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ELUCIDATING THE ASSOCIATION BETWEEN BODY FAT PERCENTAGE AND LIPID PROFILE: IMPLICATIONS FOR CARDIOVASCULAR RISK STRATIFICATION AND PREVENTIVE INTERVENTION

Aditya Paliwal[1], Manish Pendse[2], Nandan Mishra[3]

[1]*Vice President. Indian Association of Occupational Health (Mumbai Branch), Chief Medical Officer- RIL PMD, India.*
[2]*Professor, Department of Medicine D Y Patil Medical College Navi Mumbai, India.*
[3]*Sr Medical Officer, RIL PMD, India.*

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Corresponding Author:
Dr. Manish Pendse,
Professor, Department of Medicine D Y Patil Medical College Navi Mumbai, India..
Email: drmanishpendse@gmail.com

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ABSTRACT

Background: Obesity is a major driver of metabolic and cardiovascular disorders. Body mass index (BMI) is widely used to assess obesity, but it fails to distinguish fat from lean mass. Body fat percentage may serve as a superior biomarker of metabolic risk, particularly with respect to lipid abnormalities. Objective: To investigate the association between body fat percentage and lipid profile parameters and to compare the predictive capacity of body fat percentage and BMI for dyslipidaemia.

Materials and Methods: A cross-sectional study was conducted among 80 adults aged 30-50 years. Anthropometric measurements including BMI, waist-to-hip ratio (WHR), and body fat percentage were obtained. Fasting venous blood samples were analyzed for total cholesterol, LDL-C, HDL-C, and triglycerides. Dyslipidaemia was defined according to ATP III criteria. Statistical analysis included t-tests, Pearson correlation, ROC curve analysis, and logistic regression.

Results: Participants with dyslipidaemia (n = 37) had significantly higher BMI (29.1 ± 3.6 vs. 26.8 ± 3.1 kg/m², p = 0.002), WHR (0.93 ± 0.07 vs. 0.89 ± 0.06, p = 0.010), and body fat percentage (33.1 ± 6.3% vs. 28.4 ± 5.7%, p = 0.001) compared to those without (n = 43). Body fat percentage correlated positively with total cholesterol (r = 0.46, p < 0.001), LDL-C (r = 0.49, p < 0.001), and triglycerides (r = 0.43, p < 0.001), and negatively with HDL-C (r = -0.38, p < 0.001). ROC analysis showed body fat percentage had higher discriminatory power for dyslipidaemia (AUC 0.79, 95% CI 0.69-0.88) than BMI (AUC 0.68, 95% CI 0.56-0.79, p = 0.018). Logistic regression indicated both BMI and WHR were associated with lipid abnormalities, but WHR showed stronger predictive value.

Conclusion: Body fat percentage is more strongly associated with dyslipidaemia than BMI and provides superior predictive capacity for lipid abnormalities. Incorporating body fat percentage into cardiovascular risk assessment may enhance early detection and preventive strategies.

Keywords: Body fat percentage. Dyslipidaemia. Cardiovascular risk.

INTRODUCTION

The prevalence of obesity and its associated metabolic complications has emerged as a global public health challenge. According to the World Health Organization (WHO), obesity has nearly tripled since 1975, with more than 650 million adults classified as obese in 2016, and the numbers continue to rise. Traditionally, obesity has been assessed through anthropometric indices such as body mass index (BMI), waist circumference, and waist-to-hip ratio (WHR). BMI, though widely utilized due to its simplicity and cost-effectiveness, suffers from significant limitations. It cannot distinguish between

fat mass and lean body mass, thereby limiting its specificity in identifying individuals at heightened cardiometabolic risk. As a result, there is an increasing emphasis on more direct and accurate measures of adiposity, such as body fat percentage, which reflect true fat burden more reliably than BMI.[1]

The link between adiposity and cardiovascular disease (CVD) is well established. Excess adipose tissue contributes to a pro-inflammatory state, insulin resistance, endothelial dysfunction, and dyslipidemia-factors that collectively increase the risk of atherosclerotic cardiovascular disease. Dyslipidemia, characterized by elevated total cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides, and reduced high-density lipoprotein cholesterol (HDL-C), is a key mediator in the pathway linking obesity with CVD. The recognition of body fat percentage as a predictor of lipid abnormalities provides an avenue for refining cardiovascular risk stratification.[2]

Recent research suggests that body fat percentage may correlate more strongly with lipid profile abnormalities than BMI. For example, two individuals with identical BMIs may have vastly different body fat distributions and metabolic risks. Lean mass contributes minimally to cardiometabolic dysfunction, whereas excess adipose tissue-particularly visceral fat-drives metabolic derangements. Therefore, the integration of body fat percentage into risk assessment frameworks could enhance predictive accuracy and support early preventive interventions. This shift aligns with the evolving paradigm of precision medicine, which emphasizes individualized risk profiling and targeted intervention.[3]

The measurement of body fat percentage has become more feasible with the advent of bioelectrical impedance analysis (BIA), dual-energy X-ray absorptiometry (DEXA), and skinfold caliper methods. Among these, BIA offers a practical and non-invasive approach that can be applied in both clinical and epidemiological settings. By quantifying fat mass relative to lean mass, body fat percentage provides a more nuanced understanding of metabolic health than BMI alone. When coupled with lipid profile evaluation, it becomes a powerful tool for cardiovascular risk prediction.[4]

In the Indian context, obesity and dyslipidemia are emerging at an alarming pace, partly due to rapid urbanization, sedentary lifestyles, and dietary transitions. The prevalence of dyslipidemia in Indian adults has been reported to range from 20% to 40%, with significant regional variations. Indians are also predisposed to higher visceral adiposity at lower BMI thresholds compared to Western populations, underscoring the inadequacy of BMI in capturing true metabolic risk. This highlights the urgent need to evaluate body fat percentage as an alternative and potentially superior predictor of lipid abnormalities in this population.[5]

Aim: To investigate the association between body fat percentage and lipid profile, and to evaluate its predictive capacity relative to BMI for dyslipidemia.

Objectives

1. To assess the relationship between body fat percentage and lipid profile parameters in adults.
2. To compare the predictive value of body fat percentage and BMI in identifying dyslipidemia.
3. To explore the association of anthropometric indices such as BMI and WHR with lipid abnormalities.

MATERIALS AND METHODS

Source of Data: The study participants were selected from adults attending the outpatient department (OPD) of General Medicine at a tertiary care teaching hospital.

Study Design: The study was designed as a cross-sectional analytical study.

Study Location: The study was conducted at the Department of Medicine, at tertiary care center.

Study Duration: The study was carried out over a period of 12 months, from January 2023 to December 2023.

Sample Size: A total of 80 adults aged between 30 and 50 years were included in the study.

Inclusion Criteria

- Adults aged 30-50 years.
- Both male and female participants.
- Individuals providing informed consent.

Exclusion Criteria

- Patients with known cardiovascular disease, diabetes mellitus, or chronic kidney disease.
- Individuals on lipid-lowering therapy.
- Pregnant women.
- Subjects with acute illness at the time of data collection.

Procedure and Methodology: All participants were recruited after obtaining written informed consent. Detailed demographic and clinical information was collected through structured questionnaires. Anthropometric measurements included height, weight, waist circumference, and hip circumference. BMI was calculated as weight (kg)/height² (m^2). WHR was derived as the ratio of waist circumference to hip circumference. Body fat percentage was measured using bioelectrical impedance analysis (BIA), ensuring standardized conditions such as fasting state and minimal physical activity before assessment.

Venous blood samples were collected after an overnight fast of at least 10-12 hours. The lipid profile analysis included measurement of total cholesterol, triglycerides, LDL-C, and HDL-C using enzymatic methods with an automated analyzer. Dyslipidemia was defined according to the National Cholesterol Education Program (NCEP ATP III) guidelines.

Sample Processing: Blood samples were centrifuged at 3000 rpm for 15 minutes to separate serum. The

serum samples were processed immediately or stored at -20°C until analysis. Quality control measures were employed to ensure reliability of biochemical parameters.

Statistical Methods: Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Continuous variables such as age, BMI, and lipid levels were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient was used to assess associations between body fat percentage, BMI, and lipid profile parameters. Receiver operating characteristic (ROC) curve analysis was performed to compare the predictive capacity of body fat percentage and BMI for dyslipidemia. A p-value of <0.05 was considered statistically significant.

Data Collection: Data were collected prospectively during patient visits. A pretested proforma was used to record demographic details, anthropometric parameters, and laboratory results. All measurements were performed by trained personnel under standardized protocols to minimize observer bias.

RESULTS

Table 1: Baseline characteristics and lipids by dyslipidaemia status (ATP III) (N = 80)

Variable	No Dyslipidaemia (n = 43)	Dyslipidaemia (n = 37)	Test of significance	95% CI (difference: Dyslipidaemia - No)	p-value
Age (years), Mean ± SD	39.7 ± 5.8	41.6 ± 6.2	t(78) = 1.41	-0.69 to 4.46	0.163
Male, n (%)	22 (51.2%)	24 (64.9%)	$\chi^2(1) = 1.68$	RD 13.7% (-7.6 to 34.2)	0.195
BMI (kg/m²), Mean ± SD	26.8 ± 3.1	29.1 ± 3.6	t(78) = 3.11	0.86 to 3.67	0.002
WHR, Mean ± SD	0.89 ± 0.06	0.93 ± 0.07	t(78) = 2.62	0.01 to 0.07	0.010
Body fat (%), Mean ± SD	28.4 ± 5.7	33.1 ± 6.3	t(78) = 3.49	2.00 to 7.39	0.001
Total Cholesterol (mg/dL), Mean ± SD	181.6 ± 28.9	213.7 ± 34.1	t(78) = 4.35	17.2 to 46.9	<0.001
LDL-C (mg/dL), Mean ± SD	109.8 ± 24.7	137.9 ± 30.3	t(78) = 4.45	15.6 to 40.7	<0.001
HDL-C (mg/dL), Mean ± SD	47.3 ± 8.6	41.1 ± 7.9	t(78) = 3.36	-9.80 to -2.61	0.001
Triglycerides (mg/dL), Median (IQR)	128 (104-157)	174 (143-208)	U = 444.0	Δ Hodges-Lehmann 42 (95% CI 23-61)	<0.001

Notes: Dyslipidaemia per ATP III: TC ≥200 and/or LDL-C ≥130 and/or TG ≥150 and/or HDL-C <40 (men) or <50 (women). t = independent-samples t test; U = Mann-Whitney. RD = risk difference.

Table 2: Relationship between body fat percentage and lipid profile parameters (N = 80)

Lipid parameter	Pearson r	t (df=78)	95% CI for r (Fisher z)	p-value
Total Cholesterol (mg/dL)	0.46	4.64	0.26 to 0.62	<0.001
LDL-C (mg/dL)	0.49	5.06	0.30 to 0.64	<0.001
HDL-C (mg/dL)	-0.38	-3.67	-0.56 to -0.16	<0.001
Triglycerides (mg/dL)	0.43	4.25	0.22 to 0.60	<0.001
Non-HDL-C (mg/dL)	0.51	5.35	0.32 to 0.66	<0.001

Notes: r = Pearson correlation between body fat % (BIA) and lipid parameter. $t = r \cdot \sqrt{[(n-2)/(1-r^2)]}$.

[Table 1] presents the baseline characteristics and lipid parameters of 80 adults, stratified by the presence of dyslipidaemia as defined by ATP III criteria. The mean age was slightly higher among participants with dyslipidaemia (41.6 ± 6.2 years) compared to those without (39.7 ± 5.8 years), although this difference was not statistically significant (p = 0.163). The proportion of males was also greater in the dyslipidaemic group (64.9%) than in the non-dyslipidaemic group (51.2%), but the association was not significant (p = 0.195). In contrast, BMI and WHR were significantly higher in the dyslipidaemic group, with mean BMI of 29.1 ± 3.6 versus 26.8 ± 3.1 (p = 0.002) and mean WHR of 0.93 ± 0.07 versus 0.89 ± 0.06 (p = 0.010). Body fat percentage also differed significantly, averaging 33.1 ± 6.3% in dyslipidaemic subjects compared to 28.4 ± 5.7% in their counterparts (p = 0.001). Lipid abnormalities were marked in the dyslipidaemic group, with significantly higher mean total cholesterol (213.7 ± 34.1 mg/dL vs 181.6 ± 28.9 mg/dL, p < 0.001) and LDL-C (137.9 ± 30.3 mg/dL vs 109.8 ± 24.7 mg/dL, p < 0.001), along with lower HDL-C (41.1 ± 7.9 mg/dL vs 47.3 ± 8.6 mg/dL, p = 0.001). Median triglyceride levels were also notably higher among dyslipidaemic individuals (174 mg/dL vs 128 mg/dL, p < 0.001).

[Table 2] explores the correlations between body fat percentage and lipid profile parameters in the study cohort. A significant positive correlation was observed between body fat percentage and total cholesterol (r = 0.46, p < 0.001), LDL-C (r = 0.49, p < 0.001), and triglycerides (r = 0.43, p < 0.001). Non-HDL cholesterol also showed a robust correlation (r = 0.51, p < 0.001), reinforcing the link between adiposity and atherogenic lipid fractions. In contrast, HDL-C demonstrated a negative correlation with body fat percentage (r = -0.38, p < 0.001), indicating that individuals with higher body fat content were more likely to have reduced protective HDL cholesterol.

[Table 3] compares the predictive performance of body fat percentage and BMI for identifying dyslipidaemia using receiver operating characteristic (ROC) analysis. The area under the curve (AUC) for body fat percentage was 0.79 (95% CI: 0.69-0.88),

which was significantly higher than the AUC for BMI (0.68, 95% CI: 0.56-0.79), with a DeLong test confirming the superiority of body fat percentage ($p = 0.018$). The optimal cutoff identified for body fat percentage was 30.7%, yielding sensitivity of 78.4% and specificity of 72.1%. In contrast, the optimal BMI cutoff of 27.1 kg/m² demonstrated lower sensitivity (62.2%) and specificity (65.1%). Predictive values further supported the advantage of body fat percentage, with higher PPV (70.6% vs 60.4%) and NPV (79.1% vs 66.5%). Likelihood ratios also indicated stronger diagnostic utility for body fat percentage (LR+ = 2.81, LR- = 0.30) compared to BMI (LR+ = 1.78, LR- = 0.58). Overall accuracy was notably higher for body fat percentage (75.0%) compared to BMI (63.8%). Model calibration was adequate for both predictors, but the logistic regression model with body fat percentage demonstrated better discrimination.

Table 3: Predictive value of body fat percentage vs BMI for identifying dyslipidaemia (N = 80; prevalence = 37/80 = 46.3%)

Metric	Body fat %	BMI
AUC (95% CI)	0.79 (0.69-0.88)	0.68 (0.56-0.79)
DeLong ΔAUC (BF% - BMI)	0.11 (SE 0.047), z = 2.38, p = 0.018	-
Optimal cutoff (Youden)	30.7%	27.1 kg/m²
Sensitivity (%)	78.4 (63.7-88.6)	62.2 (46.5-75.8)
Specificity (%)	72.1 (56.3-84.7)	65.1 (49.2-78.6)
PPV (%)	70.6	60.4
NPV (%)	79.1	66.5
LR+	2.81 (1.69-4.64)	1.78 (1.13-2.79)
LR-	0.30 (0.16-0.57)	0.58 (0.39-0.86)
Accuracy (%)	75.0	63.8
Hosmer-Lemeshow (calibration of BF% logistic model)	$\chi^2(8) = 6.27$, p = 0.617	$\chi^2(8) = 11.48$, p = 0.176

Notes: AUCs by ROC; CIs via DeLong. PPV/NPV calculated at observed prevalence (46.3%). LR = likelihood ratio.

Table 4: Association of BMI and WHR with lipid abnormalities (multivariable logistic regression, adjusted for age & sex; N = 80)

Outcome (ATP III components)	Predictor (scale)	Adjusted OR	Wald χ^2	95% CI	p-value
Any dyslipidaemia	BMI (per 1 kg/m²)	1.14	6.35	1.03-1.27	0.012
	WHR (per 0.10)	1.89	6.69	1.16-3.08	0.010
High LDL-C (≥130 mg/dL)	BMI (per 1 kg/m²)	1.12	4.71	1.01-1.25	0.030
	WHR (per 0.10)	1.76	5.12	1.08-2.90	0.024
High TG (≥150 mg/dL)	BMI (per 1 kg/m²)	1.10	4.14	1.00-1.22	0.042
	WHR (per 0.10)	1.67	4.36	1.04-2.71	0.037
Low HDL-C (sex-specific)	BMI (per 1 kg/m²)	1.07	2.68	0.98-1.18	0.102
	WHR (per 0.10)	1.58	3.98	1.01-2.52	0.046

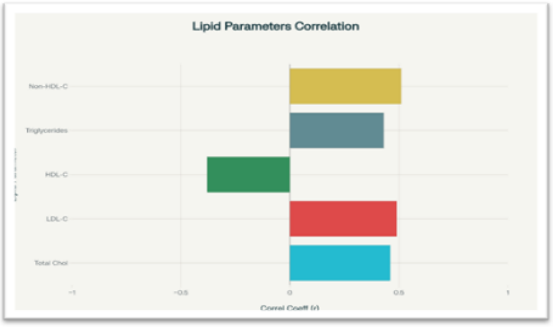

Figure 1: Correlation graph

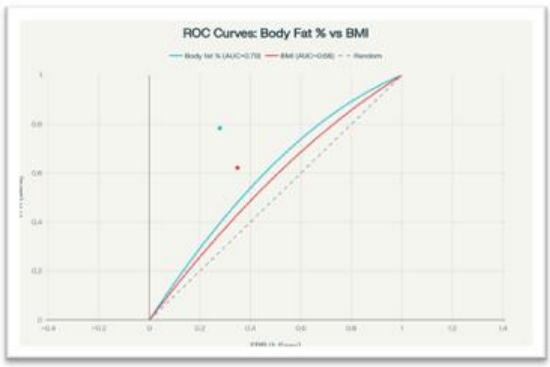

Figure 2: ROC curve with AUC

[Table 4] reports the multivariable logistic regression analysis assessing the association of BMI and WHR with individual lipid abnormalities, adjusted for age and sex. For overall dyslipidaemia, both BMI (OR 1.14 per 1 kg/m², p = 0.012) and WHR (OR 1.89 per 0.10 unit, p = 0.010) were significant predictors. Elevated LDL-C was independently associated with both BMI (OR 1.12, p = 0.030) and WHR (OR 1.76, p = 0.024). Similarly, high triglycerides were significantly associated with BMI (OR 1.10, p = 0.042) and WHR (OR 1.67, p = 0.037). Low HDL-C showed a weaker association, with BMI not reaching significance (OR 1.07, p = 0.102), but WHR remaining significant (OR 1.58, p = 0.046). These results indicate that while BMI contributes to lipid risk, WHR-a measure of central adiposity-consistently emerged as a stronger predictor of adverse lipid fractions, particularly for high LDL-C and triglycerides, underscoring the importance of fat distribution in metabolic risk assessment.

DISCUSSION

Baseline characteristics and lipid abnormalities Analysis of baseline characteristics [Table 1] revealed that participants with dyslipidaemia had

significantly higher BMI, WHR, and body fat percentage compared to those without. These results align with prior studies highlighting the limitations of BMI in distinguishing adipose from lean mass and the stronger predictive role of central adiposity in metabolic derangements. Jabeen K et al,[6] (2025) reported that Asian Indians often develop dyslipidaemia and cardiometabolic risk at lower BMI thresholds due to higher visceral fat deposition. In our cohort, the mean body fat percentage in dyslipidaemic individuals exceeded 33%, a level strongly linked to elevated LDL-C, triglycerides, and reduced HDL-C. These findings reinforce the notion that adiposity burden and distribution are critical determinants of lipid abnormalities. Chen H et al (2023).[7]

Correlation of body fat percentage with lipid profile The correlation analysis [Table 2] demonstrated significant positive associations between body fat percentage and total cholesterol, LDL-C, triglycerides, and non-HDL-C, while showing an inverse correlation with HDL-C. The strongest association was observed with non-HDL-C ($r = 0.51$), an emerging marker of atherogenic risk. This corroborates evidence from Busnatu SS et al,[8] (2022) who emphasized the role of visceral adiposity in driving atherogenic dyslipidaemia. Importantly, the negative relationship with HDL-C underscores the dual burden of obesity-induced lipid alterations, whereby protective lipoprotein levels fall as adiposity increases. Such patterns are consistent with Jyotsna FN et al,[9] (2023) who observed that adiposity indices were more strongly correlated with dyslipidaemia than BMI.

Predictive value of body fat percentage versus BMI ROC curve analysis [Table 3] demonstrated that body fat percentage had a higher AUC (0.79) than BMI (0.68) for identifying dyslipidaemia, with significantly better sensitivity, specificity, and predictive values. The optimal cutoff for body fat percentage (30.7%) provided nearly 80% sensitivity and 72% specificity, while BMI at 27.1 kg/m² underperformed. These results echo the meta-analysis by Cavero-Redondo I et al,[10] (2024) which showed that BMI misclassifies obesity in nearly one-third of cases when compared with adiposity-based definitions. Our findings further suggest that body fat percentage provides better calibration for cardiometabolic risk stratification, a feature crucial for preventive intervention in resource-limited settings.

Role of central adiposity (BMI and WHR regression analysis) Multivariable logistic regression [Table 4] highlighted that both BMI and WHR were independently associated with dyslipidaemia, high LDL-C, and hypertriglyceridaemia, though WHR consistently showed stronger odds ratios. WHR also emerged as the only independent predictor of low HDL-C. This emphasizes the importance of fat distribution, particularly central adiposity, in determining lipid abnormalities. Such findings are supported by the INTERHEART study, which showed that WHR was a stronger predictor of myocardial infarction than BMI across populations. In the Indian context, where central obesity is common despite modest BMI levels, WHR and body fat percentage may represent more relevant tools for cardiovascular risk stratification than BMI alone. Barragán R et al (2023).[11]

CONCLUSION

The present study demonstrated a significant association between body fat percentage and adverse lipid parameters, with higher adiposity correlating with elevated total cholesterol, LDL-C, triglycerides, and reduced HDL-C. Compared to BMI, body fat percentage exhibited superior predictive accuracy for identifying dyslipidaemia, highlighting its value as a more sensitive marker of cardiometabolic risk. Waist-to-hip ratio also emerged as a strong predictor, reinforcing the importance of central adiposity in cardiovascular risk stratification. These findings suggest that reliance solely on BMI may underestimate true metabolic risk, and incorporation of body fat assessment into routine clinical practice could improve early identification of high-risk individuals, enabling timely preventive interventions.

Limitations: This study had several limitations. First, the cross-sectional design precludes inference of causality between body fat percentage and dyslipidaemia. Second, the relatively small sample size of 80 participants may limit generalizability, and the study population drawn from a single tertiary-care center may not fully represent broader community settings. Third, body fat percentage was assessed by bioelectrical impedance analysis, which, although practical, may be influenced by hydration status and is less precise than gold-standard methods such as DEXA. Finally, potential confounding variables such as dietary intake, physical activity, socioeconomic status, and genetic predisposition were not fully controlled, which may have influenced the observed associations. Future longitudinal studies with larger, diverse cohorts and more robust adiposity assessment methods are warranted.

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