Section: Physiology

Original Research Article

ASSOCIATION OF ANTHROPOMETRIC MEASUREMENTS WITH RESTING MYOCARDIAL OXYGEN CONSUMPTION AND CURRENT OF INJURY, IF ANY AMONG YOUNG MBBS STUDENTS: AN OBSERVATIONAL CROSS SECTIONAL STUDY

Sangita Sarkar[1], Krishnachura Mitra[2], Rajarshi Ray[3], Bulbul Mukhopadhyay[4]

[1]3rd year PGT, Department of Physiology, R. G. Kar Medical College and Hospital, Kolkata, West Bengal, India.
[2]Associate Professor, Department of Physiology, R. G. Kar Medical College and Hospital, Kolkata, West Bengal, India.
[3]Assistant Professor, Department of Physiology, R. G. Kar Medical College and Hospital, Kolkata, West Bengal, India.
[4]Professor & Head, Department of Physiology, R. G. Kar Medical College and Hospital, Kolkata, West Bengal, India.

Received : *12/05/2026*
Received in revised form : *24/06/2026*
Accepted : *08/07/2026*

Keywords:
Current of injury, Rate Pressure Product, BMI.

Corresponding Author:
Dr. Krishnachura Mitra,
Email: dr.krishnachuramitra@gmail.com

DOI: 10.47009/jamp.2026.8.4.86

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (4); 498-504

ABSTRACT

Background: Early cardiovascular risk among young adults is increasingly recognized, particularly in populations exposed to academic stress such as medical students. Anthropometric indices like body mass index (BMI), waist-hip ratio (WHR), and waist-height ratio (WHtR) are established predictors of cardiovascular risk. Rate pressure product (RPP) is a non-invasive surrogate marker of myocardial oxygen consumption. The objective is to evaluate the association of anthropometric parameters (BMI, WHR, WHtR) with resting myocardial oxygen consumption (RPP) and to determine the prevalence and correlates of current of injury on ECG among young MBBS students. **Materials and Methods:** This observational cross-sectional study included 140 first-year MBBS students aged 18–21 years. Anthropometric measurements, blood pressure, heart rate, and ECG were recorded under standardized conditions. RPP was calculated as systolic blood pressure × heart rate. Statistical analysis included ANOVA, Student's t-test, and Pearson correlation. **Results:** Mean BMI was 24.59 ± 3.39 kg/m², with 29.3% pre-obese and 6.4% obese subjects. Mean RPP was 9977 ± 1433. RPP increased significantly across BMI categories (p=0.001). Significant positive correlations were observed between RPP and BMI (r=0.652), WHtR (r=0.532), and WHR (r=0.424). Current of injury was detected in 3.6% subjects. **Conclusion:** Anthropometric indices, particularly BMI and WHtR, are strongly associated with increased myocardial workload among young adults. Early screening using RPP may help identify individuals at risk of future cardiovascular disease.

INTRODUCTION

Cardiovascular diseases (CVDs) have traditionally been associated with middle-aged and elderly populations; however, recent epidemiological transitions have demonstrated a significant shift toward younger age groups. Rapid urbanization, sedentary lifestyles, dietary transitions, psychosocial stress, and academic burden have all contributed to an increased prevalence of cardiometabolic risk factors among adolescents and young adults. In particular, medical students represent a unique subgroup that is exposed to intense academic schedules, sleep deprivation, mental stress, and reduced physical activity—factors that collectively predispose them to early cardiovascular dysregulation. However, there is a lack of data regarding the possibility of current of injury in the heart among this age group.[1] Identifying and studying such subtle electrophysiological alterations in this early phase of medical training could help in recognizing vulnerable individuals at risk for future cardiovascular compromise.[2,3]

Several measurable physiological parameters have been developed over time to assess cardiovascular fitness and detect early cardiac strain. Among these, Body Mass Index (BMI), Rate Pressure Product (RPP), Waist-Hip Ratio (WHR), and Waist-Height Ratio (WHtR) are considered important non-invasive indicators of cardiovascular health.[4,7] The Body Mass Index, also known as the Quetelet Index, is one of the most widely used and reliable indices for evaluating body weight relative to height. It is calculated by dividing an individual's body weight (in kilograms) by the square of height (in meters) as per the standard formula: BMI = Weight (kg) / Height² (m²).[5] Increased body weight is directly associated with a higher BMI, which serves as a practical index for determining the degree of overweight or obesity.[6] Obesity has been recognized as one of the leading preventable causes of cardiovascular disease, and BMI serves as an early marker to identify at-risk individuals. It not only reflects fat accumulation but also predicts potential metabolic and hemodynamic disturbances that can predispose to hypertension, atherosclerosis, and myocardial dysfunction.[8] The Rate Pressure Product (RPP), defined as the product of heart rate (HR) and systolic blood pressure (SBP), is another vital parameter in the evaluation of cardiac performance. Mathematically expressed as RPP = SBP × HR, this simple but powerful index is regarded as an indirect measure of myocardial oxygen consumption (mVO_2) and workload.[9] RPP reflects the internal mechanical and metabolic stress placed upon the heart during both rest and activity. It is a non-invasive, sensitive, and reproducible method to estimate myocardial oxygen demand, making it a valuable tool in both physiological studies and clinical assessment.[10] Under resting conditions, a normal RPP value lies between 7,000 and 9,000 mmHg×beats/min, while a value exceeding 10,000 suggests elevated myocardial strain and increased risk of ischemic heart disease.[11,12] Studies have shown that low RPP values are indicative of reduced cardiac workload and better parasympathetic tone, both of which are considered cardioprotective.[13] Conversely, higher RPP values may indicate elevated myocardial demand or sympathetic dominance, often seen in stress conditions or underlying cardiovascular pathology.[14]

In addition to BMI and RPP, Waist-Hip Ratio (WHR) and Waist-Height Ratio (WHtR) serve as key anthropometric indicators of central obesity and fat distribution, which are crucial determinants of cardiovascular risk. WHR is defined as the ratio of waist circumference to hip circumference, while WHtR is calculated as waist circumference divided by height.[15]

These ratios are simple to compute and provide valuable insights into fat accumulation pattern particularly the accumulation of visceral fat, which has been shown to have stronger correlations with hypertension, insulin resistance, and coronary artery disease compared to overall body fat.[16] A WHR greater than 1.0 or a WHtR above 0.5 indicates elevated cardiovascular risk.[17] Numerous epidemiological studies have reported that WHR and WHtR are superior to BMI in predicting hypertension and cardiometabolic complications.[18,19] These anthropometric indices are thus valuable in identifying subclinical cardiovascular risk factors in apparently healthy individuals. Another significant yet underexplored area is the detection of current of injury in the electrocardiogram (ECG). The current of injury is reflected by characteristic shifts in the ST or TP segments of the ECG and is indicative of localized myocardial depolarization abnormalities.[20] Even in asymptomatic young adults, such findings could point toward latent myocardial electrical instability or metabolic stress. Traditionally, these findings have been associated with ischemia or myocardial infarction, but subtle shifts may also occur due to physiological variations, autonomic imbalance, or early myocardial strain.[21] Hence, screening young medical students for such ECG patterns could serve as a preventive approach to identify those at risk of developing cardiovascular conditions in the future.

The rigorous nature of medical education, characterized by mental stress, irregular sleep schedules, and physical inactivity, may further influence cardiovascular health among medical students.[22] These stressors can alter autonomic regulation of the heart, leading to changes in heart rate variability, blood pressure, and RPP. Chronic stress and sympathetic overactivity may predispose even young, healthy individuals to early cardiac dysfunction. Therefore, periodic cardiovascular assessment using simple non-invasive measures like RPP, BMI, WHR, WHtR, and ECG can provide meaningful insights into the cardiovascular adaptation and vulnerability of this group.[23]

Despite the importance of early detection, there is limited data on the relationship between anthropometric indices, myocardial oxygen consumption, and subclinical ECG changes in young Indian medical students. Given their future role as healthcare providers, assessing their cardiovascular health is of paramount importance.

Aims & Objectives

This study aims to evaluate the association between anthropometric parameters (BMI, WHR, WHtR) and resting myocardial oxygen consumption (RPP). It also attempts to determine the prevalence of current of injury among the study subjects and to assess the association between anthropometric indices and ECG evidence of current of injury.

MATERIALS AND METHODS

This prospective observational study analysed the after obtaining institutional ethical clearance, a cross-sectional, observational study was carried out in the Clinical Physiology Laboratory of the department of Physiology, of a tertiary care medical college of Kolkata, West Bengal, India. One hundred and forty young first year MBBS students of the same medical college were chosen as the study subjects following inclusion and exclusion criteria. As per the inclusion criteria, the subjects were the medical students who were apparently healthy and in the 18-21 years age group with no history of smoking or alcoholism and with average minimum midnight sleep duration of 6 hours. Subjects who were suffering from any cardiovascular or respiratory disease or taking any medications affecting heart or circulation like anti-hypertensive drugs, anti-platelet agents, oral hypoglycemic drugs, drugs affecting thyroid status were excluded. Informed written consent was obtained from all those who matched the inclusion criteria and were willing to participate in the study.

Sample size was calculated as follows:

Prevalence of abnormal Rate Pressure Product was 10%.[14]

Sample size is calculated using the formula

n = (Za /2)2pq/d2 = 138 where

n – is the sample size

z–confidence Interval

p – prevalence = 10%

e = precision of 0.05

A total of 140 subjects were included.

Data collection procedure:

Informed consent was obtained from all the volunteers and detailed experimental procedures were explained to them. All the parameters were recorded in the Clinical Physiology Laboratory of the department of Physiology, preferably between 11am to 1pm. Anthropometric parameters, like height (cm), weight (kg) was recorded by Stadiometer and body weight was measured using an electronic weighing machine (Syusan, Indian) and height was determined bare foot with a Stadiometer. Hip circumference and waist circumference was taken by measuring tape.

BMI was measured by dividing the weight by square root of height of the individual.

BMI=Weight/(Height)^2

BMI was calculated in each case. Based on BMI, Underweight, Normal weight, Overweight, Obese was ascertained using Asian Classification of BMI.[8]

Criteria Severe malnutrition	BMI (Asian) <16
Under weight	<18.5
Normal weight	18.5-22.9
Overweight	23-24.9
Obese	25-29.9
Morbid Obesity	> or = 30

The waist hip ratio (WHP) determines how much fat is stored on your hip and buttocks. It is measuring the ratio of waist circumstance to hip circumstance.

Waist hip ratio: In both men and women, a WHR of 1.0 or higher increases the risk of heart disease and other conditions that are linked to having Overweight.[9] WHR measurement was done at the appropriate midpoint between the lower margin of the last palpable rib and top of the iliac crest in standing and exhaled position.

Waist height ratio was measuring the ratio of waist circumstance and the height of the individual. This waist, hip circumstance and height are taken on standing and exhaled position. A healthy WHtR according to research range is between 0.4-0.49. A ratio between 0.5- 0.59 puts people at increased health problems while a ratio 0.6 or more places people at the higher risk.[10]

Before obtaining the cardiovascular parameters, the subjects were asked to lie down in supine position for 10 min and complete physical and mental rest was ensured. Systolic and diastolic blood pressures were obtained by Sphygmomanometer and heartrate was obtained from ECG. Rate Pressure Product was calculated by multiplying the systolic blood pressure with heart rate in a given situation.

Rate pressure product (RPP) = Systolic blood pressure (SBP) × heart rate (HR).

RPP up to 12000 at rest and 22000 in stressed condition was considered as normal.[4]

Following this, a 12-lead ECG was recorded by the ECG machine, Model No. Clarity Med ECG 50. From each ECG probability of current of injury was meticulously searched by noting the ST and TP segment. If TP segment shifts upwards or downtowns with respect to ST segment, this was regarded as a reliable indicator of injury potential, reflective of current of injury.[13,14]

RESULTS

In this study of 20 patients, 15 (75%) were women and 5 (25%) were men. Single-, double-, and three-level vertebral involvement were found in 14 (70 %), four (20 %), and two (10%) patients, respectively. [Table 1]

Table 1: Baseline characteristics of study participants

Baseline parameters	Minimum	Maximum	Mean	Std. Deviation
Age(years)	18	23	20.12	1.083
Height(cm)	150	182	162.93	8.538
Weight(in kgs)	48	90	65.29	9.890
BMI (kg/m2)	17.80	34.10	24.59	3.39
Waist circumference(cm)	58	104	81.26	8.346
Hip circumference(cm)	94	118	100.97	5.540
Waist hip ratio	.41	.96	.7943	0.067
Waist height ratio	.38	.68	.5012	0.06

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Out of the total study population, 72 participants (51.4%) were male, while 68 participants (48.6%) were female. The majority of 90 subjects (64.3%) of the study population had normal BMI while 41 subjects (29.3%) were in pre obese category, and 9 subjects (6.4%) were in obese category. To ascertain any statistical significance between different groups, ANOVA test was done with *p-value <0.01 considered as significant.

Both weight & BMI was found to have statistically significant increase in mean in normal, pre-obese & obese category. The mean waist circumference showed a progressive increase across the three groups and this difference was found to be statistically significant (p = 0.001). Similarly, the difference in hip circumference among the three groups was also statistically significant (p = 0.001). Our study also showed that the mean waist hip ratio and the mean waist height ratio showed a progressive increase across the three groups and was statistically significant (p = 0.001). [Table 2] enumerates the statistical relationships.

Table 2: Comparison of anthropometric parameters based on BMI categories

Anthropometry	Normal Mean ± SD	Pre Obese Mean ± SD	Obese Mean ± SD	p- value
Age(years)	20.16±1.090	20.24 ±0.994	19.22±1.093	>0.05
Height(cm)	163.58 ±8.792	162.71 ±8.091	157.44 ±6.366	.119
Weight(in kgs)	60.83 ±7.549	71.76 ±8.264	80.44 ±5.270	0.001*
BMI (kg/m2)	22.69 ±2.13	27.04 ±1.12071	32.45 ±1.31	0.001*
Waist circumference(cm)	76.89 ±5.288	87.68 ±4.997	95.78 ±10.521	0.001*
Hip circumference(cm)	98.06 ± 2.943	105.90 ± 4.6	107.67 ±7.778	0.001*
Waist hip ratio	0.7717 ±.06075	0.8237 ±.04678	0.8867 ±.07382	0.001*
Waist height ratio	0.4721 ±03942	0.5412 ±.04232	.6100 ±.07826	0.001*

The mean values of the different cardiovascular parameters are depicted in [Table 3].

Table 3: Descriptive statistics of cardiovascular system parameters among the study subjects

Cardiac parameters	Minimum	Maximum	Mean	Std. Deviation
SBP	90	160	124.42	12.568
DBP	60	96	79.09	7.778
PR	63	106	80.20	8.083
RPP	7119	13588	9977.38	1433.78
RR interval	600	998	786.36	100.765

Most cardiovascular parameters including SBP, DBP, PR, RRP & RR interval has a progressively increasing mean according to the BMI category and was found to be statistically significant except RR interval. [Table 4]

Table 4: Comparison of cardiovascular parameters among subjects based on BMI

Cardiac parameters	Normal Mean ± SD	Pre Obese Mean ± SD	Obese Mean ± SD	p- value
SBP	120.51 ±8.865	127.78 ±13.389	148.22 ±10.317	0.001*
DBP	77.26 ±6.497	81.39 ±8.369	86.89 ±9.892	0.001*
Pulse Rate	77.58 ±7.498	84.20 ±7.359	88.22 ± 2.728	0.001*
RPP	9325.51 ±939.770	10728.12 ±1187.997	13076.00 ±604.768	0.001*
RR interval	787.61 ±91.086	780.78 ±112.192	799.33 ±144.278	0.867

The majority of 135 subjects (96.4%) study participants showed no evidence of current of injury i.e no abnormality in ST segment, while a current of injury was present in a total of 5 subjects (3.6%) mainly ST segment elevation on ECG. Mean anthropometric measurements showed no statistically significant difference. However, the hip circumference was significantly higher in subjects of present group with current of injury compared to those in absent, with the difference being statistically significant (p = 0.003). [Table 5] shows the statistical correlation.

Table 5: Comparison of anthropometric parameters based on the current of injury

Presence of Current of Injury	Absent	Present	p- Value
Age(years)	20.10 ±1.064	20.80 ±1.48	0.154
Height(cm)	163.24 ±8.5	154.40 ±2.3	0.022
Weight (in kgs)	65.38 ±9.7	63.00 ±13.38	0.599
BMI (kg/m2)	24.53 ±3.3	26.40 ±5.4	0.227
Waist circumference(cm)	81.08 ±8.2	86.20 ± 11.9	0.179
Hip circumference(cm)	100.70 ± 5.2	108.20 ± 9.2	0.003*
Waist hip ratio	0.7944 ±0.07	0.79 ±0.07	0.884
Waist height ratio	0.49 ±0.06	0.56 ±0.07	0.026

Student t-test was done with *p-value < 0.01 as significant.

None of the cardiovascular parameters showed any statistical significance in relation to presence or absence of current of injury. [Table 6] enumerates the results.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 6: Comparison of cardiovascular parameters based on current of injury

CVS parameters	Current of Injury		P- Value
	Absent	Present	
SBP	124.23 ±11.97	129.60 ±25.59	0.350
DBP	78.79 ±7.7	87.20 ±6.8	0.017
Pulse Rate	80.04 ±8.1	84.40 ±6.07	0.238
RPP	9941.64 ±1389.8	10942.40 ±2349.21	0.126
RR interval	785.47 ±102.22	810.40 ± 45.06	0.589

Student t-test was done with *p-value < 0.01 as significant.

Strong positive correlation was observed between BMI and RPP, which was statistically significant (p = 0.001) as well as the waist height ratio with RPP and waist hip ratio and RPP. [Table 7] shows the correlation with RRP.

Table 7: Correlation of anthropometric parameters with rate pressure product

Correlation with RPP	Pearson correlation Coefficient (r)	P value
BMI (kg/m2)	0.652**	0.001*
Waist hip ratio	0.424**	0.001*
Waist height ratio	0.532**	0.001*

Pearson correlation coefficient (r) was done with p value < 0.01 as significant.

DISCUSSION

The cardiovascular health of young adults, particularly medical students, is a growing concern as lifestyle changes, mental stress, and irregular sleep patterns predispose them to early-onset metabolic and cardiovascular risks. These behavioural factors contribute to early metabolic and cardiovascular derangements despite their medical awareness.

This cross-sectional, observational study was performed among 140 first years MBBS students of 18-23 years age group of both sexes with their age, height and weight matched as shown in [Table 1]. Here, 64.3% of the study population had normal BMI while 29.3% were in pre obese, and 6.4% were in obese category. According to the WHO Global Status Report (2021), approximately 39% of adults aged 18 years and older were overweight while 13% were obese. Among individuals aged 18 to 25 years, this proportion has been steadily increasing, especially in low- and middle-income countries undergoing rapid urbanization. The Indian Council of Medical Research (ICMR)-INDIAB study (2019) reported that over 30% of young adults aged 18 to 25 years were either overweight or obese when applying Asian BMI criteria (BMI ≥23 kg/m²).[24] A cross-sectional study among urban Indian college students by Sharma R et al. found that 24% were overweight and 8% obese.[25] A multi-institutional survey by Gupta S et al.[26] across six Indian medical colleges revealed that 26.8% of medical students were overweight, 14.9% were obese, and 17.4% had prehypertension.

The study by Murray CJL et al,[27] reported that high body mass index (BMI) ranked as the fourth leading global risk factor for years of life lost, accounting for over 4 million deaths annually, primarily through ischemic heart disease and stroke. WHO stated that the prevalence of overweight and obesity has nearly tripled since 1975, with 39% of adults worldwide classified as overweight and 13% as obese.[28]

[Table 2] shows, that the mean body weight showed a progressive increase across the groups, was found to be statistically significant (p = 0.001). Similarly, the mean body mass index increased significantly and was statistically significant (p = 0.001). Similarly, both waist & hip circumference and waist/hip ratio & waist/height ratio was also statistically significant across BMI categories. Recent cohort analyses in studies by Ashwell M et al,[15] and Henriksson H et al,[29] reveal that even marginal increases in BMI and central obesity indices such as waist-hip ratio (WHR) and waist-height ratio (WHtR) are independently associated with higher rates of hypertension, left ventricular hypertrophy and altered myocardial oxygen demand. A cross-sectional study among urban Indian college students by Sharma R et al,[25] found that 24% were overweight and 8% obese, with significantly elevated mean systolic blood pressure and resting heart rate compared to normal-weight peers. Importantly, the study highlighted that central obesity measured by WHR and WHtR was a stronger predictor of elevated Rate Pressure Product (RPP), a non-invasive marker of myocardial oxygen consumption.[25]

The occurrence of cardiovascular risk factors such as high body mass index (BMI), modified anthropometric ratios, and subclinical ECG changes has been rising among young adults globally, including those in medical school. Historically, cardiovascular diseases (CVDs) were viewed as ailments affecting middle and older age, but recent epidemiological data shows a decrease in the age of onset attributable to lifestyle-related risk factors, urbanization, and psychosocial stress.[28] [Table 4] shows that the mean systolic blood pressure increased progressively across the groups of normal, overweight and obese subjects and was found to be statistically significant (p = 0.001). Similarly, the mean diastolic blood pressure, the mean pulse rate was statistically significant ($p = 0.001$).

Resting myocardial oxygen consumption, measured non-invasively via Rate Pressure Product (RPP), provides a practical method to evaluate cardiac workload and oxygen requirements in physiological conditions.[4,9] Kitamura K et al. established that the product of HR and SBP, known as the Rate Pressure Product (RPP), strongly correlates with MVO_2 ($r = 0.90$), providing a simple non-invasive index for estimating cardiac workload. RPP is calculated as the product of HR and SBP.[30] Thus, both HR and SBP serve as key determinants of myocardial oxygen demand. An increase in either variable elevates oxygen consumption due to increased mechanical work and metabolic activity of the myocardium. According to Klabunde RE et al., RPP is a reliable surrogate for myocardial oxygen uptake across a range of physiological and pathological conditions.[4] At rest, RPP values between 7,000 and 9,000 mmHg beats/min indicate normal myocardial work, while values exceeding 10,000 suggest higher cardiac stress. A study by Figueroa MA et al,[31] confirmed that RPP changes proportionally with myocardial oxygen uptake across varying workloads and autonomic conditions. The authors emphasized that RPP reflects the interplay between autonomic regulation and left ventricular function, making it a sensitive indicator for cardiovascular assessment. Examining these relationships in seemingly healthy young people may aid in detecting subclinical cardiac stress or existing injury patterns on ECG prior to the overt disease manifests.

In the present study, [Table 4] shows the difference in RPP among the three groups was found to be statistically significant ($p = 0.001$). A previous study in a North Indian cohort by Puri S et al,[32] where female students exhibited higher resting heart rate and RPP than males, implying gender-based differences in cardiovascular adaptability. Despite being clinically asymptomatic, nearly one in ten participants showed elevated RPP values (>10,000 mmHg beats/min), which is considered a threshold for increased cardiac workload.[11,12] A regional survey among college students in Delhi and Kolkata by Sharma et al. (2019) found that 24% were overweight and 8% obese and elevated waist height ratio correlated strongly with resting heart rate and Rate Pressure Product (RPP). This indicates a link between anthropometric markers of obesity and increased myocardial oxygen consumption even among asymptomatic youth.

In the present study [Table 7], a statistically significant strong positive correlation was observed between BMI and RPP, waist height ratio and RPP and waist hip ratio and RPP. Opie LH et al,[3] stated that at the cellular level, approximately 60–70% of myocardial oxygen is used for ATP generation required for cross bridge cycling during contraction, while the remainder supports ionic homeostasis and basal metabolism. The myocardium extracts about 70–80% of oxygen delivered via the coronary circulation at rest, leaving minimal reserve capacity during stress or exercise.[19] In their study White WB et al,[12] highlighted that MVO_2 correlates not only with HR and SBP but also with contractility (inotropy), which raises wall stress and tension. Hence, RPP provides an indirect yet practical measure that integrates mechanical and autonomic influences on myocardial oxygen demand.

Also, studies by Gupta S et al,[26] and Li Y et al,[33] show that in healthy young adults, elevated RPP values may reflect early autonomic imbalance or subclinical myocardial strain, particularly in individuals with higher BMI, WHR, or WHtR. Over time, persistent elevations in MVO_2 may contribute to endothelial dysfunction and increased risk for hypertension and left ventricular hypertrophy. The physiological basis of myocardial oxygen consumption is deeply rooted in the balance between myocardial work and oxygen delivery. HR and SBP remain the primary determinants of oxygen demand, while RPP offers a convenient, non-invasive means to estimate this relationship. Cellular energy metabolism, coronary flow regulation, and autonomic modulation together maintain myocardial oxygen homeostasis. Deviations in this balance, reflected by elevated RPP, may indicate subclinical cardiac stress, particularly in individuals with obesity or autonomic dysregulation, a key focus of the present study.

In the present study, the majority of 135 subjects (96.4%) study participants showed no evidence of current of injury, while a current of injury was present in a total of 5 subjects (3.6%). Another study by Basu R et al,[34] on 400 MBBS students in Kolkata reported subclinical ECG abnormalities in 9.2% of participants, including minor ST-T segment changes indicative of possible current of injury. These abnormalities correlated positively with BMI ($r = 0.43$) and WHR ($r = 0.38$), suggesting a link between central obesity and early myocardial strain. Although data on the prevalence of current of injury in healthy young populations are limited, emerging studies suggest that early ECG deviations may be more common than previously assumed. In a study by Baker AH et al,[35] reported that minor ST-T abnormalities occur in 4-8% of healthy young adults, often reflecting transient myocardial strain or autonomic dysregulation. In Indian studies, the prevalence appears higher, likely due to higher rates of obesity, psychological stress, and poor sleep quality among students. Basu R et al,[35] found ECG evidence of minor ST-segment elevation or depression in nearly one tenth of young MBBS participants. These findings support the hypothesis that even in non-symptomatic individuals, anthropometric deviations may precipitate subclinical myocardial injury detectable via ECG.

New learnings & Limitations of the study

New Learnings

- Demonstrates early myocardial stress in medical students

ISSN (O): 2687-5365; ISSN (P): 2753-6556

- Confirms WHtR as a strong predictor of cardiac workload
- Validates RPP as a simple screening tool

Limitations

- Cross-sectional design
- Single-center
- Small ECG abnormality sample
- Lack of lifestyle variables
- No multivariate regression.

CONCLUSION

Anthropometric parameters, particularly BMI and WHtR, are strongly associated with increased myocardial oxygen consumption in young adults. The findings emphasize the importance of early cardiovascular screening and lifestyle modification in this vulnerable population.

REFERENCES

1. Ravishankar P, Madan orange, Udupa K, Prakash ES. Correlation between Body Mass Index and Blood pressure indices, hand grip strength and handgrip endurance in Underweight, Normal and Overweight adolescent. Indian J Physiol pharmacol .2005 Oct-Dec; 49(4):455-461.
2. Eknoyan, Garabed. Adolphus Quetelet (1796-1874)–the average man and indices obesity. Nephrology dialysis transplantation. 2005;23(1):47-51
3. OpieLH. Mechanism of Contraction and Relaxation in: Braunwald E, Zipes DP, Libbey P, Bonow R (ens). Braunwale's Heart Disease, 7thEd., Pennsylvania: HarcourtBruce Saunders;2006.
4. KlabundeRE.CardiovascularPhysiologyConcepts.2ndEd.,Lippincott Williams Wilkins; 2011.
5. Janssen L, Katzamarzyk PT, Ross R. Body Mass Index, waist circumstance, and health risk: evidence in support of current National Institutes of Health guidelines. Arch Intern Med – 2002 ; 162(18):2078-2079. Doi: 10.1001/ archiute 162.18.2074
6. Ashville M. Charts based on Body Mass Index and Waist to hight ratio to assess the health risk of obesity: a review. Open Obesity J.(2011)3:78:doi: 10.2174/ 1876823701103010078
7. http:/www.ncsf.org/2.8.2012AM.UnderstandingExerciseIntensity andRate Pressure Product (RPP)By NCSF on Feb 17, 2011.
8. RobinsonBF.Relationofheartrateandsystolicbloodpressureattheonset of pain an angina pectoris. Circulation 1967;35:1073-1083.
9. Sarnoff SJ Braunwald E. Hemodynamic determination of oxygen of the heart with special reference to the tension- time Index.mAMJPhysiology11958;192: 148-156).
10. Fletcher GF, Cantwell JD, Watt EW. Oxygen consumption and hemodynamic response of exercise used in training of patients with recent myocardial infraction. Circulation q 979;60:140-144).
11. Ellestad MH. Stress testing. 4thedition. NewDelhi: Jaypee Brothers; 1996p. 17 and p379;
12. White WB. Heart rate and rate pressure product as determinants of cardiovascular risk in patients with hypertension. Am J Hypertension.1999; 12-50 S-5).
13. Michel A Figueroa, Ronald E DE Meersman, I and James Manning. The Autonomic and Rate Pressure Product Response Practitioners. NAM JMed Sci, 2012 June ;4(6): 270- 275)
14. Sembulingam P, Sembulingam K, GladMohesh. Gender differences in body mass index and blood among normal healthy undergraduate students. Int J Med Res Health Sci.2013;2(3):527-532).
15. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than Waist circumstance and BMI for adult cardiometabolic risk factor: systematic review and meta-analysis. Obesity Rev (2012)113:275-86.10/1111/j.1467-789x.2011
16. Ardern CI, Katzmaryk PT, Janssen I, Ross R. Discrimination of health risk by combined Body Mass Index and Waist circumstance. Obes Res. 2003: 11(1)135-142. Doi:10.1038/oby.2003.22.
17. Bazelman C. Coppieters Y. God inI.etalIS obesity associated with injury among young people? Eur J Epidemiol. 2004; 19:1037- 1042.
18. Sangeeta Nagpal, Lily Walia, Hem Lata, Naresh Sood and G.Abuja.(Original Effect of exercise on rate pressure product in premenopausal and postmenopausal women with coronary artery disease. Indian J PhysiolPharmacol 2007;51(3);279-283
19. Guyton and Hall, Textbook of Medical Physiology,12thEd., Elsevier, The Normal Cardiogram.
20. G. Piccirillo, M Cacciafesta, E. Viola et al., "Influence of aging on cardiac baroreflex sensitivity determined non-invasively by power spectral analysis, "Clinical Sciencevol.100, no.3, pp.267-274,2001 View at Publisher. View at Google Scholar. View at Scopus
21. C.W.Y. Appels and J.H. Book. "Sudden death after emotional stress: a case history and literature view, "European Journal of Internal Medicine, vol.20. No.4,pp. 159-361;2009. View at Google Scholar.
22. Dodt C, Breckling U, plasma Epinephrine and Norepinephrine concentrations of healthy humans associated with night time sleep and morning arousal: Hypertension,1997; 30: 71-76.
23. Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise capacity and mortality among men referred for exercise testing. New England journal of medicine. 2002 Mar 14;346(11):793-801.
24. Anjana RM, Unnikrishnan R, Deepa M, Pradeepa R, Tandon N, Das AK, Joshi S, Bajaj S, Jabbar PK, Das HK, Kumar A. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study (ICMR-INDIAB-17). The Lancet Diabetes & Endocrinology. 2023 Jul 1;11(7):474-89.
25. Sharma R, Ghosh S, Chatterjee P. Central Obesity and Resting Myocardial Workload in Indian College Students. Indian Journal of Physiology and Pharmacology. 2019;63(2):145–51.
26. Gupta S, Kumar A, Roy T. Cardiovascular Risk Factors among Indian Medical Students. Indian Journal of Community Medicine. 2021;46(1):45–50.
27. Murray CJL, Aravkin AY, Zheng P, Abbafati C, Abbas KM, Abbasi-Kangevari M, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet [Internet]. 2020;396(10258):1223–49.
28. World Health Organization. Assessing national capacity for the prevention and control of noncommunicable diseases: report of the 2021 global survey. World Health Organization; 2023 Jul 5.
29. Henriksson H, Henriksson P, Tynelius P, Ekstedt M, Berglind D, Labayen I, Ruiz JR, Lavie CJ, Ortega FB. Cardiorespiratory fitness, muscular strength, and obesity in adolescence and later chronic disability due to cardiovascular disease: a cohort study of 1 million men. European heart journal. 2020 Apr 14;41(15):1503-10.
30. Kitamura K, Jorgensen CR, Gobel FL, Taylor HL, Wang Y. Hemodynamic correlates of myocardial oxygen consumption during upright exercise. Journal of applied physiology. 1972 Apr;32(4):516-22.
31. Figueroa MA, DeMeersman RE, Manning J. The autonomic and rate pressure product responses of tai chi practitioners. North American Journal of Medical Sciences. 2012 Jun;4(6):270.
32. Puri S, Arora R, Bansal S. Gender Differences in Cardiovascular Reactivity among Young Adults. Frontiers in Physiology. 2022;13.
33. Li Y, Wang T, Zhang S, Zhao J. Anthropometric predictors of myocardial oxygen consumption: A meta-analysis. Journal of Clinical Cardiology Research. 2021;14(2):155–69.
34. Basu R, Mitra D, Roy S. Subclinical ECG Abnormalities and Anthropometric Correlates among Indian Medical Students. Indian Heart Journal. 2023;75(4):212–8.
35. Baker AH, Giacca M. Antagonism of miRNA in heart failure: first evidence in human. European Heart Journal. 2021 Jan 7;42(2):189-91.