Original Article

Association of Physical Factors (BMI and WHR) with Physical Activity Level (PAL) and Gender-wise Comparison among College Students

Nadim Haider[1], Somnath Gangopadhyay[2], Alok Chattopadhyay[3]

[1]Research Scholar, Department of Physiology, Harimohan Ghose College, Kolkata, West Bengal, India, & Assistant Professor, Department of Physiology, Netaji Nagar Day College, Kolkata, West Bengal, India, [2]Professor, Department of Human Physiology, University of Calcutta, Kolkata, West Bengal, India, [3]Associate Professor, Department of Physiology, Harimohan Ghose College, Kolkata, West Bengal, India

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Abstract

Background: Assessment of physical factors such as Body Mass Index (BMI) and Waist Hip Ratio (WHR) and their association with Physical Activity Levels (PAL) is essential among college student population for assessing their health risk & creating a healthy environment through the implementation of effective strategies by educational institutions.

Methods: A cross sectional study was conducted on 202 adult college students (male:105 & female: 97) of Kolkata, West Bengal, India, under the age group 18-23 years. They were randomly selected through Convenient sampling method and their PAL(MET-Min/Week) was estimated and classified using the guideline of International Physical Activity Questionnaire (IPAQ) Short. Their BMI & WHR were also measured and categorized as per WHO guideline. Co-relation of the BMI & WHR with their PAL has been analysed and the risk of chronic disease was observed. The study wasapproved by the Institutional Human Ethical Committee.

Conclusions: Majority (82.18%) of students had 'High' physical activity levels, with males showing significantly higher total mean PAL & WHR than females ($p < 0.05$). Physically inactive were (4.46%) &Obese were 10.40% yet 25.25% of students were found at high cardiovascular & other health risk. While physical activity is crucial for overall health, its impact on BMI & WHR can be inconsistent as individual variability in response to exercise, dietary habits, metabolic rate and genetic predispositions etc. and also some other health matrices or hidden factors which should be explored through further research. While PAL had no significant correlation with BMI or WHR, the PAL-WHR correlation (Beta coefficient = 0.034) was comparatively stronger than PAL-BMI (Beta coefficient = 0.006), suggesting WHR is a more significant health indicator than BMI. This study thus highlighted the need for targeted health interventions in college student's populationspecially the females to address obesity and the associated risks of cardiovascular and other chronic diseases.

Key words: 1. Body Mass Index (BMI), 2. Chronic Diseases, 3. Health Risk, 4. Metabolic Equivalent of Task (MET), 5. Physical Activity Levels (PAL), 6. Waist-Hip Ratio (WHR)

Corresponding Author: Alok Chattopadhyay, Associate Professor, Department of Physiology, Harimohan Ghose College, Kolkata, West Bengal, India.

E-mail: alokc1972@gmail.com

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Introduction

The rising prevalence of chronic diseases among young adults is a growing public health concern, impacting academic performance and long-term well-being. Adult students face unique health risks like obesity and cardiovascular issues, influenced by academic stress, lifestyle habits, and low physical activity[1]. Monitoring key health metrics is vital for developing prevention strategies tailored to this group.

Assessing Physical Activity Level (PAL), Body Mass Index (BMI), and Waist-to-Hip Ratio (WHR) is crucial for understanding physical health in students. This knowledge helps design interventions to lower obesity and cardiovascular disease risks. The sedentary academic lifestyle, marked by long study hours, further raises chronic disease risks[2].

Regular physical activity reduces risks of cardiovascular disease, obesity, diabetes, depression, and anxiety. Yet many students struggle to stay active due to academic pressures[3]. Addressing these health risks is a public health priority. This paper examines key physical factors and their co-relation to PAL among male and female students, using research-based evidence.

BMI and WHR are common health indicators. While BMI measures body composition and obesity, it has limitations. WHR better predicts cardiovascular and metabolic risks by reflecting fat distribution[4].

Higher PAL is associated with lower risks of obesity, diabetes, and heart disease, with activity levels assessed through the International Physical Activity Questionnaire[5]. Gender differences exist, with males typically reporting higher PAL due to lifestyle and social factors[6]. Despite the benefits of physical activity, many college students remain inactive, increasing health risks[7]. Research suggests WHR may more strongly predict health risks in young adults than BMI[8].

The main objectives of our study are:

1. To assess the PAL, BMI and WHR among college student population.
2. To categorise their PAL, BMI and WHR.
3. To assess the risk of obesity, cardio-vascular disease and other lifestyle-oriented diseases.
4. To study the association of PAL with BMI and WHR.
5. To compare the PAL, BMI and the WHR (health risks) between the male and female participants.
6. To find out which of the physical factors between BMI and WHR is a better indicator of the health risk in student population.

Materials and Methods

A cross-sectional study was conducted with 202 undergraduate students (105 males and 97 females) from Netaji Nagar Day College, Kolkata, West Bengal, India. The study was carried out between November 2022 and April 2023.Solvin's formula has been applied for sample size calculation. PAL of 464 participants has been estimated using IPAQ. All the 464 participants have been invited in the laboratory to participate in BMI & WHR measurement but only 272 turned out. Following exclusion criteria only the measurement of 202 students were considered for the study. So, association of PAL of those 202 students with their BMI & WHR has been analysed and their health status has been studied. The age of the participants ranged between 18 and 23 years. A convenient sampling method was employed ensuring representation from diverse socio-economic backgrounds. Eligibility criteria includes, participants to be healthy male or female adults aged 18-23 years and enrolled in an undergraduate general degree program. All participants provided informed consent before taking part in the study. Individuals younger than 18 or older than 23, as well as those with any known illness or physical disability, were excluded. The study protocol was reviewed and approved by the University of Calcutta Human Ethical Committee.

PAL Estimation Procedure

The PAL score was determined based on energy expenditure, measured in Metabolic Equivalent Task minutes per week (MET-min/week), using the International Physical Activity Questionnaire (IPAQ). The questionnaire was administered through Google Forms. The validity and reliability of the IPAQ short form have been evaluated across multiple nations, confirming its suitability for large-scale research[9].

The MET values for vigorous, moderate, and walking activities were calculated using the IPAQ short form[10]. The total PAL score, expressed in MET-min/week, was obtained by summing up these three values. Based on the scores, participants were classified as Low, Moderate, or High Physical Activity (PA) categories, following standard IPAQ guideline and scoring protocols.

Low PAL: < 600 MET-minutes/week

Moderate PAL: 600-3000 MET-minutes/week

High PAL: > 3000 MET-minutes/week

BMI Measurement Procedure

BMI was calculated using the formula of Corrada et al., 2006[11] (weight in kg/height in m^2) and categorized according to WHO standards (underweight, normal weight, overweight and obese)[12].

BMI<18.5	Underweight
BMI18.5–24.9	Normal weight
BMI 25.0–29.9	Overweight
BMI ≥30.0	Obesity

1. Weight Measurement: A calibrated scale was used to measure the weight in Kilogram (Kg) ensuring the individual is in light clothing and without shoes.

2. Height Measurement: The individual's height was measured in meters (m) using an Anthropometric rod.

Method for Measuring Waist-Hip Ratio

WHR was measured by measuring the waist and Hip circumferences, using a measuring tape. The WHO report emphasizes that WHR is a significant indicator of health risks, independent of BMI.[13].

Calculating the Waist-Hip Ratio (WHR)[14]. Formula: WHR is calculated by dividing the waist circumference by the hip circumference: WHR=Waist Circumference/ Hip Circumference.

This ratio is used to assess the distribution of body fat and the associated risk of cardiovascular and other obesity-related diseases.

Low risk: ≤ 0.90 (for men) and ≤ 0.85 (for women).

Moderate risk: 0.91 - 0.99 (for men) and 0.86 - 0.89 (for women).

High risk: ≥ 1.00 (for men) and ≥ 0.90 (for women).

Statistical Analysis

PAL, BMI and WHR scores are presented as mean ± Standard deviation. BMI and Health risk categorization has been shown in terms of percentage. Bar diagrams have been used and independent sample t-test was done to show the comparison of PAL, BMI and WHR between male and female participants. The normality and linearity analysis were applied to all variables. The comparative co-relation of PAL scores with BMI and WHR has been shown by Multiple regression analysis. The SPSS 26.0 for Windows was used to carry out the statistical analysis.

Results and Discussion

Table 1: Independent sample t-test of the Means of Physical Activity Level (PAL) categories, Body Mass Index (BMI) and Waist-Hip Ratio (WHR), showing gender wise comparison (values are shown in terms of Means ± Standard deviation; t-test was done and values are found to be significant, p<0.5)

	PAL (IPAQ)				BMI	WHR
	Total PAL	High PAL	Moderate PAL	Low PAL		
	(MET-Min/ Week)	(MET-Min/ Week)	(MET-Min/ Week)	(MET-Min/ Wee)		
	(p=0.02)*	(P=0.08)	(P=0.54)	(P=0.17)	(P=0.42)	(P=0.01) *
All Participants (N=202)	6224.36	7175.31	2152.41	900.56	23.98	0.87
	±	±	±	±	±	±
	4007.99	3778.36	870.36	306.16	4.69	0.08
Male (n=105)	6850.36	7649.37	2004.56	1030.8	23.72	0.88
	±	±	±	±	±	±
	4169.27	3890.74	880.12	333.86	4.2	0.09
Female (n=97)	5546.73	6600.11	2226.33	737.75	24.26	0.85
	±	±	±	±	±	±
	3729.62	3578.98	881.3	194.24	5.17	0.05

The study revealed that mean & SD of PAL scores of all participants is 6224.36 ± 4007.99 When the means of total PAL score and WHR score of male and female are compared, the difference has been found statistically significant ($p<0.5$), with males having higher values than females.

Table 2: Gender wise comparison of Physical Activity Level (PAL) categorization (IPAQ), Body Mass Index (BMI) Categorization (WHO) & Health risk Categorization (WHO) (Values are shown in terms of percentage)

(n=202)	PAL (IPAQ)			BMI (WHO)				WHR/Health risk (WHO)		
	High PAL	Moderate PAL	Low PAL	Normal weight	Over weight	Obese	Under weight	High risk	Moderate risk	Low risk
All Participants	166 (82.18%)	27 (13.36%)	09 (4.46%)	104 (51.48%)	55 (27.23%)	21 (10.40%)	22 (10.89%)	51 (25.25%)	36 (17.82%)	115 (56.93%)
Male (105)	91 (86.67%)	9 (8.57%)	5 (4.76%)	53 (50.48%)	34 (32.38%)	7 (6.67%)	11 (10.47%)	6 (5.71%)	3 (2.86%)	96 (91.43%)
Female (97)	75 (77.32%)	18 (18.56%)	4 (4.12%)	51 (52.58%)	21 (21.65%)	14 (14.43%)	11 (11.34%)	45 (46.39%)	33 (34.02%)	19 (19.59%)

A significant majority (82.18%) fell into the High PAL category. Such findings suggest that as a whole, the student population demonstrates a commendable level of physical activity, which could help lower the risk of chronic diseases. A study by Sahin et al., 2017[15] found that 59.1% of students at a Turkish university engaged in adequate physical activity, with the rest reporting low or no activity. Similarly, our results are consistent with the findings. Young adults may be motivated to stay active due to social influence from their peers and an increased awareness of the importance of physical health and its long-lasting benefits, which may drive them to maintain higher physical activity levels[16].

The BMI analysis revealed that the mean and SD of BMI values of all participants is 23.98 ± 4.69 (Table-1). 27.23% of the students were classified as Overweight and 10.40% were Obese (Table-2). The results underscore a significant proportion of students, who are overweight or obese, reflecting potential concerns related to their nutritional intake and overall lifestyle. The data suggests a need for interventions focused on balanced nutrition and weight management[17].

Males showed a higher percentage of 'Overweight' (32.38%) compared to females (21.65%). Conversely, a higher percentage of female were 'Obese' (14.43%) compared to male (6.67%) (Table-2 & Fig-2).

The WHR results indicated that the mean & SD of WHR value of all participants is 0.87 ± 0.08 (Table-1). 56.93% of students had a low risk of cardiovascular diseases, 17.82% were at moderate risk, and 25.25% were at high risk. (Table: 2). Similar observation has been made by Flint et.al 2010[18] who found that "both higher BMI and larger waist circumference were independently associated with an increased risk of Coronary Heart Disease (CHD). Importantly, waist circumference provided additional predictive value for CHD risk beyond BMI, suggesting that central obesity (indicated by waist circumference & waist-hip ratio) may be a stronger predictor of heart disease than overall obesity. This research highlights the significance of measuring waist-hip ratio in assessing cardiovascular risk, supporting the use of waist circumference along with BMI in clinical settings for a more accurate risk assessment. The distribution suggests that while a majority of students are at lower risk, a significant portion still faces a higher risk of cardiovascular and other chronic diseases.

Central adiposity is associated with elevated levels of visceral fat, which is metabolically active and strongly linked to insulin resistance, inflammation, and increased CVD risk. Studies suggest that even in younger populations, such as college & university students, elevated WHR is associated with an increased likelihood of developing metabolic syndrome and other chronic conditions over time if preventive measures are not taken [19].

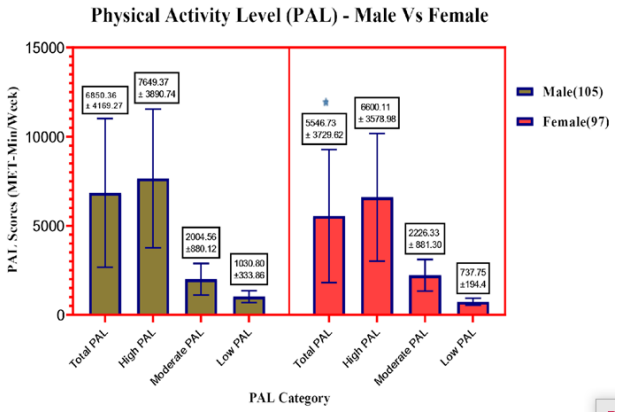

Figure-1: Comparison of Physical Activity Level Categories between Male and Female (values are Mean ± Standard deviation; "t" test was done and *p < 0.05 was considered to be significant.)

The results indicated a statistically significant difference in the mean of total PAL scores between male and female (p-value < 0.05). Specifically, male students exhibit a higher mean PAL compared to females. (Table-1,2 & Figure-1). These findings are consistent with the studies of Wang et al., 2021[20], that have noted gender differences in physical activity patterns and body composition. The probable cause behind this may be the metabolic and Physiological differences (Body composition & Hormonal influences)[21]. Dietary and Eating Habits[22] & Socio-cultural and Psychological Factors[23].

The BMI scores revealed statistically insignificant difference between male and female (p value >0.05) (Table-1 & Figure-2). Al-Isa et.al; (2004)[24] observed similar patterns among Kuwaiti adolescents.

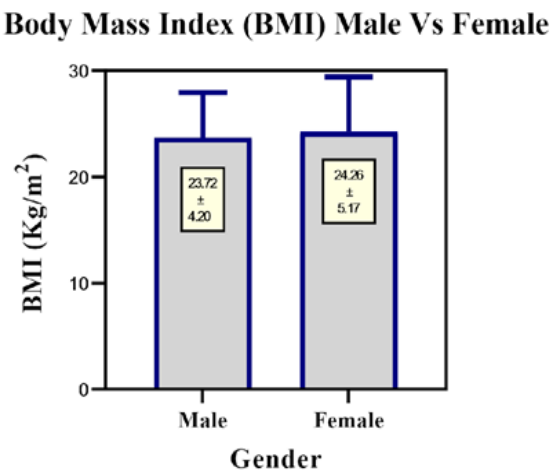

Figure-2: Comparison of Body Mass Index (BMI) between Male and Female (values are Mean ± Standard deviation; "t" test was done and p > 0.05 was considered to be insignificant).

A higher percentage (91.43%) of male students were classified under 'Low risk' compared to females (46.39%). Females had a higher percentage of 'High risk' (19.59%) compared to their male counterparts (2.86%) (Table:2 & Fig:3).

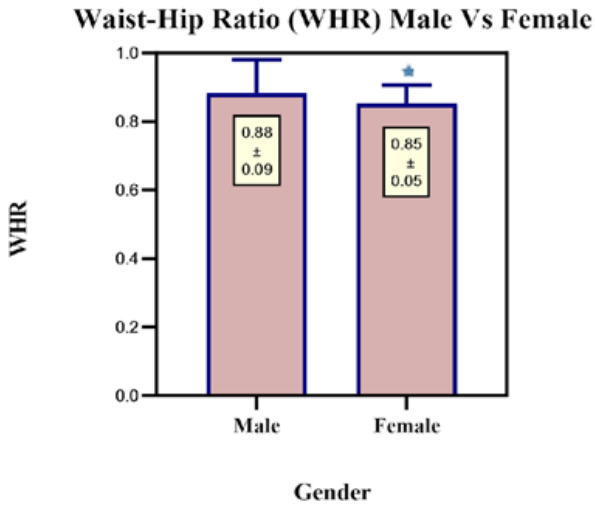

Figure 3: Comparison of Waist-Hip Ratio (WHR) between Male and Female (values are Mean ± Standard deviation; "t" test was *doneand* *p < 0.05 was considered to be significant).

This study emphasizes the importance of waist circumference & WHR as useful measures for assessing obesity-related health risks.

Results revealed that majority of students fall within a moderate to high level of physical activity, with a significant portion at risk for chronic diseases due to elevated BMI and WHR. Females are significantly more under obese category (indicated by BMI) and at a higher risk to cardio-vascular diseases (indicated by WHR) than the males. Although the WHR data aligns with the BMI findings yet more proportion of female are under high risk (46.39%) than the obese (14.43%) (Table-2) indicating that Central obesity/WHR is a more significant indicator of the health status within this population. This finding also corroborates with the finding of Lee C.M et.al 2008[25] which revealed that the Indices of abdominal obesity (Waist circumference & WHR) are better discriminators of cardiovascular risk factors than BMI.

The analysis of the correlation between PAL scores and the two health-related measures i.e., BMI and WHR, yielded results indicating that PAL scores do not significantly explain the variance in either independent variable, suggesting a lack of statistical significance in these relationships.

Although not statistically significant, the correlation between PAL scores with WHR (β = 0.034) was slightly stronger than with BMI (β = 0.006), indicating a marginally better association of PAL score with WHR than BMI. (Table-3)

Table 3: PAL co-relation with BMI &WHR (PAL-Dependent variable, BMI &WHR- Independent variable)

Co-relation	p-value	Standard co-efficient Beta
PAL with BMI	0.928	0.006
PAL with WHR	0.632	0.034

This observation is consistent with findings from a study by Slentz et al., 2004[26], which reported that physical activity may have a more pronounced effect on body fat distribution than on overall body weight. These results highlight the complexity of the relationship between physical activity and various health matrices. Factors such as individual variability in response to exercise, dietary habits, and genetic predispositions may contribute to the observed lack of significant correlation. Future research should consider these factors and explore more precise models that account for the multifaceted nature of physical activity and health.

This study raised a critical question that in spite of high PAL value (82.18%) and Low percentage of Obese (10%) observed among college student population why a significant no. of students (25.25%) falls under the category of high risk of chronic disease? (Figure- 4)

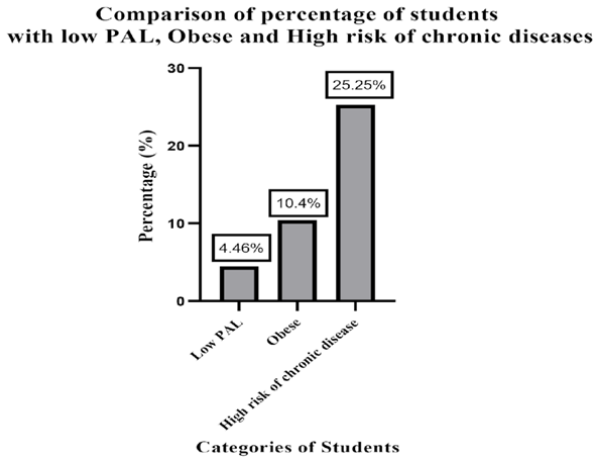

Fig 4: Comparison of percentage of students with Low PAL, Obese and High risk of chronic diseases (Values are shown in percentage)

Conclusion

This study underscores the importance of examining the relationship between Physical factors like BMI and WHR with physical activity levels (PAL) and the risk of chronic disease among college students. While physical activity is essential, its effects on BMI and WHR are influenced by factors such as diet, metabolism, and genetics. The lack of significant correlation between PAL and WHR suggests that physical activity alone does not determine health status. Despite high PAL among students, elevated rates of overweight and central obesity point to other contributing factors. WHR proves to be a more specific indicator of central obesity risk than BMI, especially among females who, despite normal BMI, show higher obesity risk. Comprehensive health programs promoting physical activity, balanced diets, and regular check-ups are crucial. Educational institutions must actively support such initiatives. Limitations include self-reported PAL data, small sample size, and unexamined behavioural factors, warranting further research.

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Ethical clearance: Ethical clearance has been taken from Institutional Human Ethical Committee, Department of Physiology, University of Calcutta, Ref.no. IHEC/AC/P89/2019 dated 18.12.2019.

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