

Anthropometric Predictors of Hemodynamic Changes in Third-Year Students of Grodno State Medical University

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Received date: February 20, 2026; Accepted date: February 27, 2026; Published date: March 11, 2026

Citation: Lelevich A.V., Bon E.I., Cai M., Yankovskaya E.A., Satsuta P.P., et al, (2026), Anthropometric Predictors of Hemodynamic Changes in Third-Year Students of Grodno State Medical University, *J. Neuroscience and Neurological Surgery*, 19(3); DOI:10.31579/2578-8868/404

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Abstract

In the third decade of the 21st century, obesity has evolved into a critical global health crisis of pandemic proportions. WHO data from 2022 indicates that over 390 million children and adolescents (ages 5-19) are classified as overweight, with 160 million living with obesity. Since 1990, obesity prevalence has more than doubled among the adult population and quadrupled among adolescents. Projections from the World Obesity Atlas 2023 suggest a concerning trajectory: by 2035, more than 51% of the global population (over 4 billion people) will be affected by overweight or obesity if current trends persist

Keywords: hypertension; cardiovascular ; hip circumference

Introduction

In the third decade of the 21st century, obesity has evolved into a critical global health crisis of pandemic proportions. WHO data from 2022 indicates that over 390 million children and adolescents (ages 5-19) are classified as overweight, with 160 million living with obesity. Since 1990, obesity prevalence has more than doubled among the adult population and quadrupled among adolescents. Projections from the World Obesity Atlas 2023 suggest a concerning trajectory: by 2035, more than 51% of the global population (over 4 billion people) will be affected by overweight or obesity if current trends persist [1, 2].

The prevalence of arterial hypertension is significantly higher among obese individuals than among normal-weight individuals. Obesity is the main independent risk factor for the development of hypertension; specifically, 78% of primary hypertension cases in men and 65% in women are associated with being overweight or obese. Even a 5% increase in body weight is linked to a 20-30% increase in the incidence of primary hypertension [3]. Recent longitudinal studies emphasize that the transition from adolescence to young adulthood (18-25 years) is a "critical window" where weight gain most strongly correlates with a permanent shift in the hemodynamic set-point, leading to early-onset cardiovascular aging [4].

The mechanisms by which obesity leads to hypertension are complex and include excessive activation of the sympathetic nervous system, stimulation of the renin-angiotensin-aldosterone system, increased cytokines produced by adipose tissue, insulin resistance, and structural and functional changes in the kidneys [5]. Furthermore, contemporary research highlights the role of "metabolic inflammation" (meta-inflammation) and adipokine dysregulation in young adults, where even

moderate increases in hip or waist circumference act as endocrine triggers for vascular stiffness in those who are increasingly exposed to sedentary digital lifestyles [6, 7].

In clinical practice, the assessment of excess weight traditionally relies on the Body Mass Index (BMI). However, BMI does not always reflect the specific distribution of fat depots, which possess varying levels of metabolic activity and exert different effects on the cardiovascular system. Anthropometric markers such as waist circumference (WC), hip circumference (HC), and the waist-to-hip ratio (WHR) provide a more accurate evaluation of the localization of excess fat deposits and their contribution to changes in hemodynamic parameters. Despite existing standards, it remains unclear which specific marker of excess weight is the most informative predictor of cardiovascular strain in medical students, who represent a particularly vulnerable group due to high academic stress and sedentary habits.

The aim of this study is to conduct a comparative analysis of various anthropometric indicators characterizing body fat stores using mathematical modeling and to determine their predictive value regarding arterial blood pressure levels and pulse rate among students of Grodno State Medical University (GrSMU) 2025-2026 academic year.

Research methods

The study involved 80 boys and 323 girls, third-year students of the Grodno State Medical University in the 2025-2026 academic year. The students provided voluntary informed consent to participate in the study.

Systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse, waist circumference (WC) and hips (HC) were measured. Blood pressure

was measured according to WHO recommendations with a mechanical tonometer using the Korotkov method [8]. Waist circumference (WC) was also measured in accordance with WHO recommendations at the midpoint between the lower edge of the last palpable rib and the upper part of the iliac crest, hip circumference (HC) was measured around the widest part of the buttocks. Body mass index (BMI = body weight/(height, m)²) and waist-to-hip ratio (WHR) were calculated.

Linear regression models were constructed for each of the four predictors: WC, HC, W/H, BMI. Systolic blood pressure was used as a dependent variable. Standardized regression coefficients (beta) and determination coefficients (R²) were analyzed. The threshold value of the statistical

significance level was assumed to be 0.05. Statistical data processing was carried out using the StatSoft STATISTICA 10.0 program.

Results and discussion

In the course of mathematical modeling, it was found that has the most pronounced effect on the SBP. The beta coefficient is 0.31; R² is 0.095, p=0.006 (Table 1), which indicates that HC explains 9.5% of SBP variability. WC ranks second in terms of impact: beta is 0.286, R² is 0.082, p=0.01. BMI showed the following results: beta is 0.264, R² is 0.07, p=0.02. The W/H index showed no significant effect on the level of SBP.

| Indicator | Beta | R ² | p-value |
|---------------------|-------|----------------|---------|
| Waist circumference | 0.286 | 0.082 | 0.01 |
| Hip circumference | 0.310 | 0.095 | 0.006 |
| BMI | 0.264 | 0.070 | 0.02 |

Table 1: Characteristics of the prognostic significance of anthropometric predictors of systolic blood pressure in male 3rd-year students of GrSMU (2025/2026 academic year).

When studying the influence of these factors on DBP, it was found that the greatest influence and contribution is also made by HC. For it, the beta coefficient is 0.377, R² is 0.142, p<0.001 (Table 2), explains 14.2% of the DBP variability. BMI ranks second in terms of impact: beta is 0.313,

R² is 0.098, p=0.004. WC showed the following results: beta is 0.259, R² is 0.067, p=0.02. The W/H index showed no significant effect on the level of SBP.

| Indicator | Beta | R ² | p-value |
|---------------------|-------|----------------|---------|
| Waist circumference | 0.259 | 0.067 | 0.021 |
| Hip circumference | 0.377 | 0.142 | <0.001 |
| BMI | 0.313 | 0.098 | 0.005 |

Table 2: Characteristics of the prognostic significance of anthropometric predictors of diastolic blood pressure in male 3rd-year students of GrSMU (2025/2026 academic year).

During the study of the influence of anthropometric indicators on the pulse, it was found that HC has the most pronounced effect. The beta coefficient is 0.24; R² is 0.058, p=0.032 (Table 3), which indicates that HC explains 5.8% of the pulse variability. BMI and WC factors demonstrated almost equal, but slightly less pronounced effects compared

to HC: for BMI, the beta coefficient is 0.223, R² is 0.05, p=0.047, for WC, the beta coefficient is 0.229, R² is 0.05, p=0.04. The W/H index did not show a significant effect on the pulse.

| Indicator | Beta | R ² | p-value |
|---------------------|-------|----------------|---------|
| Waist circumference | 0.229 | 0.052 | 0.041 |
| Hip circumference | 0.240 | 0.058 | 0.032 |
| BMI | 0.223 | 0.050 | 0.047 |

Table 3: Characteristics of the prognostic significance of anthropometric predictors of diastolic blood pressure in male 3rd-year students of GrSMU (2025/2026 academic year).

Thus, the HC index turned out to be the strongest predictor of SBP, DBP and pulse in young students of GrSMU, while the calculated W/H index turned out to be ineffective.

In girls, during mathematical modeling, it was found that HC has the most pronounced effect on SBP. The beta coefficient is 0.303; R² is 0.092,

p<0.001 (Table 4), which indicates that HC explains 9.2% of SBP variability. WC ranks second in terms of impact: beta is 0.27, R² is 0.076, p<0.001. BMI showed results similar to waist circumference: beta is 0.275, R² is 0.073, p<0.001. The W/H index proved to be the weakest predictor: beta is 0.13, R² it is equal to 0.0172, p=0.046.

| Indicator | Beta | R ² | p-value |
|---------------------|-------|----------------|---------|
| Waist circumference | 0.274 | 0.076 | <0.001 |
| Hip circumference | 0.302 | 0.091 | <0.001 |
| Waist-to-hip ratio | 0.131 | 0.017 | 0.046 |
| BMI | 0.270 | 0.073 | <0.001 |

Table 4: Characteristics of the prognostic significance of anthropometric predictors of systolic blood pressure in 3rd-year female students of GrSMU (2025/2026 academic year).

When studying the influence of these factors on DBP, it was found that BMI has the greatest influence and contribution (Table 5). For it, the beta coefficient is 0.224, R² is 0.05, p<0.001, which explains 5.3% of the DBP variability. The HC and WC factors demonstrated almost equal, but

slightly less pronounced effects compared to BMI: for HC, the beta coefficient is 0.224, R² is 0.05, p<0.001, for WC, the beta coefficient is 0.223, R² is 0.05, p<0.001. The W/H index showed no significant effect on the level of DBP.

| Indicator | Beta | R ² | p-value |
|---------------------|-------|----------------|---------|
| Waist circumference | 0.223 | 0.050 | <0.001 |
| Hip circumference | 0.224 | 0.050 | <0.001 |
| BMI | 0.232 | 0.053 | <0.001 |

Table 5: Characteristics of the prognostic significance of anthropometric predictors of diastolic blood pressure in 3rd-year female students of GrSMU (2025/2026 academic year).

Thus, the HC index turned out to be a stronger predictor of SBP in female students of GrSMU than the classical body mass index or a marker of abdominal obesity – waist circumference. The high beta value (0.303) for hip circumference suggests that in this sample, fat mass in the lower torso is more closely correlated with SBP than fat accumulation in the abdominal area. The low WC/HC index (1.7%) confirms that absolute linear body dimensions are more important for predicting SBP levels than their proportional differences. BMI was the most pronounced (albeit insignificant) predictor of DBP in female students of GrSMU.

The studied anthropometric indicators did not show a significant effect on the pulse.

Conclusions

1. In female students of GrSMU, the most powerful anthropometric predictor of systolic blood pressure is hip circumference, surpassing body mass index and waist circumference in terms of influence. Body mass index is an optimal marker for predicting the level of diastolic blood pressure. The waist-to-hip ratio index is the least informative in this age group. Its contribution to the variability of systolic blood pressure is minimal, and its effect on the level of diastolic blood pressure is statistically insignificant, which makes its use in female students of GrSMU impractical.
2. The hip circumference is the most significant anthropometric predictor for all studied parameters of the cardiovascular system in male students of GrSMU. It has the strongest effect on systolic and diastolic blood pressure, as well as on pulse rate. The greatest degree of determination was noted in the influence of hip circumference on diastolic pressure (14.2%), which makes this indicator the most sensitive to anthropometric changes. The waist/hip index turned out to be uninformative in the framework of this study, as it did not show a statistically significant effect on either blood pressure or pulse. This may indicate that isolated volume indicators in young students of GrSMU have a greater prognostic value than their ratio.

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