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Correlation between body mass index and autonomic function tests in medical students: A cross-sectional observational study.

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Abstract
Background:
Overweight and obesity are increasingly common in young adults and are linked to early autonomic imbalance, a pathway that can precede later cardiometabolic disease.

Objectives:
To evaluate the association between body mass index (BMI) and standard autonomic function tests among medical students.

Methods:
This observational study was conducted in the Department of Physiology, Mamata Medical College, Khammam, Telangana, India, from January 2025 to December 2025. One hundred apparently healthy medical students underwent anthropometry, resting cardiovascular assessment, and autonomic function testing (deep breathing, Valsalva manoeuvre, and heart rate response to standing). Participants were classified as underweight, normal BMI, and overweight/obese. Group differences were tested using one-way analysis of variance, and BMI correlations were assessed using Pearson's correlation.

Results:
Mean age was 21.3 ± 1.6 years, and mean BMI was 23.2 ± 3.6 kg/m²; 18% were underweight, 56% had normal BMI, and 26% were overweight/obese. Resting heart rate, systolic blood pressure, and diastolic blood pressure increased significantly across BMI categories [all $p < 0.001$]. Parasympathetic indices showed a significant decline with increasing BMI, including the E: I ratio, Valsalva ratio, and 30:15 ratio [all $p < 0.001$]. BMI correlated positively with resting heart rate, systolic blood pressure, and handgrip blood pressure response, and negatively with E: I ratio, Valsalva ratio, and 30:15 ratio [all $p < 0.001$].

Conclusion:
Higher BMI in medical students was associated with higher resting cardiovascular indices and lower parasympathetic reactivity on standard tests, suggesting early sympathovagal imbalance in overweight/obese participants.

Recommendations:
Routine BMI-based screening with brief autonomic assessment and targeted lifestyle counselling within medical colleges can support early risk reduction.

Keywords: *Body mass index; Autonomic function tests; Medical students; Parasympathetic function; Blood pressure; Heart rate*
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Introduction
Body mass index (BMI) is a simple surrogate of overall adiposity and remains widely used for risk stratification in young adults. Even modest excess weight in early adulthood can influence cardiovascular control, including resting heart rate, blood pressure, and reflex autonomic responses. The autonomic nervous system (ANS) maintains short-term cardiovascular stability through coordinated sympathetic

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and parasympathetic activity. When this balance shifts toward sympathetic predominance and reduced vagal modulation, resting hemodynamics rise, and physiological responses to postural change, respiration, and strain become blunted.

Clinical and experimental work has long suggested that obesity is accompanied by autonomic dysfunction, characterized by diminished parasympathetic tone, altered baroreflex function, and heightened sympathetic drive. Early reports described autonomic impairment in obese adults using standardized cardiovascular reflex testing [1,2]. Population-level evidence also supports altered cardiac autonomic function in overweight individuals, even before overt disease develops [3]. More recent studies using heart rate variability (HRV) likewise report lower vagal indices and disturbed sympathovagal balance with increasing BMI or body fat [4,7]. These findings are important because autonomic dysregulation is linked to hypertension risk, reduced exercise tolerance, and adverse long-term cardiometabolic outcomes.

Medical students are a relevant group for preventive physiology because they experience prolonged periods of sedentary study, irregular sleep, exam stress, and dietary changes. Such factors can interact with weight status and influence autonomic indices. Studies in young adults have reported BMI-related differences in resting cardiovascular measures and autonomic activity, including poorer parasympathetic reactivity in overweight groups and distinct patterns in underweight participants [5,6]. Comparable observations have been reported in healthy volunteers assessed with traditional autonomic tests [8] and in individuals with severe obesity, where broader autonomic neuropathy has been documented [9]. Although pediatric data suggest similar trends, the transition period from late adolescence to early adulthood needs focused local evidence [10]. Recent work in women with obesity further highlights that autonomic impairment can coexist with sensory neuropathy, reinforcing the concept of early neural involvement in obesity [11].

Despite this background, institution-level data from Indian medical colleges using bedside autonomic tests remain limited, and comparisons across BMI categories are seldom presented alongside correlation estimates. Understanding these associations in medical students can guide campus health screening and reinforce lifestyle interventions early in training. The objectives of this study were to (i) compare resting cardiovascular indices and parasympathetic autonomic test results across BMI categories, and (ii) quantify correlations between BMI and autonomic parameters among medical students.

Methodology

Study design and setting

Study design and setting: This observational, analytical, cross-sectional study was conducted in the Department of Physiology, Mamata Medical College, Khammam, Telangana, India, from January 2025 to December 2025. Mamata Medical College is a teaching medical institution with an attached 1310-bed tertiary care hospital catering to the healthcare needs of Khammam and the surrounding districts. The attached teaching hospital provides outpatient, inpatient, and operative services across major clinical specialties and super-specialty disciplines, thereby offering an appropriate academic and clinical environment for institution-based physiological research in young adults.

Participants and sampling

Participants and sampling: The study population comprised undergraduate medical students aged 18–25 years studying at Mamata Medical College during the study period. Participants were recruited through departmental notices and classroom announcements, and eligible students were enrolled by consecutive sampling until the target sample size was reached. Inclusion criteria were: undergraduate medical students of either sex, age 18–25 years, willingness to participate, provision of written informed consent, and apparent clinical health at the time of testing. Exclusion criteria were acute febrile illness, known cardiovascular disease, endocrine disorder, diabetes mellitus, chronic respiratory disease, history of syncope, current smoking, alcohol dependence, and regular use of drugs known to influence autonomic function, such as beta-blockers, antidepressants, or stimulants. Participants were also instructed to avoid heavy exercise, caffeine, and large meals for at least 12 hours before testing.

Study Size

As this was an institution-based exploratory cross-sectional study, and because no prior local data were available to support a formal effect-size estimate for autonomic function parameters across BMI categories in this population, a pragmatic sample size of 100 participants was chosen. This number was considered feasible within the study period, adequate to permit comparison across BMI strata, and sufficient to estimate correlations between BMI and

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autonomic parameters with reasonable precision for an initial observational analysis.

Data collection and study measurements

After obtaining written informed consent, all participants were evaluated in the Physiology laboratory using a structured proforma. Anthropometric measurements were recorded in a standardized manner. Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale, with participants barefoot and wearing light clothing. Body mass index [BMI] was calculated as weight in kilograms divided by height in metres squared [kg/m^2]. Based on BMI, participants were categorized into three groups for analysis: underweight [<18.5 kg/m^2], normal BMI [18.5-24.9 kg/m^2], and overweight/obese [≥25 kg/m^2]. Resting cardiovascular parameters were assessed under standardized conditions. After at least 10 minutes of seated rest in a quiet, temperature-controlled laboratory, resting heart rate was recorded using an electrocardiogram or pulse monitor. Blood pressure was measured in the right arm with a validated automated sphygmomanometer using an appropriately sized cuff. Two blood pressure readings were obtained at an interval of 2 minutes, and the average value was considered for analysis.

Autonomic function was evaluated using standard non-invasive cardiovascular reflex tests performed in a fixed sequence with adequate rest between manoeuvres, in accordance with established clinical protocols [12]. Parasympathetic reactivity was assessed by the deep breathing test, expressed as the expiratory-to-inspiratory [E:I] ratio during six breathing cycles per minute; the Valsalva manoeuvre, expressed as the Valsalva ratio using a standardized expiratory strain; and the heart rate response to standing, expressed as the 30:15 ratio. Sympathetic reactivity was assessed using the isometric handgrip test, and the blood pressure response was recorded as the change from baseline during sustained contraction. Test performance, recording procedures, and artifact handling were standardized according to reproducible bedside methods described in previous methodological studies [14].

Bias

Several steps were taken to reduce potential sources of bias. Selection bias was minimized by inviting all eligible undergraduate medical students during the study period and enrolling consecutive volunteers who met the eligibility criteria. Information bias was reduced by using standardized operating procedures for anthropometry, resting cardiovascular assessment, and autonomic reflex testing. Height and weight were measured using calibrated instruments, blood pressure was recorded with an appropriate cuff size using a validated automated sphygmomanometer, and the average of two readings was used for analysis. Measurement variability was further reduced by performing testing in a quiet, temperature-controlled laboratory after a defined period of seated rest and by conducting autonomic maneuvers in a fixed order with adequate recovery intervals. Pre-test instructions regarding exercise, caffeine, and meals were given uniformly to all participants to reduce short-term physiological confounding. Data were checked for completeness before analysis. Residual confounding due to lifestyle factors such as sleep, diet, stress, and physical activity could not be fully eliminated in this cross-sectional design.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of Mamata Medical College. Written informed consent was obtained from all participants, and confidentiality was maintained by de-identifying data before analysis.

Statistical analysis

Data were entered in a password-protected worksheet and checked for completeness. Continuous variables are presented as mean ± standard deviation, and categorical variables as number (%). Between-group comparisons across BMI categories were performed using one-way analysis of variance, with $p < 0.05$ considered statistically significant. Associations between BMI and autonomic parameters were examined using Pearson correlation coefficients (r). Because bedside autonomic tests have known sensitivity limits, interpretations were made in the context of clinical screening performance described in previous work [13].

Results

Participant flow

Undergraduate medical students aged 18–25 years were approached through departmental notices and classroom announcements during the study period. A total of 100 apparently healthy volunteers who met the eligibility criteria and provided written informed consent were enrolled using

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consecutive sampling. All enrolled participants underwent anthropometric assessment, resting cardiovascular evaluation, and autonomic function testing. There were no post-enrolment exclusions, no dropouts during testing, and no missing data for the analysed variables. Therefore, all 100 enrolled participants were included in the final analysis.

All 100 enrolled students completed anthropometry, resting cardiovascular assessment, and autonomic testing. Baseline demographic and anthropometric characteristics are summarized in Table 1. The cohort had a mean age of 21.3 ± 1.6 years with a near-equal sex distribution. Based on BMI, 18% were underweight, 56% had normal BMI, and 26% were overweight/obese.

Table 1. Baseline Demographic and Anthropometric Characteristics (n = 100)

Variable	Value
Age (years), mean ± SD	21.3 ± 1.6
Sex, n (%)	Male: 52 (52%); Female: 48 (48%)
Height (cm), mean ± SD	165.8 ± 8.4
Weight (kg), mean ± SD	63.7 ± 10.9
BMI (kg/m²), mean ± SD	23.2 ± 3.6
BMI category, n (%)	Underweight (<18.5): 18 (18%); Normal (18.5–24.9): 56 (56%); Overweight/Obese (≥25): 26 (26%)

Resting cardiovascular indices differed significantly across BMI categories (Table 2). Resting heart rate increased from the underweight group to the overweight/obese group, and both systolic and diastolic blood pressures demonstrated a similar graded rise (all p < 0.001).

Table 2. Comparison of Resting Cardiovascular Parameters Across BMI Categories

Parameter	Underweight (n=18)	Normal BMI (n=56)	Overweight/Obese (n=26)	p-value
Resting heart rate (beats/min)	70.4 ± 6.1	73.2 ± 5.8	78.6 ± 6.9	<0.001
Systolic BP (mmHg)	108.6 ± 7.4	114.2 ± 8.1	121.8 ± 9.3	<0.001
Diastolic BP (mmHg)	68.9 ± 5.6	72.3 ± 6.0	77.1 ± 6.8	<0.001

Parasympathetic autonomic indices showed an inverse association with BMI category (Table 3). The deep breathing E: I ratio, Valsalva ratio, and 30:15 ratio were highest in underweight students, intermediate in normal BMI students, and lowest in the overweight/obese group (all p < 0.001), indicating reduced cardiovagal reactivity with higher BMI.

Table 3. Parasympathetic Autonomic Function Tests by BMI Category

Test	Underweight (n=18)	Normal BMI (n=56)	Overweight/Obese (n=26)	p-value
Deep breathing test (E: I ratio)	1.42 ± 0.12	1.35 ± 0.10	1.24 ± 0.09	<0.001
Valsalva ratio	1.48 ± 0.11	1.41 ± 0.09	1.31 ± 0.08	<0.001
Heart rate response to standing (30:15 ratio)	1.29 ± 0.08	1.25 ± 0.07	1.18 ± 0.06	<0.001

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Correlation analysis across the entire sample supported these trends (Table 4). BMI correlated positively with resting heart rate (r = +0.46) and systolic blood pressure (r = +0.52), while correlations with the E: I ratio (r = −0.49), Valsalva ratio (r = −0.44), and 30:15 ratio (r = −0.41) were negative (all p < 0.001). The isometric handgrip blood pressure response also showed a positive association with BMI (r = +0.38, p < 0.001).

Table 4. Correlation Between BMI and Autonomic Function Parameters (n = 100)

Autonomic parameter	Correlation coefficient (r)	p-value
Resting heart rate	+0.46	<0.001
Systolic BP	+0.52	<0.001
Deep breathing test (E: I ratio)	−0.49	<0.001
Valsalva ratio	−0.44	<0.001
30:15 ratio	−0.41	<0.001
Handgrip BP response	+0.38	<0.001

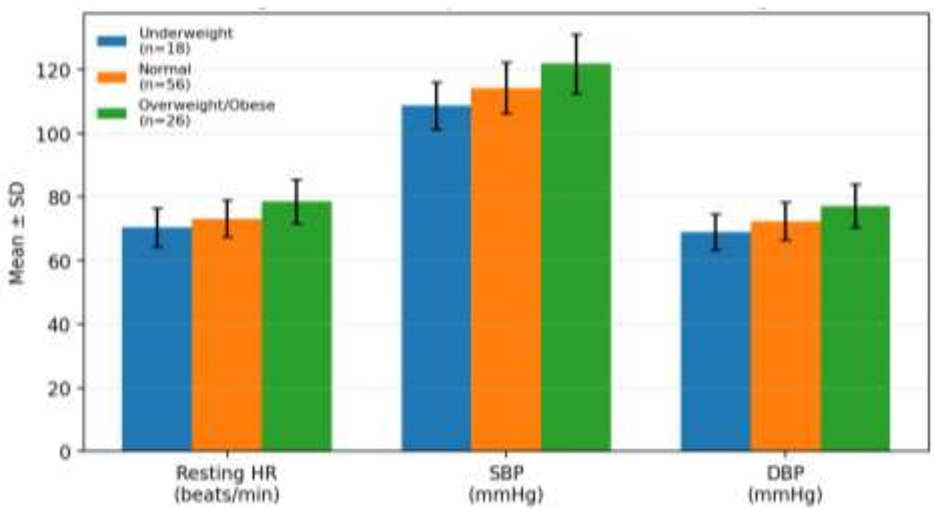

Figure 1. Resting cardiovascular parameters across BMI categories.

Bars represent mean ± SD for resting heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) in underweight, normal BMI, and overweight/obese groups.

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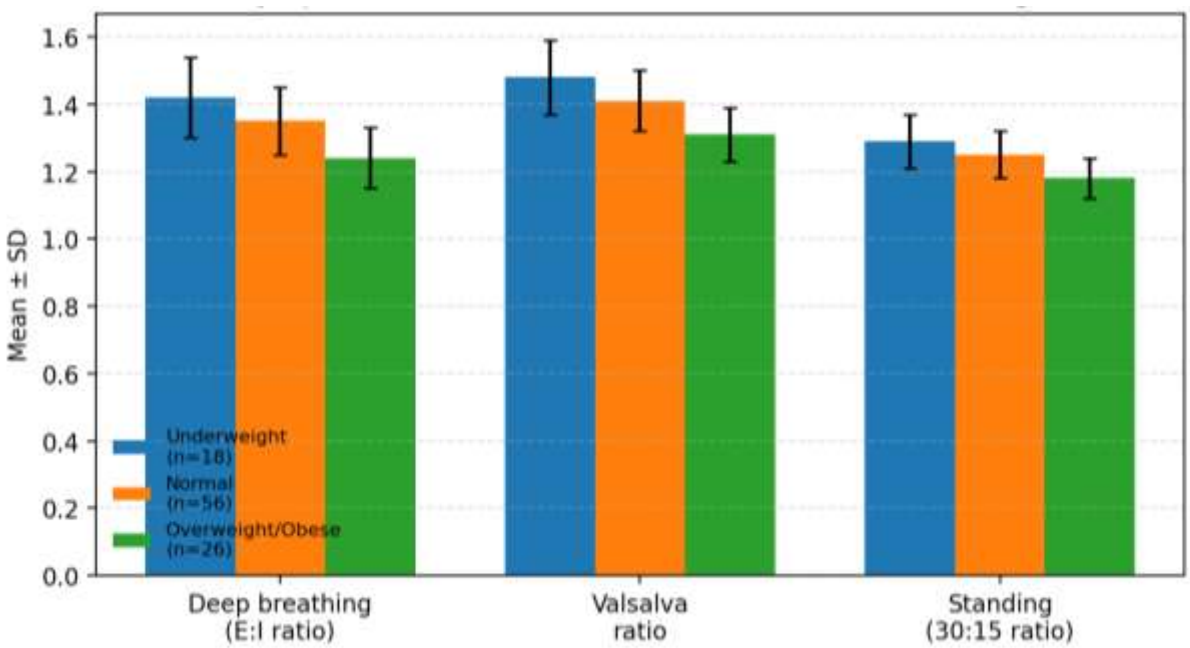

Figure 2. Parasympathetic autonomic function tests across BMI categories.

Bars represent mean ± SD for deep breathing E: I ratio, Valsalva ratio, and 30:15 ratio in underweight, normal BMI, and overweight/obese groups.

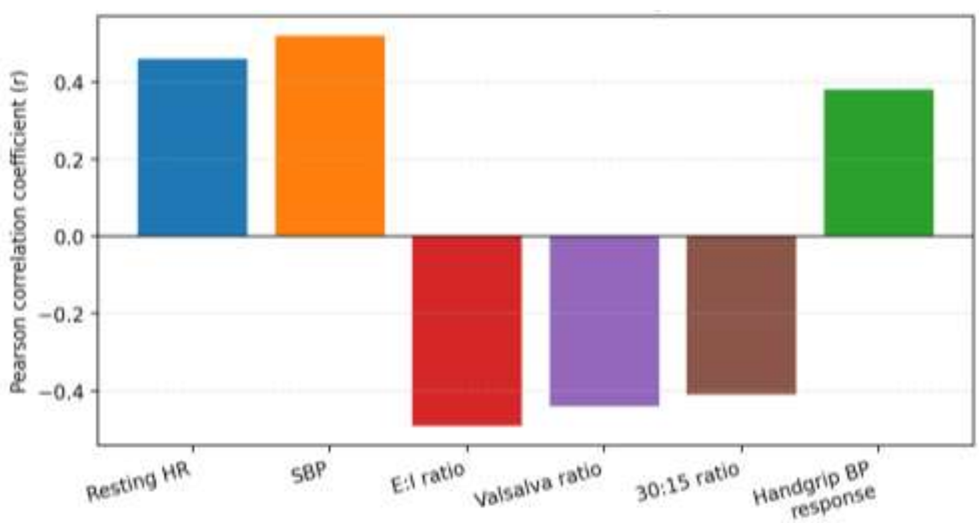

Figure 3. Pearson correlation coefficients (r) between BMI and autonomic parameters

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Positive values indicate higher parameter values with increasing BMI; negative values indicate lower parameter values with increasing BMI.

Discussion

This study demonstrates a clear BMI-related gradient in autonomic and resting cardiovascular indices among medical students. The overweight/obese group showed significantly higher resting heart rate [78.6 ± 6.9 vs 70.4 ± 6.1 beats/min], systolic blood pressure [121.8 ± 9.3 vs 108.6 ± 7.4 mmHg], and diastolic blood pressure [77.1 ± 6.8 vs 68.9 ± 5.6 mmHg], together with lower E: I ratio [1.24 ± 0.09 vs 1.42 ± 0.12], Valsalva ratio [1.31 ± 0.08 vs 1.48 ± 0.11], and 30:15 ratio [1.18 ± 0.06 vs 1.29 ± 0.08] than the underweight group [all $p < 0.001$]. BMI also correlated positively with resting heart rate [$r = 0.46$], systolic blood pressure [$r = 0.52$], and handgrip blood pressure response [$r = 0.38$], and negatively with E: I ratio [$r = -0.49$], Valsalva ratio [$r = -0.44$], and 30:15 ratio [$r = -0.41$] [all $p < 0.001$], indicating relative sympathetic predominance with cardiovagal withdrawal. Similar findings have been reported in obese adults and overweight populations without overt disease [1-3].

The inverse trend observed in deep breathing, Valsalva, and 30:15 ratios is consistent with reduced vagal modulation reported in young and middle-aged cohorts assessed using HRV and conventional reflex testing [4,7]. Studies specifically in young adults have reported BMI-linked differences in autonomic activity, including lower parasympathetic indices in overweight groups, which parallels our findings in a student population [5,6]. In addition, data from healthy volunteer cohorts tested with standard autonomic maneuvers show lower parasympathetic reactivity in obesity, reinforcing that the effect is detectable in otherwise healthy individuals [8].

Several mechanisms can explain these observations. Excess adiposity is associated with insulin resistance, low-grade inflammation, altered leptin signaling, and impaired baroreflex sensitivity, each of which can increase sympathetic outflow and blunt vagal responsiveness. Higher resting heart rate and higher blood pressure in the overweight/obese category in our study are physiologically compatible with this framework. Severe obesity has also been linked with broader autonomic neuropathy [9], and neural involvement has been reported across different age and sex groups, including children and women with obesity [10,11]. From a preventive physiology standpoint, the student setting is critical because early autonomic imbalance can coexist with modifiable behaviors such as physical inactivity, poor sleep regularity, and dietary excess.

The correlation analysis strengthens the categorical comparisons by showing a continuous association between BMI and autonomic measures. Moderate positive correlations of BMI with resting heart rate and systolic blood pressure suggest that higher BMI is linked with higher basal cardiovascular drive. Conversely, the negative correlations with E: I ratio, Valsalva ratio, and 30:15 ratio indicate progressively reduced parasympathetic reserve as BMI increases. The positive association between BMI and the isometric handgrip blood pressure response also aligns with enhanced sympathetic reactivity. Together, these results support incorporating weight status into student wellness programs and using brief physiological testing as a motivational tool for lifestyle change.

Generalizability

The findings arise from medical students in one teaching hospital campus in Telangana, assessed using standardized procedures and common BMI cutoffs. Given broadly similar academic routines, stress exposure, and lifestyle constraints across Indian medical colleges, the BMI-linked autonomic pattern applies to comparable undergraduate settings across regions. Extension to adolescents, older adults, athletes, or individuals with established cardiometabolic disease needs separate studies using community-based sampling, additional adiposity indices, and longitudinal designs.

Conclusion

In this observational study of 100 medical students, increasing BMI was associated with a graded rise in resting heart rate and blood pressure and a parallel decline in parasympathetic autonomic indices on deep breathing, Valsalva, and standing tests. Across the entire cohort, BMI correlated positively with resting cardiovascular measures and the handgrip blood pressure response, while showing negative correlations with cardiovagal reflex ratios. These findings indicate that overweight and obesity in early adulthood are linked with measurable sympathovagal imbalance, even in apparently healthy students. Integrating simple anthropometry with brief autonomic assessment can strengthen early identification of risk and support timely lifestyle counselling during undergraduate medical training and routine follow-up.

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Limitations

Limitations include the cross-sectional design, which prevents causal inference, and the single-centre student sample, which restricts external validity beyond similar undergraduate settings. BMI was the only adiposity index; waist circumference, body fat percentage, HRV metrics, and biochemical markers were not collected. Potential confounders such as sleep duration, acute stress level, dietary intake, and habitual physical activity were not quantified with validated instruments.

Recommendations

Medical colleges should implement periodic screening of BMI and blood pressure with brief autonomic testing for students identified as overweight/obese. Structured counselling on diet quality, regular aerobic activity, strength training, sleep hygiene, and stress management should be offered through campus wellness clinics. Follow-up assessments each semester can track improvement and reinforce adherence. Peer-led programs and mobile reminders improve engagement. Future studies should include waist circumference and body composition, objective physical activity measures, and HRV analysis to refine risk stratification. Longitudinal designs can evaluate whether early autonomic changes predict later hypertension, metabolic abnormalities, or reduced academic well-being.

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Abbreviations

ANS – Autonomic nervous system
BP – Blood pressure
BMI – Body mass index
DBP – Diastolic blood pressure
E: I ratio – Expiration: Inspiration ratio
HR – Heart rate
HRV – Heart rate variability
SBP – Systolic blood pressure

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

Amrutha Kanagala-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.**Ankur-**Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation.

Data availability

Data available on request

Author Biography

Dr. Amrutha Kanagala is an Associate Professor in the Department of Physiology at Mamata Medical College, Khammam, Telangana, India. She is actively involved in undergraduate and postgraduate teaching and contributes to competency-based medical education through academic mentoring and curriculum development. Her research interests span cardiovascular physiology, metabolic regulation, and applied clinical physiology, with a focus on translating basic physiological principles into clinical relevance. She has participated in institutional research projects and academic initiatives aimed at strengthening evidence-based medical education. **ORCID iD: https://orcid.org/0009-0004-8413-2859**

Dr. Ankur is a Professor in the Department of Physiology at Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India. He has extensive experience in teaching physiology to undergraduate and postgraduate medical students and is actively engaged in academic administration and curriculum planning. His academic interests include cardiovascular and respiratory physiology, integrative human physiology, and medical education research. He has guided student research projects and contributes to institutional academic and faculty development activities, with a sustained focus on strengthening conceptual learning and clinical application of physiological principles.

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