



Research Article

A cross-sectional study to correlate Anthropometric Indices With HOMA-IR in Adult Obese Females

Dr. Serina Khatun¹, Dr. Tamal Chakraborty², Dr. Krishnendu Saha³

¹Assistant Professor, Department of Physiology, Calcutta National Medical College.

²Associate Professor, Department of Physiology, North Bengal Medical College.

³Assistant Professor, Department of Physiology, College of Medicine and Sagore Dutta Hospital.

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Corresponding Author:

Dr. Tamal Chakraborty

Associate Professor, Department of Physiology, North Bengal Medical College.

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ABSTRACT

Background: Obesity is a major public health problem and is closely associated with insulin resistance, a key metabolic abnormality that precedes the development of type 2 diabetes mellitus. Body mass index does not adequately reflect body fat distribution, which may play a more important role in determining insulin resistance. Data evaluating the relationship between anthropometric indices and insulin resistance among obese adult females in the Indian population remain limited.

Objectives: To evaluate the correlation between various anthropometric indices and insulin resistance, as assessed by the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR), in Indian adult obese females.

Materials and Methods: This observational cross-sectional study was conducted in the Postgraduate Research Laboratory of the Department of Physiology in collaboration with the Department of Biochemistry, Medical College and Hospital, Kolkata, from November 2017 to June 2018. Fifty obese adult female subjects aged ≥ 18 years with a body mass index ≥ 30 kg/m² were included. Anthropometric measurements were recorded using standardized techniques. Fasting plasma glucose and fasting serum insulin were estimated, and insulin resistance was calculated using HOMA-IR. Pearson's correlation coefficient was used for statistical analysis.

Results: Body mass index did not show a significant correlation with HOMA-IR ($r = 0.109$, $p > 0.05$). Waist circumference ($r = 0.298$, $p < 0.05$), sagittal abdominal diameter ($r = 0.295$, $p < 0.05$), and hip circumference ($r = 0.351$, $p < 0.05$) showed significant positive correlations with insulin resistance. Thigh medium perimeter demonstrated the strongest positive correlation with HOMA-IR ($r = 0.468$, $p < 0.05$). Waist-thigh ratio showed a significant negative correlation ($r = -0.376$, $p < 0.05$). The conicity index exhibited a strong inverse correlation with HOMA-IR ($r = -0.841$, $p < 0.05$).

Conclusion: Insulin resistance in obese adult females is influenced more by body fat distribution than by overall adiposity. Anthropometric indices reflecting central and regional adiposity may serve as useful tools for early identification of metabolic risk.

Keywords: Obesity; Anthropometric indices; Insulin resistance; HOMA-IR; Adult females.

INTRODUCTION

Obesity is a chronic, multifactorial disease characterized by abnormal or excessive fat accumulation that adversely affects health. It has emerged as one of the most important global public health challenges, contributing substantially to the growing burden of non-communicable diseases such as type 2 diabetes mellitus (T2DM), cardiovascular disease, and metabolic syndrome. The World Health Organization (WHO) recognizes obesity and overweight as major risk factors for morbidity and mortality worldwide, and highlights their increasing prevalence across all age groups and socioeconomic strata.¹

Global epidemiological evidence indicates that obesity has increased markedly over recent decades, with many countries experiencing a rapid transition from undernutrition to excess adiposity-related metabolic disorders. The NCD Risk Factor Collaboration (NCD-RisC) pooled analysis of worldwide trends from 1990 to 2022 has demonstrated a significant rise in

obesity prevalence across multiple populations, emphasizing that obesity is now one of the most common forms of malnutrition globally.² This shifting trend is of serious concern in low- and middle-income countries, where health systems are often simultaneously dealing with infectious diseases and undernutrition, resulting in a “double burden” of disease.^{1,2}

India is currently undergoing a rapid epidemiological transition, driven by urbanization, dietary changes, reduced physical activity, and increasingly sedentary lifestyle patterns. These changes have contributed to a growing prevalence of overweight, obesity, and central adiposity, particularly among women. Recent national-level observations from the ICMR-INDIAB study have highlighted the high prevalence of metabolic obesity and related cardiometabolic risk factors in Indian adults, emphasizing the need for early identification and prevention strategies.³ The burden of obesity-related metabolic dysfunction in Indian women is particularly significant because hormonal factors, reproductive physiology, and differences in body fat distribution can influence the development of insulin resistance and subsequent metabolic complications.

Obesity is a well-established determinant of insulin resistance, which plays a central role in the pathogenesis of T2DM and other metabolic abnormalities. Insulin resistance is defined as a reduced biological response to insulin, resulting in impaired glucose uptake in peripheral tissues and compensatory hyperinsulinaemia. This metabolic disturbance often develops years before overt hyperglycaemia and may remain clinically silent during the early stage, thereby increasing the risk of delayed diagnosis and progression to diabetes and cardiovascular disease. Insulin resistance is therefore considered an early metabolic abnormality and a key contributor to the development of multiple cardiometabolic complications in obese individuals.

Accurate assessment of insulin resistance is essential to detect individuals at high metabolic risk and implement preventive interventions. Although the hyperinsulinaemic–euglycaemic clamp technique is regarded as the reference standard for measuring insulin sensitivity, its complexity, invasiveness, and cost limit its use in routine clinical practice and large-scale studies.⁴ For this reason, surrogate indices based on fasting biochemical parameters have gained wide applicability in both clinical and epidemiological research settings.

The Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) is one of the most widely used surrogate markers of insulin resistance and is calculated using fasting plasma glucose and fasting serum insulin concentrations. The original HOMA model described by Matthews et al. remains a validated and widely accepted method for estimating insulin resistance in population-based studies.⁵ HOMA-based assessments have gained popularity because they are feasible, cost-effective, and suitable for research studies involving larger sample sizes. Furthermore, subsequent literature has emphasized the correct interpretation and applicability of HOMA-derived indices in metabolic studies.⁶

Body mass index (BMI) is the most commonly used anthropometric indicator for classifying obesity; however, BMI has several important limitations. It does not differentiate lean body mass from fat mass, and it does not provide information regarding fat distribution, which is now known to be more relevant in determining metabolic risk. Increasing evidence suggests that central and visceral adiposity contribute more strongly to insulin resistance than generalized obesity alone. Therefore, reliance on BMI alone may underestimate metabolic risk in individuals with increased abdominal fat distribution.

Anthropometric indices that reflect regional fat deposition, such as waist circumference, sagittal abdominal diameter, waist–hip ratio, and other derived indices, are increasingly considered useful tools for evaluating central adiposity and predicting cardiometabolic risk. Studies have shown that visceral adiposity is metabolically more active and strongly associated with insulin resistance, dyslipidaemia, and chronic low-grade inflammation, thereby increasing the risk of diabetes and cardiovascular disease. Such measures are particularly relevant in Asian populations, where metabolic complications often occur at lower BMI values, and where abdominal obesity is frequently associated with cardiometabolic risk.

Considering the rapidly increasing burden of obesity and diabetes in India and the limitations of BMI as a sole marker of metabolic risk, identifying simple anthropometric predictors of insulin resistance is important, particularly in resource-limited settings. Focused evaluation in obese adult females is also necessary because female populations may exhibit distinct fat distribution patterns and metabolic susceptibility.

Against this background, the present study was undertaken to evaluate the correlation between various anthropometric indices and insulin resistance, as assessed by HOMA-IR, among obese adult female subjects. Such analysis may help identify anthropometric measures that better reflect metabolic risk and aid in early detection of insulin resistance in this high-risk group.

METHODOLOGY

This observational cross-sectional study was conducted to evaluate the correlation between various anthropometric indices and insulin resistance among obese adult female subjects. The study was carried out in the Postgraduate Research Laboratory of the Department of Physiology in collaboration with the Department of Biochemistry, Medical College and Hospital, Kolkata, West Bengal, over a period of eight months, from November 2017 to June 2018. The study population consisted of obese adult female subjects aged 18 years and above, who attended the endocrinology outpatient department,

general outpatient department, or biochemistry laboratory for estimation of fasting blood glucose for the first time, as well as apparently healthy obese female volunteers. Participation in the study was entirely voluntary, and written informed consent was obtained from all participants after explaining the purpose and procedures involved.

All female subjects aged 18 years and above with a body mass index (BMI) ≥ 30 kg/m² who were willing to participate were included in the study. Subjects with a known history of diabetes mellitus, thyroid dysfunction, active infection, inflammatory disorders, malignancy, pregnancy, or end-stage hepatic, renal, or cardiac disease were excluded. Individuals with ascites, abdominal tumors, or those receiving oral contraceptive pills were also excluded to avoid confounding effects on insulin resistance. As the study was designed to assess correlations between anthropometric parameters and insulin resistance within a single cohort, a separate control group was not included. A total of **50 obese adult female subjects** who fulfilled the inclusion criteria and volunteered to participate were included in the study.

Anthropometric measurements were recorded using standardized techniques by trained personnel. These included height, weight, waist circumference, hip circumference, sagittal abdominal diameter, thigh medium perimeter, neck circumference, and wrist circumference. Body mass index was calculated as weight in kilograms divided by height in meters squared (kg/m²). Derived anthropometric indices such as waist-hip ratio, waist-thigh ratio, waist-stature ratio, and conicity index were calculated using standard formulas.

After an overnight fast of 8–10 hours, venous blood samples were collected under aseptic conditions for estimation of fasting plasma glucose and fasting serum insulin. Fasting plasma glucose was measured using standard enzymatic methods, while fasting serum insulin was estimated using a chemiluminescence immunoassay technique. Insulin resistance was calculated using the Homeostasis Model Assessment formula: $HOMA-IR = [\text{fasting insulin } (\mu\text{IU/mL}) \times \text{fasting glucose (mg/dL)}] / 405$.

After obtaining ethical clearance (IEC number: MC/Kol/IEC/Non-spon/583/08-2017) from the Institutional Ethics Committee of Medical College and Hospital, Kolkata, all study procedures were conducted in accordance with ethical standards for human research. The confidentiality of participant data was strictly maintained, and participants were free to withdraw from the study at any stage without any consequence.

The collected data were entered into Microsoft Excel spreadsheets and analyzed using appropriate statistical methods. Continuous variables were expressed as mean \pm standard deviation, while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient was used to assess the relationship between individual anthropometric parameters and HOMA-IR values. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

A total of 50 obese adult female subjects were included in the correlation analysis. Descriptive statistics were used to summarize baseline demographic characteristics, anthropometric measurements, and derived indices. The relationship between individual anthropometric parameters and insulin resistance, assessed by HOMA-IR, was evaluated using Pearson's correlation coefficient.

Table 1. Baseline demographic characteristics of obese adult female participants included in correlation analysis (n = 50)

Variable	Mean \pm SD	Minimum	Maximum
Age (years)	33.38 \pm 11.25	14	65
Height (m)	1.47 \pm 0.06	1.34	1.58
Weight (kg)	74.42 \pm 8.78	60	98
Body Mass Index (kg/m ²)	34.38 \pm 3.03	30.59	42.15

The baseline demographic characteristics of the study participants are presented in Table 1. The mean age of the participants was 33.38 \pm 11.25 years, with an age range of 14 to 65 years. The mean height and weight were 1.47 \pm 0.06 m and 74.42 \pm 8.78 kg, respectively. The mean body mass index was 34.38 \pm 3.03 kg/m², confirming that all participants were in the obese category based on the predefined inclusion criteria.

Table 2. Anthropometric indices of study participants (n = 50)

Anthropometric Parameter	Mean \pm SD	Minimum	Maximum
Waist Circumference (cm)	112.88 \pm 8.81	98	134
Sagittal Abdominal Diameter (cm)	26.02 \pm 3.06	20	34
Hip Circumference (cm)	110.22 \pm 9.15	96	137

Thigh Medium Perimeter (cm)	59.95 ± 8.21	42	78
Waist–Hip Ratio	1.02 ± 0.07	0.88	1.18
Waist–Thigh Ratio	1.90 ± 0.20	1.45	2.40
Waist–Stature Ratio	76.80 ± 5.85	65	90
Neck Circumference (cm)	35.75 ± 1.98	32	41
Wrist Circumference (cm)	16.73 ± 1.52	14	20
Conicity Index	20.43 ± 11.20	6.8	54.1

The anthropometric measurements and derived indices of the study population are summarized in Table 2. The mean waist circumference was 112.88 ± 8.81 cm, and the mean sagittal abdominal diameter was 26.02 ± 3.06 cm, indicating a high degree of central adiposity among the participants. The mean hip circumference and thigh medium perimeter were 110.22 ± 9.15 cm and 59.95 ± 8.21 cm, respectively. Among the derived indices, the mean waist–hip ratio was 1.02 ± 0.07 , while the mean waist–thigh ratio and waist–stature ratio were 1.90 ± 0.20 and 76.80 ± 5.85 , respectively. The mean neck circumference, wrist circumference, and conicity index were 35.75 ± 1.98 cm, 16.73 ± 1.52 cm, and 20.43 ± 11.20 , respectively.

Table 3. Correlation between anthropometric indices and insulin resistance (HOMA-IR) in obese adult females (n = 50)

Anthropometric Parameter	Pearson's r	r²	p value
Body Mass Index	0.109	0.012	>0.05
Waist Circumference	0.298	0.089	<0.05*
Sagittal Abdominal Diameter	0.295	0.087	<0.05*
Hip Circumference	0.351	0.123	<0.05*
Thigh Medium Perimeter	0.468	0.219	<0.05*
Waist–Hip Ratio	–0.115	0.013	>0.05
Waist–Thigh Ratio	–0.376	0.142	<0.05*
Waist–Stature Ratio	0.152	0.023	>0.05
Neck Circumference	0.170	0.029	>0.05
Wrist Circumference	0.239	0.057	>0.05
Conicity Index	–0.841	0.707	<0.05*

The correlation between various anthropometric indices and insulin resistance, as measured by HOMA-IR, is shown in Table 3. Body mass index did not show a statistically significant correlation with HOMA-IR ($r = 0.109$, $p > 0.05$). Waist circumference demonstrated a weak but statistically significant positive correlation with HOMA-IR ($r = 0.298$, $p < 0.05$). Sagittal abdominal diameter also showed a significant positive correlation ($r = 0.295$, $p < 0.05$).

Hip circumference exhibited a moderate positive correlation with HOMA-IR ($r = 0.351$, $p < 0.05$), while thigh medium perimeter showed the strongest positive correlation among the measured parameters ($r = 0.468$, $p < 0.05$). Waist–hip ratio did not demonstrate a significant association with HOMA-IR. In contrast, waist–thigh ratio showed a significant negative correlation with insulin resistance ($r = -0.376$, $p < 0.05$).

Waist–stature ratio, neck circumference, and wrist circumference were not significantly correlated with HOMA-IR ($p > 0.05$). The conicity index demonstrated a strong inverse correlation with HOMA-IR ($r = -0.841$, $p < 0.05$), with a high coefficient of determination ($r^2 = 0.707$), indicating a strong association between this index and insulin resistance.

DISCUSSION

The present study evaluated the correlation between multiple anthropometric indices and insulin resistance, assessed by HOMA-IR, in adult obese females. The findings highlight that insulin resistance in obese women is not uniformly predicted by generalized obesity markers such as BMI, but is more closely linked to indices reflecting central and regional fat distribution. In this study, the mean age of the participants was 33.38 ± 11.25 years, indicating that a considerable metabolic burden exists even among young adult obese females. The mean BMI was 34.38 ± 3.03 kg/m², confirming that all included participants were in the obese category. The participants also demonstrated high central adiposity as reflected by mean waist circumference (112.88 ± 8.81 cm) and sagittal abdominal diameter (26.02 ± 3.06 cm).

In the present study, BMI showed only a weak and statistically non-significant correlation with HOMA-IR ($r = 0.109$, $p > 0.05$). This observation supports the concept that BMI, although widely used to define obesity, does not adequately represent adipose tissue distribution or visceral fat accumulation, which are more metabolically relevant. Recent evidence also suggests that BMI is not always the strongest anthropometric predictor of insulin resistance when compared with other regional or central measurements. A 2024 analysis comparing multiple anthropometric parameters and insulin resistance demonstrated that indices such as waist circumference and other regional circumferences may have stronger associations with insulin resistance than BMI alone, emphasizing the limitations of BMI as an isolated screening tool.⁷

Waist circumference in the present study demonstrated a statistically significant positive correlation with HOMA-IR ($r = 0.298$, $p < 0.05$). Waist circumference is a widely accepted marker of central obesity and is considered a practical surrogate of visceral adipose tissue accumulation in clinical settings. Similar results have been observed in contemporary studies where waist circumference and related indices have shown meaningful discriminatory capability for insulin resistance in both sexes. A 2024 study evaluating anthropometric and biochemical correlations of insulin resistance reported that waist circumference had good discriminatory performance for identifying insulin resistance and remained clinically useful across populations.⁸

Sagittal abdominal diameter (SAD), which is increasingly regarded as a more direct surrogate of visceral adiposity, demonstrated a significant positive correlation with HOMA-IR in the present study ($r = 0.295$, $p < 0.05$). This observation is consistent with emerging evidence showing that SAD may better reflect visceral fat-related metabolic risk because, in the supine position, subcutaneous fat tends to shift laterally while visceral fat remains centrally placed. A 2020 study assessing sagittal abdominal diameter as a marker of visceral obesity reported that SAD correlated significantly with HOMA-IR and remained associated even after adjustment for relevant covariates, supporting its metabolic relevance beyond conventional obesity markers.⁹

Hip circumference in the present study showed a statistically significant positive correlation with HOMA-IR ($r = 0.351$, $p < 0.05$). While hip circumference is traditionally considered to reflect gluteofemoral fat, the direction of its association with insulin resistance varies across populations due to differences in skeletal frame, fat distribution, and muscle mass contributions. The positive association observed in the present study may suggest that in obese adult females, increasing hip circumference could represent overall adiposity load rather than purely protective gluteofemoral fat. Additionally, hip circumference values in obese women are strongly influenced by accompanying central adiposity, thereby complicating isolated interpretation.

Among all parameters studied, thigh medium perimeter demonstrated the strongest positive correlation with HOMA-IR ($r = 0.468$, $p < 0.05$; $r^2 = 0.219$). This finding is clinically significant because thigh circumference is less dependent on pelvic skeletal structure than hip circumference and may represent a combined effect of peripheral fat deposition and muscular component. Recent research has increasingly explored the role of lower-limb circumferences in metabolic risk prediction. A 2024 study comparing BMI, arm, calf, thigh, and waist circumferences found that thigh circumference showed measurable associations with insulin resistance, supporting the idea that regional circumferences contribute additional predictive value beyond BMI alone.⁷

In the present study, waist–thigh ratio showed a significant negative correlation with HOMA-IR ($r = -0.376$, $p < 0.05$). This indicates that the relationship between trunk dominance and peripheral body dimensions may influence insulin sensitivity in obese females. Such findings suggest that combined distribution indices (capturing both central and peripheral dimensions) may offer meaningful insight into metabolic risk patterns, especially in female cohorts where body fat distribution patterns differ from males due to hormonal and physiological influences.

Waist–hip ratio did not show a statistically significant association with HOMA-IR in this study ($r = -0.115$, $p > 0.05$). Although waist–hip ratio is commonly used to reflect central obesity, its predictive strength often varies depending on ethnicity, population characteristics, and whether hip circumference is driven predominantly by bone structure, muscle, or fat. Likewise, waist–stature ratio did not show a significant correlation with HOMA-IR ($r = 0.152$, $p > 0.05$). These findings suggest that single-ratio indices may not uniformly capture visceral adiposity-related metabolic risk across all obese adult female populations.

Neck circumference and wrist circumference were not significantly correlated with HOMA-IR in the present analysis (neck circumference $r = 0.170$, $p > 0.05$; wrist circumference $r = 0.239$, $p > 0.05$). In recent years, neck circumference has been proposed as an alternative marker of upper-body subcutaneous fat and metabolic risk. However, evidence

remains inconsistent across studies, and its utility may depend on sample size, sex distribution, and obesity severity. Therefore, the absence of significant correlation in this cohort could be explained by the relatively modest sample size and the exclusive inclusion of obese females.

One of the most striking results of the present study was the strong inverse correlation between conicity index and HOMA-IR ($r = -0.841$, $p < 0.05$; $r^2 = 0.707$). Conicity index is intended to reflect central obesity by relating waist circumference to height and weight, conceptually describing the degree to which the body approximates a “double cone.” Recent studies continue to include conicity index among anthropometric indices assessed for insulin resistance prediction. A 2024 study evaluating anthropometric indices and insulin resistance incorporated conicity index into its analysis framework, reinforcing its continuing relevance as a central adiposity indicator in metabolic risk research.¹⁰ However, the inverse direction and the magnitude of correlation observed in the present study are unusual compared to the general expectation that increasing central adiposity indices correlate positively with insulin resistance. This may reflect population-specific body shape characteristics, variation in index calculation distribution, or measurement sensitivity in a small sample. It also suggests that further larger-scale studies are required to validate conicity index behavior specifically in adult obese Indian females and to determine whether this inverse association is reproducible or represents cohort-specific findings.

Overall, the present study supports the growing concept that insulin resistance in obese females is influenced more by body fat distribution than generalized adiposity. The statistically significant relationships seen with waist circumference, sagittal abdominal diameter, hip circumference, thigh medium perimeter, waist–thigh ratio, and conicity index emphasize the importance of incorporating regional anthropometry into clinical metabolic risk stratification. These indices are non-invasive, economical, and feasible for use in routine clinical practice, particularly in resource-limited settings. Recent population research also supports the need to evaluate multiple indirect measures of insulin resistance and risk markers, since insulin resistance screening and its metabolic implications vary across cohorts.¹¹

The findings of this study therefore suggest that obese adult women with higher central and regional adiposity, even when having similar BMI, may exhibit differing degrees of insulin resistance, reinforcing the limitation of BMI as a standalone marker and supporting the use of additional anthropometric measures for early detection of metabolic risk. Furthermore, in settings where insulin assays may not be easily available for large-scale screening, the strategic use of robust anthropometric indices could support early identification and preventive interventions.¹²

CONCLUSION

The present study evaluated the relationship between various anthropometric indices and insulin resistance, as assessed by HOMA-IR, among Indian adult obese females. The findings demonstrate that insulin resistance is highly prevalent in this population and that its association varies considerably across different anthropometric measures. While body mass index did not show a significant correlation with insulin resistance, several indices reflecting central and regional fat distribution, including waist circumference, sagittal abdominal diameter, hip circumference, thigh medium perimeter, waist–thigh ratio, and conicity index, showed significant associations with HOMA-IR. These observations highlight that fat distribution rather than overall adiposity alone plays a crucial role in determining insulin resistance.

Among the assessed parameters, thigh medium perimeter showed the strongest positive correlation with HOMA-IR, while the conicity index demonstrated a strong inverse correlation, emphasizing their potential utility as markers of metabolic risk. Sagittal abdominal diameter also emerged as an important indicator, supporting the concept that visceral adiposity is more closely related to insulin resistance than generalized obesity. The lack of significant association between insulin resistance and indices such as waist–hip ratio, waist–stature ratio, neck circumference, and wrist circumference suggests that not all anthropometric measures are equally informative in assessing metabolic risk among obese women.

Based on these findings, it is recommended that anthropometric assessment in obese adult females should extend beyond BMI to include selected measures of central and regional adiposity. Incorporating parameters such as waist circumference and sagittal abdominal diameter in routine clinical evaluation may improve early identification of insulin resistance. Early detection should be accompanied by targeted lifestyle interventions aimed at reducing visceral fat, thereby helping to prevent progression to type 2 diabetes mellitus and associated cardiometabolic complications.

LIMITATIONS

The present study has certain limitations that should be considered while interpreting the findings. The cross-sectional design limits the ability to establish causal relationships between anthropometric parameters and insulin resistance. The relatively small sample size and inclusion of only obese adult female subjects may restrict the generalizability of the results to males and other age groups. Insulin resistance was assessed using HOMA-IR rather than the hyperinsulinemic euglycemic clamp technique; however, HOMA-IR remains a validated surrogate measure. Additionally, potential confounding factors such as dietary intake, physical activity levels, and hormonal status were not assessed, which may have influenced insulin sensitivity.

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