

COMPREHENSIVE ASSESSMENT OF THE BIOLOGICAL AGE OF YOUNG ADULTS BASED ON ANTHROPOMETRIC AND HEMODYNAMIC PARAMETERS

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Abstract. According to international studies, the prevalence of metabolic syndrome (MetS) ranges from 20% to 40% among the adult population, with an increasing trend observed among young people. The aim of this study was to assess the prognostic significance of anthropometric parameters (body mass index [BMI] and body roundness index [BRI]) and hemodynamic parameters (blood pressure) in determining biological age in young adults. The study included 382 medical university students aged 18–24 years. A comprehensive set of clinical, hygienic, and statistical methods was employed, including anthropometric assessment, evaluation of hemodynamic parameters, questionnaire-based assessment, and calculation of biological age. Overweight was identified in 28.2% of the students, obesity in 9.8%, and abdominal obesity in 31.4%. Elevated blood pressure was recorded in 15.3% of participants. Biological age was found to increase significantly with increasing BMI and BRI ($p < 0.001$). The strongest association was observed between BRI and biological age ($r = 0.61$), indicating the important role of visceral adiposity.

Keywords: abdominal adiposity, body mass index, body roundness index, anthropometry, biological age, prediction.

Relevance. According to international studies, the prevalence of metabolic syndrome (MetS) ranges from 20% to 40% among the adult population, with an increasing trend observed among young people.

In Uzbekistan, an increase in the prevalence of obesity and metabolic disorders has been observed: approximately 27.4% of young people are overweight, while among medical university students this figure reaches 28.2%. Of particular concern is the increasing prevalence of abdominal obesity and elevated blood pressure among young adults.

Although the traditional body mass index (BMI) is widely used, it has certain limitations, as it does not reflect the distribution of adipose tissue. Therefore, in recent years, the body roundness index (BRI) has been actively studied as a parameter that more accurately reflects visceral adiposity and has considerable predictive value for metabolic disorders. Biological age is regarded

as an integral indicator of the functional state of the body and the rate of aging, allowing early signs of physiological deterioration to be identified.

The aim of the study was to assess the prognostic significance of anthropometric parameters (BMI and BRI) and hemodynamic parameters (blood pressure) in determining biological age in young adults.

Materials and Methods. The study included 382 medical university students aged 18–24 years. The study was conducted at the Department of Modeling of Hygienic and Medical Processes of Central Asian Medical University during the period from 2023 to 2025.

A comprehensive set of clinical, hygienic, and statistical methods was used, including anthropometric assessment, evaluation of hemodynamic parameters, questionnaire-based assessment, and calculation of biological age.

Anthropometric assessment was performed according to standard procedures using standardized equipment. Body weight was measured to the nearest 0.1 kg, and height to the nearest 0.5 cm. Based on these measurements, body mass index (BMI) was calculated as body weight (kg) divided by height squared (m^2). Abdominal obesity was assessed using the body roundness index (BRI), calculated based on waist circumference and height.

Hemodynamic parameters were assessed by measuring blood pressure (systolic and diastolic) in a sitting position after a 10-minute rest using an automated sphygmomanometer. Measurements were performed under standardized conditions in accordance with methodological recommendations, and the results were recorded in mmHg.

A questionnaire-based method was used to identify behavioral risk factors. The questionnaire included items assessing dietary patterns, level of physical activity, harmful habits, sleep patterns, and the level of psycho-emotional stress. The collected data made it possible to characterize the students' lifestyles and identify the main modifiable risk factors for metabolic syndrome.

Biological age was calculated using a regression model that included anthropometric parameters (BMI and BRI), hemodynamic parameters (systolic and diastolic blood pressure), and chronological age. The calculated biological age values were compared with chronological age to determine the rate of biological aging.

Statistical analysis was performed using SPSS version 23.0. Descriptive statistics, correlation analysis, and regression analysis were applied. Statistical significance was assessed at a significance level of $p < 0.05$.



Results and Discussion. The questionnaire data revealed a high prevalence of behavioral and metabolic risk factors among university students, which was reflected in changes in anthropometric parameters and accelerated biological aging.

A considerable proportion of students reported unhealthy dietary patterns, insufficient physical activity, high levels of psycho-emotional stress, and sleep disturbances. These factors represent key components in the pathogenesis of metabolic syndrome and are directly associated with the development of abdominal obesity and hemodynamic abnormalities.

Anthropometric analysis showed that 31.4% of students had signs of abdominal obesity, whereas overweight and obesity based on BMI were identified in a total of 38.0% of participants. Of particular interest was the subgroup of students with normal BMI but elevated BRI values, in whom biological age exceeded chronological age by an average of 1.9 years. This finding suggests the presence of latent metabolic abnormalities that may not be detected when only conventional anthropometric criteria are used.

Analysis of associations showed that unfavorable behavioral factors identified through the questionnaire were closely correlated with increased BRI values. Irregular eating patterns, frequent consumption of fast food and sweets, as well as insufficient intake of vegetables and water, may contribute to the accumulation of visceral adipose tissue, which is reflected in increased BRI values.

In turn, physical inactivity, identified in 41.6% of students, and prolonged sedentary behavior, reported in 62.7%, may exacerbate lipid and carbohydrate metabolism disorders, thereby promoting abdominal adiposity.

The BRI demonstrated the strongest association with biological age ($r=0.61$; $p<0.001$), exceeding the strength of the association observed for BMI ($r=0.52$; $p<0.001$). This finding indicates the potentially important role of visceral adiposity in the mechanisms underlying accelerated biological aging. Increasing BRI values were accompanied by a progressive increase in biological age: when BRI exceeded 5.0, the difference between biological and chronological age reached 4 years or more, which was interpreted as pronounced accelerated aging.

Hemodynamic abnormalities represented an additional factor associated with biological aging. Elevated blood pressure was observed in 15.3% of the students and was statistically significantly associated with both BMI and BRI. Elevated blood pressure in combination with abdominal obesity forms an unfavorable cardiometabolic profile and contributes substantially to an increase in biological age, as confirmed by the regression analysis.



Correlation analysis demonstrated statistically significant positive associations between biological age and all the parameters studied. The strongest association was observed with BRI ($r=0.61$; $p<0.001$), followed by BMI ($r=0.52$; $p<0.001$), systolic blood pressure ($r=0.41$; $p<0.001$), and diastolic blood pressure ($r=0.29$; $p<0.001$). Physical activity showed a negative correlation with biological age ($r=-0.38$; $p<0.001$), suggesting a potentially protective role.

Psycho-emotional status was also of particular importance. A high level of stress (6.8 ± 1.9 points), sleep disturbances, and the absence of effective stress-management strategies in a considerable proportion of students may contribute to activation of neuroendocrine mechanisms, including the hypothalamic-pituitary-adrenal axis, which may in turn promote lipogenesis and visceral adiposity. This is indirectly supported by the higher BRI and biological age values observed among students with unfavorable psycho-emotional characteristics.

The low level of awareness of metabolic syndrome (39.5%), despite the high reported importance attached to a healthy lifestyle, indicates a gap between knowledge and actual behavior. This is reflected in the high prevalence of risk factors and their association with biological age.

Thus, the findings demonstrate that the combination of behavioral risk factors identified through the questionnaire may contribute to the development of abdominal obesity, assessed using BRI, and hemodynamic abnormalities, which are associated with accelerated biological aging in young adults. In this context, BRI may serve as a sensitive integrative marker of early metabolic changes and may be considered for use in screening programs.

The greatest contribution to the variability of biological age was found to be associated with BRI, as demonstrated by both correlation analysis ($r=0.61$) and regression analysis ($\beta=2.10$; $p<0.001$).

Based on the findings of the study, the implementation of a comprehensive set of preventive and diagnostic measures aimed at the early identification and reduction of the risk of metabolic disorders among university students appears warranted. Calculation of BRI should be considered for inclusion in student screening programs as a potentially sensitive marker of abdominal adiposity. Biological age may also be used as an additional indicator for the early identification of metabolic abnormalities. Preventive programs aimed at improving dietary habits, increasing physical activity, and reducing stress should be implemented. It is also important to increase young people's awareness of metabolic syndrome and its risk factors.

Conclusions:



1. Overweight was identified in 28.2% of the students, obesity in 9.8%, and abdominal obesity in 31.4%;
2. Elevated blood pressure was recorded in 15.3% of the students;
3. Biological age was found to increase significantly with increasing BMI and BRI ($p < 0.001$). The strongest association was observed between BRI and biological age ($r = 0.61$), indicating the important role of visceral adiposity;
4. A subgroup of students with normal BMI but elevated BRI values was identified; these students demonstrated accelerated biological aging, suggesting the presence of latent metabolic abnormalities;
5. Unfavorable lifestyle factors, including unhealthy dietary patterns, physical inactivity, and stress, were statistically significantly associated with increased BRI values ($p < 0.001$), supporting their role in the development of metabolic risk;
6. Regression analysis showed that the most significant predictors of biological age were BRI ($\beta = 2.10$) and BMI ($\beta = 0.95$).

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