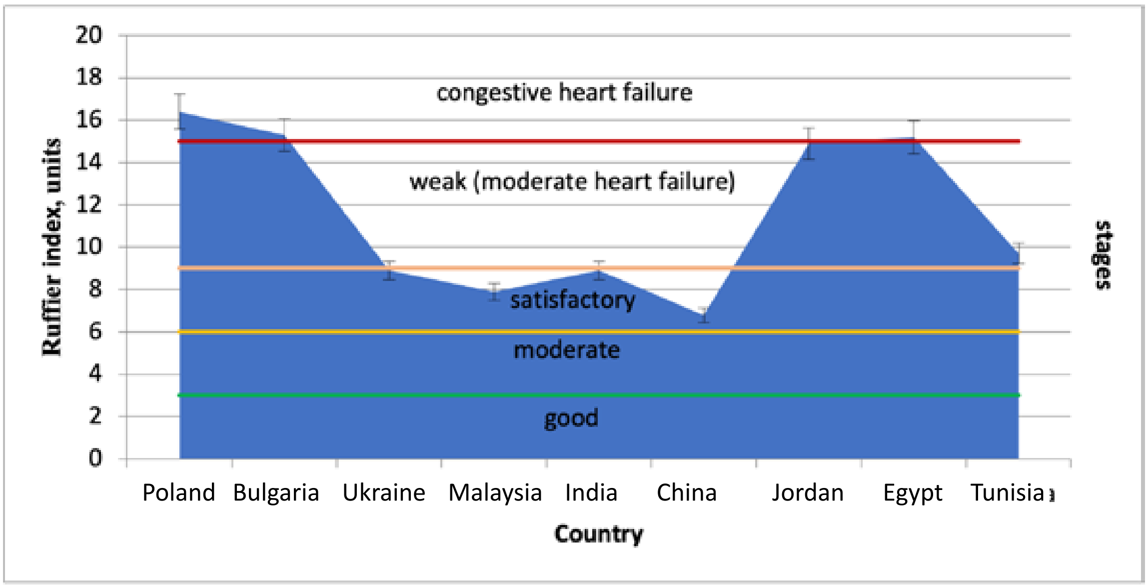


Figure 5. Value of Ruffier index for students

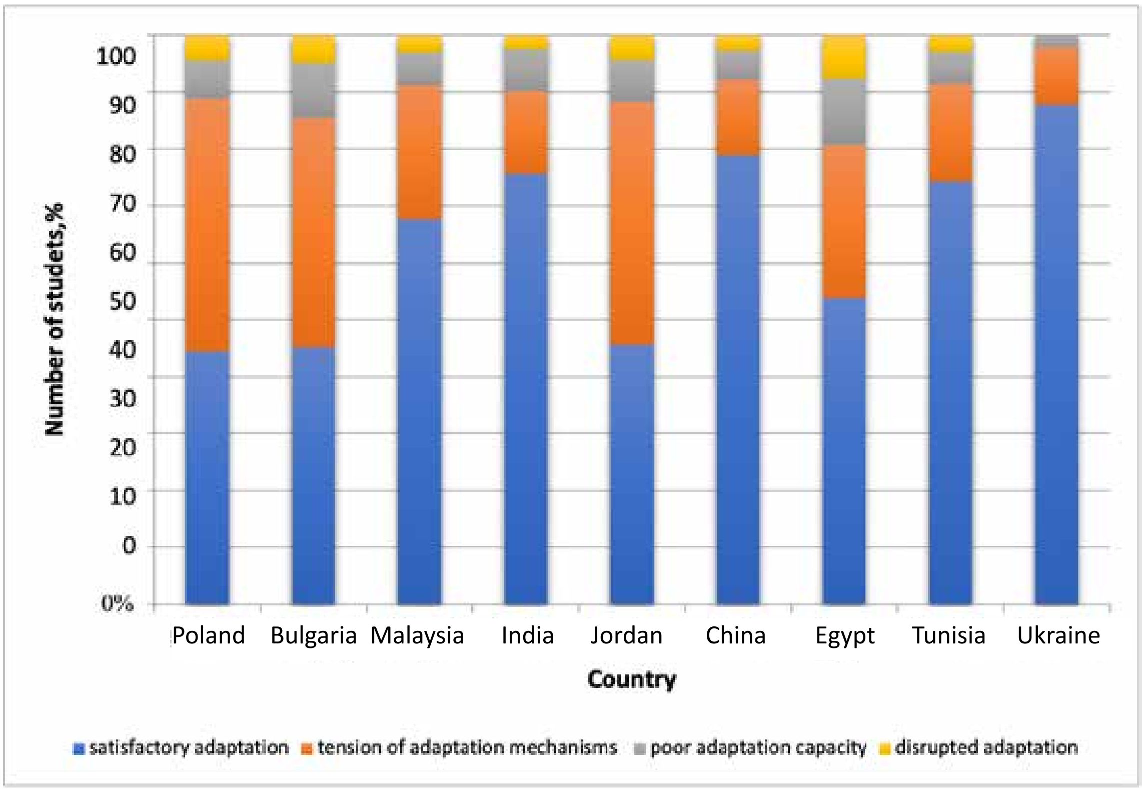


Figure 6. Distribution of students according to Baevsky adaptive capacity values

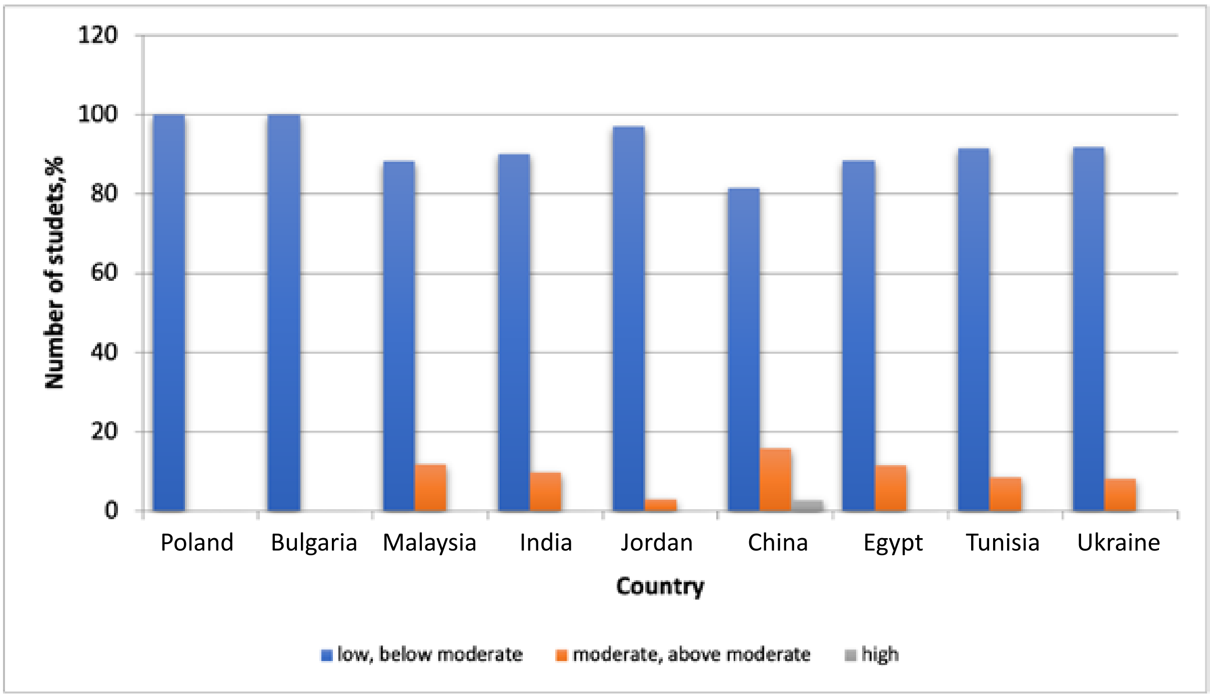


Figure 7. Distribution of students by Level of physical condition (PCL, units)

of students (81–100%) were below physiological norms, as evidenced by the integrative indicator of the level of physical condition (PCL, units) (fig. 7).

Students from China were characterized by the best PCL indicators: among them, 15.79% had an average and above average level, and 2.63% had a high level (fig. 7). From 8 to 12% of students from Ukraine, Tunisia, Egypt, India, Jordan and Malaysia had an average and above average level of physical condition, and 100% of students from Poland and Bulgaria - only low and below average.

Discussion

The current state of health of the global population is characterized by an increase in morbidity [46]. It can be stated that the priority direction of work for institutions of a medical profile and for institutions of physical education is the formation of special programs. These programs should be aimed at preventing various diseases and improving the general health of students. This is especially relevant for young people, who in the near future will form the basis of the working population of the planet [7, 8, 9, 46].

Physiometric indicators of students aged 18-25 years of different ethnic groups differ significantly among themselves, as well as within ethnic groups. In our opinion, this reflects the diversity of demographic, socio-economic, behavioral, cultural and other characteristics between ethnic groups.

Thus, a number of researchers pointed out significant differences in the capabilities of the respiratory system. Based on the results of research by Donnelly et al. [47] the mean total lung capacity and vital capacity in the Caucasian group were 5–10% higher than in the Chinese group and 17–20% higher than in the Indian group and Chinese values were 10–12% greater than Indian. They noted that chest circumferences, height and race explained 90% of the variation in forced vital capacity and 86% of the variation in total lung capacity.

Bhakta et al. [48] found highest values of FVC **(**Forced vital capacity, or the full amount of air that can be exhaled with effort in a complete breath**)** and FEV_1 (Forced expiratory volume in one second, or the volume of breath exhaled with effort in one second) in EAs, intermediate values in Asians, and lowest values in blacks for the same height, age, and sex. The same results were obtained by Korotzer et al. [49] among 65,000 subjects (82% whites, 14% blacks, and 4% Asians), especially, they found FVC and FEV_1 to be highest in EAs and lowest in blacks.

Quanjer et al. [50] noted that Caucasians have had the largest lung size for equivalent height and age, compared with African and Asian populations. For example, African American and Southeast Asian populations have forced expiratory volume in 1 s (FEV_1) that is approximately 13% less than Causasian [50, 51]. Similar, though generally slightly smaller, reductions (~11%) have been observed among South Asian (Indian subcontinent) [52, 53] and Southeast Asian (e.g., China, Thailand, Malaysia) subjects [54]. Since these 'ethnic' reductions in FEV_1 and FVC are proportional, the FEV_1/FVC ratio, which is the most commonly used outcome to assess airways obstruction, is independent of ethnic background [55].

Braun et al. in reviews [56, 57] grouped all explanations of this fact into seven categories: 1) inherent differences between racial/ethnic groups; 2) anthropometric differences; 3) environmental and social factors; 4) mechanical factors; 5) technical factors; 6) other; 7) no explanation. Mostly ethnic differences in lung function have been well reported between blacks of African and whites of European descent and it has been explained by anthropometric differences between these ethnic groups, particularly by larger trunk-to-leg ratio at a given height [58, 59, 60]. Few authors [61, 62, 63] were investigated ethnic differences in lung function taking into account anthropometric, socioeconomic and psychosocial factors and made a conclusion that differences in the length of upper body segment explained more of the ethnic differences in lung function than height. Social correlates had a smaller but significant impact too. This is also agreed with results obtaining in our research [64, 65].

According to our data, the blood pressure values of students in most countries (with the exception of Malaysia, India, China) exceed the generally accepted norm. This confirms the fact that over the last decade, an increase in blood pressure and HR_{rest} values has been established in the global population [66, 67, 68, 69].

An evaluation of children aged 8–17 years found that systolic blood pressure was 2.9 mmHg and 1.6 mmHg higher in black boys and girls compared to age-matched white boys and girls [70]. Also, estimates based on the Demographic and Health Surveys (DHS) Program (2016) show that South Africans (who identify as colored) are approximately 1.67 times more likely to have hypertension than those who identify as black/African [71].

Lane et al. [72] was to examine the prevalence of hypertension and mean blood pressures among Afro-Caribbeans (16%) and South-Asians (8%) in England compared with Caucasians (76%). The authors shown that the prevalence of hypertension was greater in both Afro-Caribbean men (31%) compared with Caucasians (19%), while South-Asian men had a similar overall prevalence to Caucasians (16%).

According to the data obtained by Hardy et al. [73] among US adults mean SBP was 4.1 and 3.8 mmHg higher among non-Hispanic Black compared with non-Hispanic White adults, in 1999 to 2002 and 2015 to 2018, respectively. Modesti et al. [74] found that Sub-Saharan Africans had higher BP values than Europeans men for both SBP (3.38 mmHg) and DBP (3.29 mmHg). On the contrary, South Asians had SBP values lower than Europeans (-4.57 mmHg). They also tended to have lower, albeit not significantly, DBP values (-0.56 mmHg). This is consistent with our data. In our study, students from Poland, Bulgaria and Ukraine had 7.67 mmHg higher SBP values and 7.64 mmHg higher DBP values than representatives of Asian countries. Mostly of scientists postulated that the risk of hypertension increased with BMI and waist circumference [74, 75]. It is interesting that the authors also conducted a study of the dependence of blood pressure on religious preferences. The authors note that participants from Muslim countries showed significantly lower BP values than EU for both SBP (-9.22 mmHg) and DBP (-3.23 mmHg). Differences between Muslim and non-Muslim participants were significant for both SBP and DBP ($p < .001$ for all comparisons) regardless of gender. But these data deny the results we obtained. From our point of view, it can be explained by the fact that the adaptation to the educational process of students from the countries of Asia, Africa, the Near and Middle East is combined with adaptation to new climate-geographic and social conditions. This leads to a significant tension of the body's physiological systems, and sometimes to their breakdown and deviations in the state of health.

Seitova et al. [76] received analogical to our research data. She investigated of 350 participants aged until 25 years old and adapted within 1 year to the study at medical faculties of Osh State University and divided them into 4 groups. The groups were randomized by gender, age, time and examination conditions, and lifestyle of all students in the medical faculties of Osh State University. Comparative functional studies of male and female students the main and control groups revealed higher systolic and diastolic blood pressure and heart rates in students from India in all seasons. Similar changes in autonomic functions in the form of increased blood pressure and heart rate were noted in first year students who came from humid and sub-tropical countries [77]. Foreign students have less functional reserves, which is leads to more frequent development of maladaptive reactions, as well as more frequent detection of acute respiratory and intestinal infections in their first year. This was confirmed in the values of the Robinson index (criterion of reserve and economy of functions of cardiovascular systems) obtained by us for students of Poland, Bulgaria, Jordan and Egypt. Unexpectedly, the Robinson index values of students from China, India and Tunisia were approximately the same as those of Ukrainian students. Although more pronounced climate-geographical differences are observed. From the obtained values of the physical condition level indicator, it follows that only for representatives of China they are at a below average level. For the population of other countries, this indicator corresponds mostly to a low level. This confirms the assumption of global health problems that exist in modern society [8, 9, 78, 79, 80, 81, 82].

Psychoemotional stress in foreign students precedes physiological adaptation disorders in their systems and organs. As it was established in our study, the majority of foreign students from Poland, Bulgaria, Jordan and Egypt were in prenosological, pre-morbid states and state of astenization of regulatory systems. Among students from China, India, Tunisia and Malaysia, the share of such students was 20–30%. The presence of these conditions at rest indicates an inadequate response of the body to environmental factors. The presence of constant stress leads to the accelerated use of vital resources and the occurrence of diseases. Such reactions of the organism for a long time can lead to the disruption of adaptation and nosological symptoms and to the formation of new levels of adaptation of the organism to the changing conditions of the external environment [11, 83].

On the opinion of a lot of researchers there still is an additional reserve for adaptation process acceleration, which lies in the field of physical activity [84, 85, 86, 87, 88, 89]. Authors note that physical activity is a powerful tool of recovery from mental and physical health problems, which, as is already known today, is helpful in coping with problems of adaptation to new living conditions and educational activities [90, 91, 92]. Physical activity indirectly influences adaptation performance via stress reduction, lowering anxiety and depression, and boosting self-esteem [93, 94, 95]. Regular physical exercise also reduces a risk of the appearance and progression of various illnesses [88, 89, 96, 97].

Another scientists concluded that the adaptation of different races to varied environments provides them with a number of physical and psychological advantages and disadvantages in relation to each other in various sports. Differing levels of racial accomplishment in sports requiring different physical and psychological abilities reflect these adaptations [98, 99].

Conclusions

The obtained results of the study broaden the data about peculiarities of foreign students' physiological state and their adaptation capabilities. To our mind, what are important, students with tensed adaptation mechanisms or its unsatisfactory level are able to reveal high functional capabilities under individualized physical activity. The obtained results regarding the own state of functional systems can stimulate students to increase the adaptive resources of their own body through motor activity on the one hand, and help to improve physical education courses with individualized education program training on the other hand.

Further work is required to determine the peculiarities of fitness 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.

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