Section: Miscellaneous

Original Research Article

PREVALENCE OF INSULIN RESISTANCE ESTIMATED BY MEANS OF HOMEOSTATIC MODEL ASSESSMENT FOR INSULIN RESISTANCE (HOMA-IR) IN MEDICAL UNDERGRADUATES IN AGE RANGE 18- 21 YEARS, AND ITS CORRELATIONS WITH ANTHROPOMETRIC MEASUREMENTS

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ABSTRACT

Background: Insulin resistance (IR) is a key metabolic abnormality underlying type 2 diabetes mellitus, metabolic syndrome, and cardiovascular diseases. Early identification in young adults is essential to prevent long-term complications. Medical students are particularly vulnerable due to sedentary lifestyles, academic stress, and irregular dietary habits. Therefore, screening for insulin resistance in this population is of significant clinical importance. The objective are 1. To estimate the prevalence of insulin resistance among medical undergraduates using HOMA-IR. 2. To correlate anthropometric parameters (body mass index, waist circumference, waist–hip ratio and waist-height ratio) with fasting blood glucose, fasting insulin levels and HOMA-IR.

Materials and Methods: A cross-sectional observational study was conducted among 55 medical undergraduates aged 18–21 years. Anthropometric parameters, including body mass index (BMI), waist circumference (WC), waist–hip ratio (WHR) and waist-to-height ratio (WHtR)were measured using standardized techniques. Fasting blood glucose and fasting insulin levels were estimated after overnight fasting. Insulin resistance was calculated using the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), with a cut-off value of >2.6. Statistical analysis was performed using SPSS, employing Pearson's and spearmans correlation and Chi-square tests, with a p-value <0.05 considered statistically significant.

Results: The mean fasting blood glucose and fasting insulin levels were 92.8 ± 10.6 mg/dL and 11.9 ± 5.2 µIU/mL, respectively, with a mean HOMA-IR of 2.73. Insulin resistance was observed in 32.7% of participants. HOMA-IR showed significant positive correlations with BMI ($r = 0.56$), WC ($r = 0.62$), WHR ($r = 0.49$) and WHtR ($r = 0.65$), ($p < 0.01$). Central obesity indices, particularly WHtR and WC, demonstrated the strongest associations with insulin resistance. No significant association was observed between IR and sociodemographic variables.

Conclusion: A considerable proportion of apparently healthy medical students exhibited insulin resistance. Anthropometric indices, especially waist-to-height ratio and waist circumference, serve as simple, cost-effective screening tools for early detection. Routine screening and lifestyle interventions are recommended to mitigate future metabolic risk.

Keywords: Insulin Resistance, HOMA-IR, Medical Students, Anthropometry, Waist-to-Height Ratio, Fasting Insulin, Screening.

INTRODUCTION

Insulin resistance (IR) is a metabolic condition in which target tissues such as skeletal muscle, adipose tissue, and liver exhibit a diminished response to normal circulating levels of insulin. As a compensatory mechanism, pancreatic β-cells increase insulin secretion, resulting in hyperinsulinemia in the early stages. Over time, this adaptive response becomes inadequate, leading to impaired glucose tolerance and eventual progression to type 2 diabetes mellitus (T2DM).[1,2]

Insulin resistance is widely recognized as a key underlying factor in the development of multiple chronic non-communicable diseases. It contributes significantly to the pathogenesis of T2DM, metabolic syndrome, cardiovascular diseases, hypertension, non-alcoholic fatty liver disease (NAFLD), and polycystic ovarian syndrome (PCOS).[2,3] Persistent IR promotes endothelial dysfunction, chronic low-grade inflammation, and accelerated atherosclerosis, thereby increasing long-term morbidity and mortality.[3]

Assessment of insulin resistance can be performed using both direct and indirect techniques. The hyperinsulinemic-euglycemic clamp is considered the gold standard; however, its complexity and cost limit its use in large-scale or screening settings.[4] Therefore, surrogate markers such as fasting insulin levels, fasting blood glucose, and derived indices like the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) are widely used in clinical and research practice.[4-7] Additionally, anthropometric parameters such as body mass index (BMI), waist circumference, waist–hip ratio and waist-height ratio provide simple, non-invasive, and cost-effective tools for early screening, especially in resource-constrained environments.[8]

The global burden of insulin resistance is 26% to 30% which varies across different populations and geographical regions, this can be seen as substantial and continues to rise.[9]

In India, the situation is particularly concerning due to a combination of genetic susceptibility, rapid urbanization, sedentary lifestyles, and dietary transitions. Studies conducted in Indian populations have demonstrated a high prevalence of insulin resistance even among apparently healthy individuals and those at increased familial risk of diabetes.[10-13] This indicates that a significant proportion of the population may remain undiagnosed during the early, reversible stages of metabolic dysfunction.

Young adults, particularly medical students, are frequently overlooked in metabolic screening despite being at risk due to irregular diets, physical inactivity, academic stress, and poor sleep patterns, which predispose them to early insulin resistance and related disorders.[14,15] Early detection is essential, as timely lifestyle interventions can reverse insulin resistance and prevent long-term complications. Given the increasing burden of metabolic diseases and the lack of routine screening in asymptomatic individuals, the combined use of anthropometric measurements with fasting blood glucose and fasting insulin levels provides a simple, reliable, and cost-effective strategy for large-scale screening and early identification of insulin resistance.[16]

Therefore, the present study aims to screen medical undergraduates for insulin resistance and its correlation with anthropometric measurements. Identifying insulin resistance at an early stage in this population may help in implementing preventive strategies and reducing the long-term risk of metabolic diseases.

Objectives

1. To estimate the prevalence of insulin resistance among medical undergraduates using HOMA-IR.
2. To correlate anthropometric parameters (body mass index, waist circumference, waist–hip ratio and waist-height ratio) with fasting blood glucose, fasting insulin levels and HOMA-IR.

MATERIALS AND METHODS

This was a cross-sectional, observational study conducted in a tertiary care teaching hospital among medical undergraduates. The study was carried out over a period of 14 months after obtaining institutional approval.

Inclusion Criteria

- Age between 18–21 years
- Students who provided informed written consent

Exclusion Criteria

- Known cases of diabetes mellitus or endocrine disorders
- Students on medications affecting glucose metabolism (e.g., corticosteroids)
- Those with acute illness at the time of study
- Students unwilling to participate

Sample Size: Sample size was calculated using formula for finite population. Where, Z α is the standard normal deviate, 1.96 at 95% confidence interval.

Prevalence of insulin resistance in medical students as per study by Sannamadhu et al, it was 28.9%.[17]

Hence P = Prevalence is 28.9%. i.e P = 0.289, 1-P = (1-0.289)

e = allowable error was 10%

N = study population (No. of students in 2nd MBBS in our institute) = 180,

$$Sample\ size(n) = \frac{\frac{z^2 X\, p(1-p)}{e^2}}{1 + \frac{z^2 X\, p(1-p)}{e^2 N}}$$

$$Sample\ size(n) = \frac{\frac{(1.96)^2 X\ 0.289(1-0.2)}{(0.1)^2}}{1 + \frac{(1.96)^2 X\ 0.289(1-0.289)}{(0.1)^2\ 180}}$$

Sample size(n)required is=55

Thus a total of 55 students were included in the study with 10% absolute precision and 95% confidence considering the feasibility and availability of eligible participants during the study period.

Sampling method: Students were selected by random sampling method.

Ethical Considerations: Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study. Confidentiality of the collected data was strictly maintained.

Data Collection Procedure: After obtaining students consent data was collected using a semi-structured questionnaire. data was collected on socio-demography, anthropometric assessment, and biochemical investigations.

1. Anthropometric Measurements

Anthropometric parameters were recorded using standardized techniques:

- Height (cm): Measured using a stadiometer with participants standing barefoot
- Weight (kg): Measured using a calibrated digital weighing scale
- Body Mass Index (BMI): Calculated as weight (kg)/height (m^2)
- Waist Circumference (WC): Measured at the midpoint between the lower margin of the last rib and the iliac crest
- Hip Circumference (HC): Measured at the level of the greater trochanters
- Waist–Hip Ratio (WHR): Calculated as WC/HC
- Waist- height ratio (WHtR) : Calculated as WC/ Height

2. Biochemical Assessment

Participants were instructed to undergo overnight fasting (8–12 hours) prior to sample collection.

- Fasting Blood Glucose (FBG): Measured using venous blood samples by standard enzymatic methods
- Fasting Serum Insulin: Estimated using immunoassay techniques

3. Assessment of Insulin Resistance

Insulin resistance was calculated using the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR):

$$HOMA\text{-}IR = \frac{\text{Fasting Insulin (\textbackslash muU/mL)} \times \text{Fasting Glucose (mg/dL)}}{405}$$

A predefined cut-off value (commonly >2.5 or as per population standards) was used to classify participants as insulin resistant.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using statistical software such as SPSS version 28.

- Continuous variables were expressed as mean ± standard deviation (SD)
- Categorical variables were expressed as frequencies and percentages
- Association between insulin resistance and anthropometric/biochemical variables was assessed using appropriate statistical tests such as the Chi-square test and pearsons and spearmans correlation coefficient.
- A p-value of <0.05 was considered statistically significant.

RESULTS

Out of the 55 students included in this study age was 19, 20 and 21 years in 45.5%, 38.1% and 16.4% respectively. Males were 40% and females were 60% showing almost equal distribution. Regarding religion, most participants were Hindu, comprising 40 individuals (72.7%). Muslims represented 8 participants (14.5%), and Christians accounted for 7 participants (12.8%). With respect to socioeconomic status, a predominant majority belonged to the upper class, with 48 participants (87.2%), whereas 7 participants (12.8%) were from the middle socioeconomic group. [Table 1]

Table 1: Distribution by patient's characteristics

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	19	25	45.5
	20	21	38.1
	21	9	16.4
Gender	Male	22	40
	Female	33	60
Religion	Hindu	40	72.7
	Muslim	8	14.5
	Christian	7	12.8
Socioeconomic Status (SES)	Upper	48	87.2
	Middle	7	12.8

The anthropometric parameters of the study participants showed that the mean Body Mass Index (BMI) was 23.6 ± 3.8 kg/m². The mean waist circumference was 82.4 ± 9.5 cm, reflecting the central fat distribution among the participants. The average waist–hip ratio (WHR) was 0.87 ± 0.06, suggesting a tendency toward central adiposity in a proportion of individuals. Similarly, the mean waist-to-height ratio (WHtR) was 0.51 ± 0.06, which is slightly above the commonly recommended cutoff of 0.5. [Table 2]

Table 2: Distribution by Anthropometric measurements

Parameter	Mean ± SD
BMI (kg/m²)	23.6 ± 3.8
Waist Circumference (cm)	82.4 ± 9.5
Waist–Hip Ratio (WHR)	0.87 ± 0.06
Waist-height ratio (WHtR)	0.51 ± 0.06

The biochemical profile of the study participants showed that the mean fasting blood glucose level was 92.8 ± 10.6 mg/dL and the mean fasting insulin level was 11.9 ± 5.2 µIU/mL, and Mean HOMA-IR ≈ 2.73± 0.5. indicating the baseline insulin status of the participants. The observed variation suggests differences in insulin sensitivity among individuals within the study population. [Table 3]

Table 3: Distribution by biochemical measurements

Parameter	Mean ± SD
Fasting Blood Glucose (mg/dL)	92.8 ± 10.6
Fasting Insulin (µIU/mL)	11.9 ± 5.2
HOMA-IR	2.73± 0.5

A predefined cut-off value (commonly >2.5 or as per population standards) was used to classify participants as insulin resistant, of 55 participants IR was seen in 32.7%. [Figure 1]

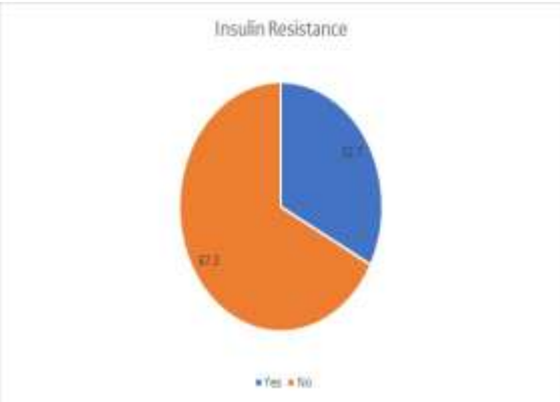

Figure 1: Distribution by insulin resistance as per HOMA IR

Pearson's and spearmans correlation analysis demonstrated positive associations between anthropometric parameters and biochemical indicators of insulin resistance.

Fasting glucose showed weak but statistically significant correlations with BMI ($r = 0.28$, $p < 0.05$), waist circumference ($r = 0.31$, $p < 0.05$), and waist-to-height ratio (WHtR) ($r = 0.34$, $p < 0.05$), while its associations with waist–hip ratio (WHR) ($r = 0.22$).

Fasting insulin exhibited moderate and highly significant positive correlations with all anthropometric indices: BMI ($r = 0.52$), waist circumference ($r = 0.58$), WHR ($r = 0.46$), WHtR ($r = 0.61$).

Similarly, HOMA-IR showed strong and statistically significant correlations with WHtR ($r = 0.65$) and waist circumference ($r = 0.62$), followed by BMI ($r = 0.56$) and WHR ($r = 0.49$) ($p < 0.01$). Among all anthropometric measures, WHtR emerged as the strongest predictor of insulin resistance. [Table 4]

Table 4: Correlation of Biochemical parameters with anthropometry.

Parameter	Fasting Glucose (r)	Fasting Insulin (r)	HOMA-IR (r)
BMI	0.28*	0.52**	0.56**
Waist Circumference (cm)	0.31*	0.58**	0.62**
Waist–Hip Ratio (WHR)	0.22	0.46**	0.49**
Waist-to-Height Ratio (WHtR)	0.34*	0.61**	0.65**

* $p < 0.05$, ** $p < 0.01$

The distribution of insulin resistance (IR) across different variables was assessed.

With respect to age, among participants aged 19 years, 9 (36.0%) had IR while 16 (64.0%) did not. In the 20-year age group, 7 (33.3%) had IR and 14 (66.7%) were IR absent. Among those aged 21 years, 2 (22.2%) had IR while 7 (77.8%) did not. The association between age and IR was not statistically significant ($p = 0.78$).

Regarding gender, 10 males (45.4%) had IR and 12 (54.6%) did not, whereas among females, 8 (24.4%) had IR and 25 (75.6%) were IR absent. There was no significant association between gender and IR ($p = 0.1$).

In terms of religion, 13 Hindus (32.5%) had IR and 27 (67.5%) did not, while among participants of other religions, 5 (33.3%) had IR and 10 (66.7%) were IR absent. This association was also not statistically significant ($p = 0.94$).

With respect to socioeconomic status, among participants from the upper class, 17 (33.3%) had IR and 31 (66.7%) did not, whereas in the middle class, 1 (33.3%) had IR and 6 (66.7%) were IR absent. No statistically significant association was observed between socioeconomic status and IR ($p = 0.88$).

Overall, none of the studied variables showed a significant relationship with insulin resistance ($p > 0.05$). [Table 4]

Table 5: Association of patient's characteristics with Insulin resistance.

Variable	Category	IR Present n (%)	IR Absent n (%)	p-value
Age	19	9 (36.0)	16 (64.0)	0.78
	20	7 (33.3)	14 (66.7)	
	21	2 (22.2)	7 (77.8)	
Gender	Male	10 (45.4)	12 (54.6)	0.1
	Female	8 (24.4)	25(75.6)	
Religion	Hindu	13 (32.5)	27 (67.5)	0.94
	Others	5 (33.3)	10 (66.7)	
SES	Upper	17 (33.3)	31 (66.7)	0.88
	Middle	1 (33.3)	6 (66.7)	

DISCUSSION

The present study evaluated the relationship between anthropometric parameters and insulin resistance (IR) among young adults, along with their association with fasting glucose and insulin levels. The findings highlight the significant role of adiposity—particularly central obesity—in influencing metabolic risk.

Out of the 55 students included in this study age was 19, 20 and 21 years in 45.5%, 38.1% and 16.4% respectively. Males were 40% and females were 60%. Regarding religion, most participants were Hindu, comprising 40 individuals (72.7%). Muslims represented 8 participants (14.5%), and Christians accounted for 7 participants (12.8%). With respect to socioeconomic status, a predominant majority belonged to the upper class, with 48 participants (87.2%), whereas 7 participants (12.8%) were from the middle socioeconomic group. Similarly in study by Sannamadhu M et al out of 460 students, 228 (49.6%) were males and 232 (50.4%) were females. The mean age of the subjects was 19.73±1.4years.[17] Also in study by Ms Shaila et al mean age was 21.6 ± 2.3 which was almost similar.[18]

In this study, the mean BMI (23.6 ± 3.8 kg/m²) and waist circumference (82.4 ± 9.5 cm) suggest that the study population largely falls within the normal to borderline overweight category. However, despite relatively normal BMI values, the observed waist–hip ratio (0.87 ± 0.06) and waist-to-height ratio (0.51 ± 0.06) indicate a tendency toward central adiposity. In study by Sannamadhu M et al BMI (kg/m²) was 22.63±3.17, WC (cm) was 78.60±9.31 and WHR was 0.84±0.05.[17] In study by Shaila Ms et al, the participants' mean BMI was 24.3 ± 3.5 kg/m² [18], thus our study findings are in same trend with the other studies.

The biochemical findings revealed that mean fasting blood glucose levels (92.8 ± 10.6 mg/dL) were within normal limits, whereas fasting insulin levels (11.9 ± 5.2 µIU/mL) showed variability, indicating early metabolic alterations in this study. In study by Sannamadhu M et al FPG (mmol/L) was 8.62±0.39 and FPI (µIU/ml) was 10.54±5.5.[17] In study by shaila Ms et al, the participants' mean fasting blood sugar level was 92.4 ± 10.7 mg/dL.[18] Findings from various studies are similar and this supports existing evidence that insulin resistance may develop prior to the onset of overt hyperglycaemia and can remain undetected if only glucose levels are assessed.

A predefined cut-off value (commonly >2.5 or as per population standards) was used to classify participants as insulin resistant, of 55 participants IR was seen in 32.7% and Mean HOMA-IR ≈ 2.73 in this study. Similarly in study by Sannamadhu M et al The mean HOMA-IR value of the participants was 2.19±1.2. with 71.1% had HOMA-IR value <2.5 and remaining 28.9% had ≥2.5 indicating the presence of IR,[17] which was similar to our study finding.

Pearson's correlation analysis demonstrated positive associations between anthropometric parameters and biochemical indicators of insulin resistance in this study. Fasting glucose showed weak but statistically significant correlations with BMI ($r = 0.28$, $p < 0.05$), waist circumference ($r = 0.31$, $p < 0.05$), and waist-to-height ratio (WHtR) ($r = 0.34$, $p < 0.05$), while its associations with waist–hip ratio (WHR) ($r = 0.22$) were not statistically significant.

Fasting insulin exhibited moderate and highly significant positive correlations with all anthropometric indices: BMI ($r = 0.52$), waist circumference ($r = 0.58$), WHR ($r = 0.46$) and WHtR ($r = 0.61$).

Similarly, HOMA-IR showed strong and statistically significant correlations with WHtR ($r = 0.65$) and waist circumference ($r = 0.62$), followed by BMI ($r = 0.56$) and WHR ($r = 0.49$) ($p < 0.01$). Among all anthropometric measures, WHtR emerged as the strongest predictor of insulin resistance in this study. In study by Ms Shaila et al, a moderately positive correlation ($r = 0.47$), statistically significant ($p < 0.001$), was found between BMI and FBS.[18] In study by Sannamadhu et al HOMA-IR demonstrated significant positive correlations with several anthropometric, hemodynamic, and biochemical parameters. It showed weak-to-moderate associations with BMI ($r = 0.274$, $p < 0.001$) and waist circumference ($r = 0.345$, $p < 0.001$), while a weaker but statistically significant correlation was observed with waist–hip ratio ($r = 0.150$, $p = 0.001$). Among biochemical parameters, it showed moderate correlations with fasting plasma glucose (FPG) ($r = 0.311$, $p < 0.001$) and an exceptionally strong correlation with fasting plasma insulin (FPI) ($r = 0.986$, $p < 0.001$).[17] Thus our findings are consistent with previous studies that identify both BMI and waist circumference as strong predictors of insulin resistance, with waist circumference reflecting visceral adiposity more accurately and WHtR more strongly correlated.

In study by Davids SF et al, fasting blood glucose (7.90 mmol/L vs. 5.90 mmol/L), fasting insulin (6.7 mIU/L vs. 5.9 mIU/L) and HOMA-IR (4.58 vs. 1.27) were significantly higher in participants with IRs (all $p < 0.001$). Among all participants, the strongest correlations were observed with waist circumference ($r = 0.608$), waist-to-height ratio ($r = 0.602$), and BMI ($r = 0.599$), indicating the prominent role of central and overall adiposity in predicting insulin resistance. Moderate correlations were noted with body fat percentage ($r = 0.537$), hip circumference ($r = 0.530$), and visceral fat levels ($r = 0.528$), while waist-to-hip ratio ($r = 0.365$) demonstrated a comparatively weaker but still significant association.[19]

Overall, the present study reinforces the importance of central obesity as a key determinant of insulin resistance. Central obesity indices—particularly waist-to-height ratio ($r = 0.65$) and waist circumference ($r = 0.62$)—demonstrated the strongest correlations with HOMA-IR, highlighting their value as practical screening tools for insulin resistance.

CONCLUSION

This study revealed a notable prevalence of insulin resistance among medical undergraduates, with 32.7% of participants exhibiting insulin resistance (HOMA-IR > 2.6) and a mean HOMA-IR of 2.73. Anthropometric indices showed significant positive correlations with biochemical markers of insulin resistance. HOMA-IR demonstrated the strongest associations with waist-to-height ratio ($r = 0.65$) and waist circumference ($r = 0.62$), followed by BMI ($r = 0.56$), MUAC ($r = 0.52$), and waist–hip ratio ($r = 0.49$) ($p < 0.01$). Fasting insulin correlated more strongly with anthropometric measures than fasting glucose, highlighting its utility as an early indicator of metabolic dysfunction.

These findings indicate that central obesity—particularly reflected by WHtR and waist circumference—is a key predictor of insulin resistance. The study underscores that simple and cost-effective tools, including anthropometric measurements, fasting blood glucose, and fasting insulin, are effective for early screening. Routine assessment and timely lifestyle interventions are recommended to mitigate future cardiometabolic risks among young adults.

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