Correlation between Anthropometry and Lipid Profile in Type 2 Diabetic Patients

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Abstract

Background: Obesity-related anthropometric measures may influence lipid abnormalities in patients with type 2 diabetes mellitus (T2DM), but their independent relationships with lipid fractions remain unclear.

Objective: To determine the correlation of body mass index (BMI), waist circumference (WC), and waist-to-hip ratio (WHR) with lipid profile parameters in patients with T2DM.

Methods:: This cross-sectional study was conducted at the Endocrine and Diabetic Clinic, Shaikh Zayed Hospital, Lahore, from July 2025 to December 2025. A total of 241 patients with T2DM were enrolled. Anthropometric measurements and fasting lipid profile were recorded. Data was analyzed using SPSS version 25.0.

Results: BMI showed significant positive correlations with total cholesterol, triglycerides, LDL-C, and VLDL-C, and a significant negative correlation with HDL-C. WC also showed significant correlations with all lipid parameters, whereas WHR was not significantly correlated with triglycerides or VLDL-C. In the adjusted model, BMI remained independently associated with higher total cholesterol (β=11.003, 95% CI: 10.125,11.881, p<0.001), triglycerides (β=4.61, 95% CI: 2.42, 6.79, p<0.001), and VLDL-C (β = 1.232, 95% CI: 0.637,1.828, p<0.001), and with lower HDL-C (β=-0.930, 95% CI: -1.145, -0.715, p<0.001). WC retained positive associations with total cholesterol (β = 0.491, 95% CI: 0.028, 0.955, p=0.038) and VLDL-C (β=0.433, 95% CI: 0.119,0.748, p=0.007). WHR was the only independent predictor of LDL-C (β = 352.415, 95% CI: 179.699, 525.132, p<0.001).

Conclusion: Anthropometric measures showed significant associations with lipid abnormalities in patients with T2DM. BMI showed the strongest and most consistent independent association with adverse lipid parameters, while WHR appeared to be the most relevant independent marker for LDL-C in this cohort.

Keywords: *Anthropometric parameters, body mass index, waist circumference, lipid profile, type 2 diabetes mellitus.*

INTRODUCTION

Diabetes mellitus is a chronic metabolic disease with significant long-term complications. It is rapidly increasing worldwide, with an estimated 828 million adults living with diabetes in 2022, with a global age-standardized prevalence of 13.9% in women and 14.3% in men. In Pakistan, it is also found to be high; a survey analysis from a nationwide survey showed an overall type 2 diabetes and prediabetes (10.91%) in adults, while another meta-analysis showed a pooled prevalence of 13.7% in adults. Type 2 diabetes is highly correlated with obesity and cardiometabolic comorbidities such as hypertension, cardiovascular disease, and dyslipidemia [1, 2].

Poor glycaemic control, dyslipidemia, and large waist circumference are three ways that inactivity worsens diabetes related complications in diabetics [3]. It is important to understand the complex interactions that are involved in the risk assessment of individuals and the risk reduction due to treatment of dyslipidemia for the risk of cardiovascular events in people with type 2 diabetes [4]. A body mass index (BMI) > 21kg/m2 is responsible for approximately 21% of ischemic heart disease and 58% of diabetes globally. Due to their clinical nature and the absence of a financial burden on patients, anthropometric indicators are commonly used as research tools to assess the population's risk factors for non-communicable diseases, especially in low-income nations. Monitoring it at the community level is easily done [5, 6].

Although cut-off levels differ across populations, these anthropometric characteristics have evolved into reliable indicators of metabolic disease incidence in people of all ages, regions, and genders [7, 8]. Anthropometric measures above the threshold levels have been proven to be important factors for type 2 diabetes, as well as for cardiovascular diseases in different populations. The parameter that best predicts these remains unknown [9, 10]. Additionally, obesity and anthropometric indices are associated with type 2 diabetes mellitus and related cardiometabolic risk in various populations consistently [7, 9]. Anthropometric parameters such as body mass index, waist circumference, and waist-to-hip ratio have thus been assessed as simple community-level risk factors for diabetes and cardiometabolic outcomes [4, 6, 7]. However, there is evidence that the "best" anthropometric index may depend on population and outcome, and it is unclear which single measure can best indicate the severity of metabolic derangements (including dyslipidemia) and cardiovascular risk across

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settings [4, 6]. To the best of our knowledge, recent local data on the direct comparison of correlations between these anthropometric measures and lipid profile in patients with type 2 diabetes in our setting are still limited [2]. To overcome this deficiency, the present study was conducted among the local population to assess the correlation between anthropometric parameters (body mass index, waist circumference, and waist-to-hip ratio) and lipid profile parameters in patients with type 2 diabetes mellitus. In addition to correlation analysis, multivariable linear regression with lipid profile parameters as dependent variables and anthropometric measures as independent variables, while adjusting for age, gender, and disease duration, was done to determine the independent contribution of each anthropometric indicator to dyslipidemia.

METHODOLOGY

This cross-sectional study was conducted at Endocrine & Diabetic Clinic, Department of Medicine, Shaikh Zayed Hospital, Lahore, from July 2025 to December 2025 after obtaining ethical approval from the Technical & Ethical Review Committee (TERC), Institutional Review & Research Advisory Board (IRRAB), Shaikh Zayed Medical Complex, Lahore (TERC ID: TERC/SC/INT/2025/474; Ref. No. 02-TERC/NHRC-SZH/INT-SC/789).

Inclusion criteria included patients of both genders with an age range of 30-60 years, diagnosed with type 2 diabetes. Type 2 diabetes was labeled when there was the presence of HbA1c >6.5% for >1 year. Exclusion criteria included patients with end-stage organ failure, like CKD (creatinine>2 mg/dl or on dialysis) and congestive heart failure or history of ischemic heart disease, patients on lipid-lowering drugs, on insulin, or on GLP-1 agonists were not included. Informed written consent was taken from each patient before enrolment.

A sample size of 241 cases was estimated using the WHO calculator, with type I and type II errors set at 5% and 10%, respectively, and a correlation coefficient (r) of 0.207 between BMI and total cholesterol [11]. All diabetic patients who met the following criteria were enrolled in the study from the OPD using a non-probability, consecutive sampling technique.

Demographics like age, gender, duration of diabetes, HBA1c, occupation, residence, socioeconomic status (monthly household income as <50,000 PKR; low, PKR 50,000-100,000 PKR; middle, and >PKR 100,000 PKR; high), diet pattern, lifestyle, history of hypertension, smoking, alcoholism, any other addiction, and treatment taking for diabetes were noted. Then patients were examined for height (in meters), weight (in kg), BMI (weight in kilograms divided by height in meters squared, kg/m2), waist circumference (non-stretchable measuring tape, with the participant standing upright, and recorded at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest at the end of a normal expiration, in cm), and waist-to-hip ratio by using inches tape. Meanwhile, blood samples were collected using 5 cc disposable syringes. All samples were then sent to the laboratory at Avicenna Hospital for confirmation of lipid profile levels, including total cholesterol, triglycerides, HDL-C, LDL-C, and VLDL-C, after proper labeling. Reports were evaluated, and levels of all the parameters were noted. All the data were recorded in a pro forma.

Data was entered and analyzed in SPSS version 25.0. Categorical variables were expressed as frequency and percentage. Numerical data were expressed as medians with interquartile ranges (IQRs) after confirming the normality assumption. The Shapiro-Wilk test was applied to check the normality of the data. As the lipid variables were not normally distributed, correlations between anthropometric measures and lipid parameters were assessed using Spearman's rank correlation. Although some raw variables were non-normally distributed in univariate analyses, no variable transformation was performed before linear regression, as regression assumptions were evaluated using model residuals rather than the raw variables, and the residuals showed normal distribution. Univariate and multivariable linear regression were performed to determine the association between anthropometric measures and lipid profile measures. The lipid profile parameters total cholesterol, triglycerides, HDL-C, LDL-C, and VLDL-C were considered dependent variables. Independent variables were age, gender, disease duration, BMI, WC, and WHR. Before interpreting the multivariable linear regression models, regression assumptions were assessed. Multicollinearity was examined using tolerance, variance inflation factor, and condition index. Normality of residuals was checked using histograms and normal Q-Q plots of standardized residuals. Homoscedasticity was assessed by plotting standardized residuals against standardized predicted values. Influential observations were assessed using standardized residuals, leverage, and Cook's distance. In the multivariable analysis, models were adjusted for age, gender, and diabetes duration. Because BMI, waist circumference (WC), and waist-to-hip ratio (WHR) are related anthropometric measures (**Supplementary Table S1**), multicollinearity was assessed before interpreting regression coefficients. We examined the correlation matrix and collinearity diagnostics, including tolerance, variance inflation factor (VIF), and condition index. Multicollinearity was considered concerning if VIF >5 and/or tolerance <0.20, and severe if VIF >10 and/or tolerance <0.10. The full adjusted regression coefficients for all covariates are provided in Supplementary Table **S2**. Full collinearity diagnostics (VIF/tolerance) for all models are provided in Supplementary Table **S3**; P—values ≤ 0.05 are considered statistically significant.

Table 1: Demographic details of individuals enrolled in the study (n=241).

Variables	Frequency (%)
Age[#], years	45.0 (38.0-52.0)
Gender	
Male	123 (51.0)
Female	118 (49.0)
Occupation	
Job	96 (39.8)
Business	78 (32.4)
House wife	67 (27.8)
Residence	
Rural	56 (23.2)
Urban	185 (76.8)
Socioeconomic status[†]	
Low	108 (44.8)
Middle	89 (36.9)
High	44 (18.3)
Diet pattern	
Home-made	150 (62.2)
Fast-food / street-food	54 (22.4)
Following a diet plan	37 (15.4)
Lifestyle	
Active	86 (35.7)
Sedentary	111 (46.1)
Gym/exercise	44 (18.3)
Clinical History	
Duration of diabetes[#], years	9.0 (7.0-13.0)
HbA1c[#], %	9.54 (8.23-10.98)
Hypertension	152 (63.1)
Smoking	77 (32.0)
Alcohol use	6 (2.5)
Any other addiction, including pan, gutka, IV drug abuse, or any other	25 (10.4)
Treatment for diabetes	
Insulin	54 (22.4)
Oral	68 (28.2)
Both insulin and oral anti-glycemic medicines	62 (25.7)
Dual oral drug	57 (23.7)

#: Data are presented as n (%) for categorical variables and as median (Q1-Q3) for continuous variables with non-normal distribution.

RESULTS

A total of 241 patients with type 2 diabetes mellitus were enrolled. The median age was 45.0 (38.0-52.0) years, and 123 (51.0%) were male. The median duration of diabetes was 9.0 (7.0-13.0) years, while the median HbA1c was 9.54 (8.23-10.98%). Most participants lived in urban areas (76.8%). Home-made meals were reported by 62.2% of participants, and 46.1% had a sedentary lifestyle. Hypertension was present in 63.1% of participants (**Table 1**).

Table 2: Anthropometric measurements and lipid profile of enrolled individuals (n=241).

Anthropometric Measurements	Median (Q1-Q3)	Normality
Height, in meters	1.66 (1.57-1.74)	<0.0001
Weight, in kg	82.00 (74.00-91.00)	<0.0001
BMI, in kg/m²	29.79 (26.39-33.42)	0.001
Waist circumference, in cm	97.00 (91.00-104.00)	0.001
Hip circumference, in cm	106.00 (98.00-112.00)	<0.0001
Waist-to-hip ratio	0.93 (0.90-0.95)	<0.0001
Lipid Profile		
Total cholesterol, in mg/dL	297.00 (244.00-348.00)	<0.0001
Triglycerides, in mg/dL	296.00 (248.00-348.00)	<0.0001
LDL-C, in mg/dL	287.00 (242.00-332.00)	<0.0001
HDL-C, in mg/dL	28.00 (23.00-35.00)	<0.0001
VLDL-C, in mg/dL	51.00 (37.00-66.00)	<0.0001

Since the continuous variables were not normally distributed, they were presented as median (Q1-Q3). The median height and weight of the participants were 1.66 (1.57-1.74) meters and 82.00 (74.00-91.00) kg, respectively. The median BMI was 29.79 (26.39-33.42) kg/m². The median waist circumference was 97.00 (91.00-104.00) cm, the median hip circumference was 106.00 (98.00-112.00) cm, and the median waist-to-hip ratio was 0.93 (0.90-0.95). The median total cholesterol was 297.00 (244.00-348.00) mg/dL, triglycerides 296.00 (248.00-348.00) mg/dL, LDL-C 287.00 (242.00-332.00) mg/dL, HDL-C 28.00 (23.00-35.00) mg/dL, and VLDL-C 51.00 (37.00-66.00) mg/dL (**Table 2**).

In this study, BMI showed a significant positive correlation with total cholesterol (ϒ=0.946, p< 0.001), triglycerides (ϒ=0.516, p <0.001), LDL-C (ϒ=0.310, p<0.001), and VLDL-C (ϒ=0.543, p< 0.001), and a significant negative correlation with HDL-C (ϒ = -0.731, p< 0.001). Waist circumference also showed a significant positive correlation with total cholesterol (ϒ=0.777, p< 0.001), triglycerides (ϒ = 0.469, p < 0.0001), LDL-C (ϒ = 0.300, p<0.001), and VLDL-C (ϒ=0.517, p<0.001), and a significant negative correlation with HDL-C (ϒ=-0.619, p<0.001). Waist-to-hip ratio showed a significant positive correlation with total cholesterol (ϒ=0.200, p=0.002) and LDL-C (ϒ=0.310, p<0.001), and a significant negative correlation with HDL-C (ϒ=-0.194, p=0.003). There was no significant correlation of waist-to-hip ratio with triglycerides or VLDL-C (**Table 3**).

Table 3: Table showing correlation between BMI, Waist circumference, and waist-to-hip ratio with lipid profile of enrolled individuals (n=241).

Variables	Correlation	Total Cholesterol	Triglycerides	LDL-C	HDL-C	VLDL-C
BMI	Spearman Correlation	0.946	0.516	0.310	-0.731	0.543
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Waist circumference	Spearman Correlation	0.777	0.469	0.300	-0.619	0.517
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Waist-to-hip ratio	Spearman Correlation	0.200	0.119	0.310	-0.194	0.097
	p-value	0.002	0.065	<0.001	0.003	0.134

Table 4: Multivariable linear regression showing association of anthropometric measures with lipid profile parameters, adjusted for age, gender, and disease duration (n=241).

Dependent Variable	BMI β (95% CI)	p-value	Waist Circumference β (95% CI)	p-value	Waist-to-hip Ratio β (95% CI)	p-value	Adjusted R^2
Total Cholesterol	11.01 (10.13 to 11.89)	<0.001	0.49 (0.02 to 0.95)	0.040	-9.78 (-73.90 to 54.34)	0.764	0.894
Triglycerides	4.61 (2.42 to 6.79)	<0.001	0.99 (-0.16 to 2.14)	0.091	-3.77 (-163.33 to 155.79)	0.963	0.258
Low-Density Lipoprotein Cholesterol	2.07 (-0.29 to 4.43)	0.085	0.37 (-0.88 to 1.61)	0.563	359.01 (186.36 to 531.65)	<0.001	0.160
High-Density Lipoprotein Cholesterol	-0.93 (-1.15 to -0.72)	<0.001	-0.07 (-0.19 to 0.04)	0.200	-5.03 (-20.74 to 10.69)	0.529	0.529
Very-Low-Density Lipoprotein Cholesterol	1.24 (0.64 to 1.84)	<0.001	0.43 (0.11 to 0.74)	0.008	-18.29 (-61.99 to 25.42)	0.411	0.301

Table **4** displays the multivariable associations between anthropometric measures and lipid profile parameters, adjusted for age, gender, and disease duration. Since Table **4** is shortened, full models are reported in the supplementary Table **S4**.

In the adjusted model (Model 2), BMI was independently associated with higher total cholesterol, with an adjusted beta of 11.003 (95% CI: 10.125 to 11.881, p<0.001), and waist circumference also showed a smaller positive association, with an adjusted beta of 0.491 (95% CI: 0.028 to 0.955, p=0.038), whereas WHR, age, gender, and diabetes duration were not significant predictors (**Supplementary Table S4**).

For triglycerides, BMI remained significantly associated with higher levels in the adjusted model (adjusted beta = 4.576; 95% CI: 2.402 to 6.751; p < 0.001), while waist circumference, WHR, age, gender, and diabetes duration were not statistically significant (**Supplementary Table S5**).

In the adjusted model, BMI was significantly associated with lower HDL-C (adjusted beta = -0.930; 95% CI: -1.145 to -0.715; p<0.001), whereas waist circumference, WHR, age, gender, and diabetes duration were not significantly associated (**Supplementary Table S6**).

For LDL-C, WHR showed a significant positive association in the adjusted model, with an adjusted beta of 352.415 (95% CI 179.699 to 525.132, p<0.001, whereas BMI, waist circumference, age, gender, and diabetes duration were not statistically significant (**Supplementary Table S7**). In the adjusted model, WHR remained positively associated with LDL-C. However, this coefficient should be interpreted cautiously, as WHR is a ratio-scale variable, and the reported beta reflects a 1-unit increase. Expressed on a clinically more realistic 0.1-unit scale, the association is approximately 35.2 mg/dL. The LDL-C model also showed only modest explanatory power.

For VLDL-C, both BMI and waist circumference were significantly associated with higher VLDL-C in the adjusted model, with BMI showing an adjusted beta of 1.232 (95% CI: 0.637 to 1.828, p<0.001), and waist circumference showing an adjusted beta of 0.433 (95% CI: 0.119 to 0.748, p=0.007), while WHR, age, gender, and diabetes duration were not significant predictors (**Supplementary Table S8**).

DISCUSSION

In this study, a strong positive relationship was calculated between BMI and total cholesterol (γ = 0.946), a positive relationship with triglycerides (γ = 0.516), a weak relationship with LDL (γ = 0.310) and VLDL (γ=0.543), and a strong negative relationship with HDL level (γ=−0.731, p<0.001). Waist circumference was also found to have a strong relationship with total cholesterol (γ=0.777), a positive but weak relationship with triglycerides (γ = 0.469), a very weak relationship with LDL (γ=0.300) and VLDL (γ=0.517), and a strong negative relationship with HDL level (γ=−0.619, p<0.001). Waist-to-hip ratio showed weak relationships with lipid profile parameters. After adjusting for age, gender, and disease duration, BMI remained independently associated with higher total cholesterol, triglycerides, and VLDL-C, and with lower HDL-C; waist circumference retained independent positive associations with total cholesterol and VLDL-C, while waist-to-hip ratio showed an independent association primarily with LDL-C. These adjusted findings support an association between adiposity and adverse lipid parameters beyond basic demographic and disease-related factors. The very strong association observed between BMI and total cholesterol in our dataset was stronger than that reported in most previous studies. This finding should therefore be interpreted cautiously and as specific to the present sample rather than assumed to represent all populations. BMI showed a strong positive correlation with total cholesterol, a moderate positive correlation with triglycerides and VLDL-C, a weak positive correlation with LDL-C, and a strong negative correlation with HDL-C. BMI emerged as the most consistent anthropometric predictor across lipid parameters in the present study. A possible explanation is that BMI may reflect overall adiposity more consistently in this cohort. In contrast, waist circumference and waist-to-hip ratio may be more influenced by body-frame variation, regional fat distribution, and measurement variability. In addition, the waist-to-hip ratio is a derived ratio based on two separate measurements and may therefore be less stable than BMI. These factors may partly explain why BMI showed more uniform associations with lipid abnormalities in our analysis.

Anthropometric measures have evolved into reliable predictors of diabetes mellitus prevalence. Anthropometry and lipid profiles have been linked in several studies

[12]. However, it is unclear which anthropometric parameter is best for a particular community or ethnicity worldwide [13]. Previous studies have also shown that the predictive performance of anthropometric indices may vary according to population characteristics, sex, ethnicity, and the metabolic outcome being assessed [14].

In contrast to the stronger associations observed in the present dataset, some published work has reported very weak correlations between anthropometric indices and lipid parameters, indicating that the magnitude and direction of association may vary across populations and study settings. Population-specific differences in body composition, fat distribution, lifestyle, and metabolic characteristics may partly explain this variation across studies. Similarly, studies in other populations have shown that anthropometric measurements and lipid profiles may differ across ethnic and geographic groups [15]. In an Indian study, Sandhu *et al.* [16] found positive associations between waist-to-hip ratio, total cholesterol, triglycerides, and LDL-C among men aged 41 to 50 years. Sex differences in the predictive associations of anthropometric and biochemical markers of type 2 diabetes have also been reported: age, waist circumference, body mass index, triglycerides, total cholesterol, LDL-C, and HDL-C showed stronger associations in women than in men [17]. These findings suggest that lipid profile patterns and anthropometric associations may differ across racial, geographical, and ethnic populations.

Jabczyk *et al.* [18] observed that BMI was not correlated with total cholesterol ($p = 0.63$), while HDL-C ($\gamma = -0.68$), LDL-C ($\gamma = 0.34$), and triglycerides ($\gamma = 0.56$) were significantly correlated with BMI. However, the relationships were not uniformly strong. Palekar *et al.* [19] also reported that BMI and waist circumference showed positive correlations with triglycerides and VLDL-C and weaker correlations with total cholesterol, highlighting variability in the strength of association across cohorts.

The cross-sectional study design limits causal inference, as the temporal relationship between anthropometric measures and lipid abnormalities cannot be established. Because this was a single-center cross-sectional study, the magnitude of the observed associations may be sample-specific and may not be directly generalizable to other populations. Residual confounding is possible because factors such as dietary pattern, physical activity level, socioeconomic status, and medication use (especially lipid-lowering agents and antidiabetic therapies) were not fully accounted for. In addition, anthropometric measures are prone to measurement variability and may not fully capture body fat distribution compared with imaging-based assessments [20].

Future studies should include multicentre, population-based samples and apply longitudinal designs to evaluate whether baseline anthropometric indices predict incident dyslipidemia and cardiovascular events over time. Additional adjustment for lifestyle factors and medication use, along with stratified analyses by sex and age groups, would improve precision and clinical applicability. Comparative models evaluating single anthropometric indices *versus* combined indices (and exploring optimal cut-offs for the local population) may help identify the most practical screening measure for routine clinical use [21].

CONCLUSION

Anthropometric measures showed significant associations with lipid profile parameters in patients with type 2 diabetes mellitus. After adjustment for age, gender, and disease duration, body mass index and waist circumference remained associated with adverse lipid parameters. In contrast, the waist-to-hip ratio was mainly associated with low-density lipoprotein cholesterol. These findings suggest that simple anthropometric indices may help identify patients who may need closer lipid monitoring.

ETHICS APPROVAL

Ethical approval was obtained from the Technical & Ethical Review Committee (TERC), Institutional Review & Research Advisory Board (IRRAB), Shaikh Zayed Medical Complex, Lahore (TERC ID: TERC/SC/INT/2025/474; Ref. No. 02-TERC/NHRC-SZH/INT-SC/789). All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

Informed consent was collected from all the participants.

AVAILABILITY OF DATA

All the study data are available with the corresponding author and will be provided upon a valid request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Declared none.

AUTHORS' CONTRIBUTION

FN : Study concept, study design, data collection, data analysis, initial draft.
MUA : Protocol design, critical review, and revision.
MUN : Data collection, data entry, data analysis, manuscript drafting.
UR : Data collection, manuscript drafting.

All authors read and approved the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available on the journal's website.

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