

Using anthropometric testing of students to assess their physical health status

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Abstract:

To preempt the emergence of adverse deviations in an individual's physical well-being, vigilant monitoring of indicators reflecting the presence or absence of health deterioration risk is essential. One effective method for early detection of health status is the quantitative assessment of the body mass index (BMI). The research objective is to scrutinize and assess the utility of the body mass index method in identifying the risk of physical health disorders among students. **Materials and methods.** The study encompassed 249 students from the first, second, and third years, aged 19.2 ± 1.4 years. Gender distribution was as follows: 116 male students and 133 female students. For monitoring, anthropometric data were used - body length and weight, and the body mass index was calculated and assessed in accordance with the gradation recommended by the World Health Organization. The due body mass was calculated and assessed with actual weight, taking into account age and gender. Conventional statistical methods were used. The normality of the distribution of characteristics was assessed using the Shapiro-Wilk test; to determine the statistical significance of differences in indicators, the parametric Student's t-test was used. We proposed cluster analysis to distribute subjects into groups. **Results.** Statistically significant differences in the height and weight indicators of boys and girls were established. BMI values were near the upper limit of the normative range, which indicates excessive fat mass. There was an increase in the actual values of body weight in both groups of subjects compared to the proper value of this indicator. This allows such students to be classified as a risk group for the content of excess adipose tissue. Using cluster analysis, three groups of subjects were identified. The first group included students with excess body weight. The second group, where the value of this indicator is at the upper limit of the standard, and the third group includes students with a BMI value within the normal range. The number of boys who were found to be overweight was greater than in a similar group of girls. Most girls had an optimal BMI value. **Conclusions.** A promising direction of research is to determine the characteristics of height and mass indicators in students differentiated into medical groups. This will allow assessing the state of physical health to personalize physical education, sports and independent physical activity.

Key Words: anthropometry, body mass index, physical health, physical education

Introduction

Currently in various countries there is a negative vector of increase in the number of people diagnosed with pathologies in the state of physical health (Junger et al., 2019; Zhang et al., 2019; Zurita-Ortega et al., 2019; Chekhovska et al., 2019). Such disorders are often associated with deviations in physical development and the appearance of excess body fat or obesity in the body. A higher than normal level of adipose tissue in the body is a trigger for the development of type II diabetes, severe disorders of the cardiovascular and musculoskeletal systems, and other pathologies of non-infectious origin (Ullrich et al., 2018; Wedell-Neergaard et al., 2018; Badau et al., 2021; Kolokoltsev et al., 2023). Metabolic disorders in the body are particularly detrimental in adolescence, which affects a significant number of students. Loss of body weight against the background of negative factors caused by intense psycho-emotional stress and digitalisation of education in institutions (Tabacco, 2018; Doménech-Asensi et al., 2018) worsens the health of young people. The emergence of bad habits (Pengpid et al., 2019) and low physical activity (Syamsudin et al., 2021; Mazin et al., 2021) play a

negative role. The number of students with certain health conditions can reach half of the student population (Hollis et al., 2017).

According to the recommendations of the World Health Organization, the main directions for the prevention and normalisation of body weight disorders are the correction of food consumption, high aerobic or resistance physical activity and the prevention of stressful situations. This is particularly important for students to keep up with (WHO. Report of a WHO consultation. Obesity: Preventing and responding to the global epidemic, 2000). In order to prevent the occurrence and development of negative conditions in the body of young people, their prevention should be carried out using effective and simple non-invasive indicators. The interpretation of their parameters characterises the presence or absence of a risk of a decrease in the level of physical health (Bocharin et al., 2023).

In the studies conducted by Wu et al. (2019), strong correlations have been established in individuals with excess body weight and their blood pressure values above the age norm. At the same time, this tendency is minimized provided that body weight is maintained within standard values in accordance with body length and age. The scientific literature provides materials on assessing the level of suboptimal health and its relationship with body mass index (Kolokoltsev et al., 2021). The authors established a relationship between the level of suboptimal health and obesity and excess body mass in comparison with students who had optimal body weight.

The level of physical development of a person is the main component that determines the level of physical and mental performance as one of the main indicators of somatic health. It should be noted that the body of young people studying at the university is affected by many stress factors of the educational environment, which stimulate reserve capabilities and, thus, increase the reserve capabilities and adaptive processes of the body. However, if the potential of adaptive reserves does not correspond to stress factors, maladaptation of the body occurs. This can change the state of energy and metabolic processes (Bocharin, Guryanov et al., 2023).

Early predictors indicating a possible failure of adaptation processes include changes in anthropometric indicators (body length and weight). They are the main criteria for the state of a person's physical development. In the first half of the 19th century, the body mass index or Quetelet II index was developed (Dupuy et al., 2018; Syamsudin et al., 2021). This indicator allows the researcher to quantitatively assess the level of physical development and, in turn, the state of metabolic processes in the body. To do this, it is necessary to determine the ratio of length and body weight in the appropriate units of measurement of these indicators. The quantitative value of the body mass index (BMI) can be considered as chronic energy deficiency, normal body weight, overweight and varying degrees of obesity.

Thus, the topic of the above studies is relevant in the student environment, where there is a significant number of students with a violation of the ratio of length and body weight, which leads to disruption of energy and plastic processes. This necessitates a comprehensive study of the health status of young people in education. Moreover, during testing, one of the first indicators used is the Quetelet II index, which is advisable to use in conjunction with other indicators characterizing the state of adaptation reserves. The appearance of deviations in body mass index in the corresponding age group is one of the factors for optimizing physical activity.

In recent years, there has been an increasing interest among scientists and specialists in the field of physical culture and sports research using quantitative index assessment (Tyatenkova et al., 2020; Mazin et al., 2021). This is due to the simplicity and relative reliability of the study, the possibility of using this method for mass examinations of a large number of people. Despite the data available in the scientific literature, the issues of using the index assessment method as an indicator of the risk of the physical health of students remain poorly studied. We believe that studying this issue can help specialists in drawing up individualized health programs aimed at correcting excess body weight or obesity. The research aim is to analyze and evaluate the use of the body weight index method to identify the risk of physical health disorders in students.

Material & methods

The research work involved 249 students aged 19.2 ± 1.4 years (116 boys and 133 girls) 1-3 years of study at the Medical University of Nizhny Novgorod (Russia). The study fully complied with the requirements of the 2008 Declaration of Helsinki. All subjects signed informed voluntary consent and could refuse to continue participating in the survey at any time. Anthropometric measurements were carried out in the morning, on an empty stomach, in a quiet and comfortable room with an air temperature of 22-24 degrees Celsius and a relative humidity of 45-55%. Body length and weight were used as anthropometric data. For the above research project, we used floor-mounted electronic medical scales with an integrated stadiometer and body length measurement function VMEN-200-50/100-D1-A (Tambov, Russia). Body mass index (BMI) or Quetelet II index was calculated as the quotient of body weight in kilograms and body length squared in meters. The relationship between length and body weight was assessed using the generally accepted gradation of BMI indicators in accordance with the recommendations of the World Health Organization in 1991 (Memorandum of the meeting convened by USAID, WHO, PAHO and Mother Care Organization, "Mother Care"). We described the characteristics of the body weight status from a BMI value of ≤ 15.99 as a severe underweight to a BMI value of ≥ 40 as a state of III degree obesity.

Calculation of the proper body weight of students was carried out taking into account their age and gender using the Lorenz formula:

For boys - $P = 50 + (L - 150) * 0.72 + ((W - 21) / 4)$

For girls $P = 50 + (L - 150) * 0.36 + ((W - 21) / 5)$

Note: P – proper body weight, L – body length (cm), W – age (years)

The value of the arithmetic mean (M) and its standard error (m) were found. Cluster analysis was carried out in gender groups. For this purpose, the indicators were standardized for the best interpretation of the results obtained. To determine the number of clusters, a hierarchical clustering method was used. Cluster analysis using the K-mean method to distribute students into groups in accordance with their somatometric data was used. In order to identify differences or similarity of features in multidimensional space, the Euclidean distance between the centroids of clusters was determined. The normality of the distribution of indicators was determined using the Shapiro-Wilk test. For independent samples, the statistical significance of differences in mean values was assessed using Student's t-test. Differences between indicators were considered statistically significant at $p < 0.05$. Digital data processing was carried out using a package of licensed computer programs Excel 2016 and Statistica 10.1.

Results

Analysis of the values of anthropometric indicators of students revealed gender differences between them. It has been established that the values of length and body weight of boys exceed by 8.2 and 20.6%, respectively, those of girls, Table 1.

Table 1. Values of length, body weight and BMI of students by gender

Parameter/Gender	Boys	Girls
Body length	182.6±5.2	168.3±7.6*
Body weight	77.1±9.7	61.4±10.4*
BMI	23.3±3.6	21.6±4.1

Note: * - differences in the indicator between boys and girls are statistically significant, $p < 0.05$

We found no statistically significant differences in BMI between boys and girls. In boys, this indicator was determined to be 23.3 ± 3.6 kg/m², in girls it was 7.3% less and amounted to 21.6 ± 4.1 kg/m² ($p = 0.071$). In accordance with the generally accepted scale of BMI values, the value of this indicator in young men approaches the upper limit of standard values (18.5-24.99 kg/m²).

To additionally check the factor in the approximation of BMI values to excess body weight, the due body weight was calculated, which was compared with the actual weight of the subjects, Figure 1.

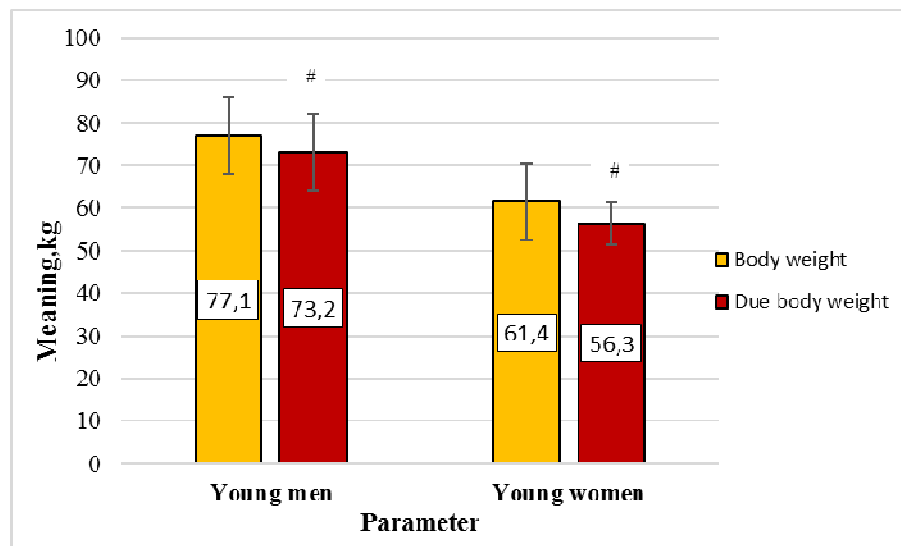


Fig. 1. Value of indicators of due and actual body weight in boys and girls

Note. No - significance of the difference at the trend level, $p=0.057$

A comparative analysis of the due level of body weight to its actual value showed that the weight of the subjects exceeded its due level. Statistically significant differences in both groups were determined at the trend level ($p=0.057$). Among boys, there was an excess of actual weight indicators over the proper values by 5.1%,

among girls by 6.7%. In the next step, a hierarchical clustering method was used to determine the number of clusters in the observed groups. To do this, dendrograms were constructed, on which the association distances were recorded and the number of groups of subjects was determined according to the studied indicators, Figure 2.

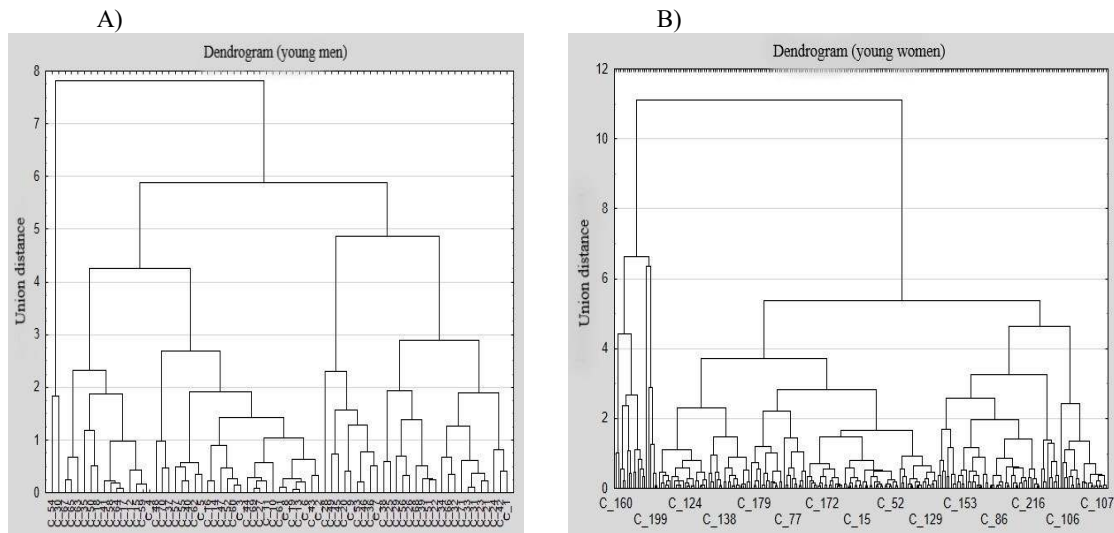


Fig. 2. Dendrogram of the number of clusters among boys (A) and girls (B)

It has been established that a group of boys can be divided into 3 groups (combination distance – 6.0 and 7.1 conventional units), the same number of groups can be established for girls (combination distance – 6.2 and 5.9 conventional units). After establishing the number of association groups, a cluster analysis was performed using the K-mean method to differentiate students into groups that made it possible to comprehensively determine the number of students with optimal anthropometric data, insufficient or overweight and obesity.

To do this, we determined the average values of length, body weight and BMI in each cluster and the Euclidean distance between centroids, Table 2.

Table 2. Average value of anthropometric indicators of students in clusters and Euclidean distance between clusters, $M \pm m$

Parameter	Average parameter values in each cluster					
	Boys			Girls		
	1 cluster (n=41)	2 cluster (n=36)	3 cluster (n=39)	1 cluster (n=31)	2 cluster (n=48)	3 cluster (n=54)
Body length	0.58±0.25	-0.92±0.21*	0.45±0.06*#	0.15±0.29	-0.88±0.31*	0.71±0.16*#
Body weight	0.91±0.21	-0.06±0.35*	-0.89±0.16*#	1.48±0.38	-0.59±0.28*	-0.15±0.11*#
Body mass index	0.76±0.13	0.28±0.11*	-1.23±0.14*#	1.51±0.49	-0.25±0.13*	-0.44±0.26*#

Note: * - $p < 0.05$ in relation to the values of indicators of cluster 1; # - $p < 0.05$ in relation to the values of indicators of cluster 2

Number of cluster	Cluster number Euclidean distance between different clusters					
	Boys			Girls		
	1 cluster	2 cluster	3 cluster	1 cluster	2 cluster	3 cluster
1	0.00	1.15	2.46	0.00	3.27	2.34
2	1.09	0.00	1.33	1.82	0.00	0.89
3	1.58	1.22	0.00	1.63	0.91	0.00

During cluster analysis, it was found that students ($n=72$) included in the first cluster can be classified as overweight (pre-obese, with a body mass index of 25.00 -29.99 kg/m²). Students assigned to the second cluster ($n=84$) belong to the group with indicator values at the upper limit of the normative range, where the BMI value approaches 25.00 kg/m². In the third cluster ($n=93$) there are students whose body mass index is within the

standard range – 18.5 -24.99 kg/m². It should be noted that among the boys in the first group there are significantly more students compared to the number of girls. This may allow us to update further research to identify factors contributing to this quantitative distribution of boys and girls.

The average values for each cluster are presented in Figure 3.

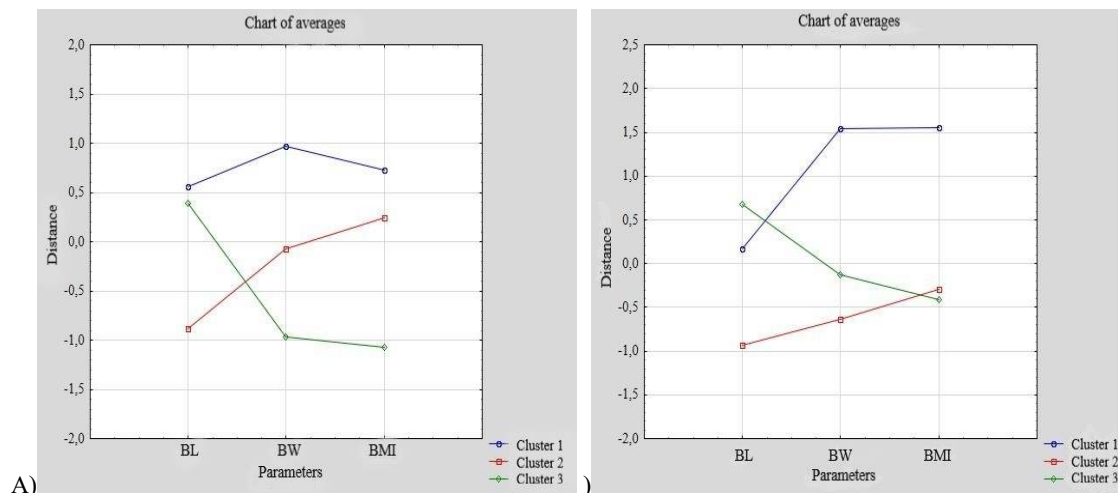


Fig. 3. Values of indicators of each cluster among boys (A) and girls (B)

The study made it possible to initially assess the risk of decline in the physical health of university students. These data must be taken into account when drawing up physical education and health programs for aerobic or strength motor activity to correct excess body fat.

Dicussion

The deterioration of physical health indicators in modern youth has been noted by many researchers (Junger et al., 2019; Zhang et al., 2019; Zurita-Ortega et al., 2019; Chekhovska et al., 2019). Therefore, there is still a relevance of scientific development of issues related to early diagnosis, correction and prevention of deviations in the health status of young people.

An important role is given to research that is aimed at studying the use of simple and accessible methods for early diagnosis of deviations in the physical health of students. In the last decade, index methods for assessing the physical development of youth have again become widely used for these purposes (Tyatenkova et al., 2020; Mazin et al., 2021). Human growth processes are actively influenced by multifaceted factors of the external and internal environment. We can highlight the presence or absence of bad habits that were acquired before or after the period of growth of the body, a genetic predisposition to high or low growth rates, as well as various psychological factors that influence the psychophysiological balance. Length and weight indicators can also be influenced by the characteristics, frequency and optimality of nutrition, general health and physical activity.

In our opinion, one of the indicators of metabolic processes in the human body is the excess of actual body weight over the due body weight, which indicates the influence of various negative factors on the values of the above parameters. These negative factors include an irrational balance between work and rest, lack of a proper diet, an adequate level of physical activity, and the emergence of bad habits. This is consistent with other researchers (Pengpid et al., 2019; Syamsudin et al., 2021; Mazin et al., 2021). A decrease in the level of adaptive reserves of the body towards maladaptation necessitates the use of physical education and health activities to prevent the negative impact of various stress factors (Bocharin et al., 2023).

Taking into account the data obtained, it becomes relevant to conduct dynamic monitoring to identify factors that influence the homeostasis of the body. The main indicators that allow us to estimate the ratio of a person's weight-height parameters are length, body weight and BMI (Dupuy et al., 2018; Syamsudin et al., 2021), which can be calculated both using generally accepted formulas and using non-invasive hardware-software complex, which allows it to be registered with a high degree of accuracy of the results obtained (Grevtseva, 2019). This characteristic of body weight is primary in assessing the risk of decline in health during periodic monitoring.

It has been established that in modern educational conditions, the health status of students, which is exposed to various factors of the educational environment, comes to the fore (Tabacco, 2018; Doménech-Asensi et al., 2018; Sokolovskaya et al., 2022). It is impossible not to note the significant physical and mental stress on students under conditions of physical inactivity. Complaints from students in the form of depressive and anxiety disorders, prolonged exposure to constant stress have an impact on the shift in body weight towards increase.

We agree with the authors (Machado, Soares, 2022; Zhang et al., 2019) that the problem of excess body fat mass and obesity among the population, including among students, is a significant issue in the healthcare system.

In the course of our research project, we analyzed the characteristics of body length and weight of a large group of students of various courses of study, differentiated by gender. Statistically significant differences in the levels of body length and weight in the groups of boys and girls were established. However, there were no statistically significant differences between them in BMI. When calculating the due body weight, it was found that its value turned out to be less than the actual weight indicators in both groups of subjects. This indicates the negative impact of environmental factors on the physical health of students. The distribution of groups of subjects using cluster analysis made it possible to note a larger number of male students who had a body weight above the norm or that this indicator was at the upper limit of the standard compared to the groups of girls. In our opinion, such students should be classified as at risk for excess body fat. For such students, personalized development of physical education curricula is necessary, which will allow them to get the maximum effect from physical activity classes.

Conclusions

Body mass index values are observed in boys and girls near the upper limit of the normative range. There is an increase in the actual values of body weight in both gender groups of subjects, compared to the due value of this indicator. This allows such students to be classified as at risk of developing excess fat mass or obesity.

Using cluster analysis, three groups of subjects were identified in the cohort of boys and girls, distinguished by the presence of excess body weight, the location of this parameter at the upper limit of the standard and its value within the normal range. The value of body mass index can serve as an informative preliminary indicator of the state of physical health of student youth.

It was found that the number of boys with an increased body mass index is greater than in a similar group of girls, who more often had an optimal ratio of body length and weight. In the course of further research, a promising direction may be to determine the characteristics of height and weight indicators in students differentiated into medical groups for physical education and sports. Assessing risk factors for deterioration in health can be valuable information for assessing factors for deterioration in health and personalizing physical activity in a student environment.

Conflicts of interest. The authors declare no conflict of interest.

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