GMR

The Original

CORRELATION OF NECK CIRCUMFERENCE WITH HBA1C AND TRIGLYCERIDE LEVELS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CROSS-SECTIONAL STUDY

Abdul Rashid Sheikh[1], Muhammad Uthman Ahmad[1], Hashmat Ullah Khan[2], Mian Asif Mujtaba[3], Rimsha Azhar[4], Rao Muhammad Kaleem Furqan[5]

[1]Department of Internal Medicine, Federal Postgraduate Medical Institute, Shaikh Zayed Hospital, Lahore, Pakistan
[2]Department of Medicine, Lady Reading Hospital MTI, Peshawar, Pakistan
[3]Department of Medicine, WAH General Hospital, Rawalpindi, Pakistan
[4]Department of Endocrinology, Pakistan Railway Hospital, Islamic International Medical College Riphah University, Rawalpindi, Pakistan
[5]Department of Medicine, KRL Hospital, Islamabad, Pakistan
*Corresponding Author: Dr. Hashmat Ullah Khan, Email: dr_hashmatkhan134@yahoo.com

ABSTRACT
Background: Type 2 diabetes mellitus carries a heavy burden of glycaemic and lipid disturbance, and upper-body fat measured through neck circumference has been tied to insulin resistance. Evidence on its relationship with metabolic control in Pakistani diabetic patients is limited.
Objective: To determine the correlation of neck circumference with HbA1c and triglyceride levels in patients with type 2 diabetes mellitus.
Methods: This cross-sectional study was carried out in the Department of Medicine, Shaikh Zayed Hospital, Lahore, over three months on 193 patients with type 2 diabetes selected through consecutive sampling. Neck circumference was measured with a non-stretchable tape, HbA1c by high-performance liquid chromatography, and triglyceride level by an automated enzymatic colourimetric method. Normality was checked with the Shapiro-Wilk test, and the Pearson correlation coefficient was applied. Analysis was done in SPSS version 27, and statistical significance was set at $p \leq 0.05$.
Results: The mean age was 52.80 ± 9.18 years and the mean neck circumference was 35.66 ± 3.16 cm. Mean HbA1c was 8.14 ± 1.38% and the mean triglyceride level was 164.90 ± 46.55 mg/dL. Neck circumference correlated positively with HbA1c ($r = 0.349$, 95% CI 0.197 to 0.484, $p < 0.001$) and with triglyceride level ($r = 0.288$, 95% CI 0.131 to 0.431, $p < 0.001$). The associations stayed significant across most subgroups defined by age, sex, and comorbidity.
Conclusion: Neck circumference showed a significant positive correlation with HbA1c and triglyceride levels and may be a useful adjunct screening measure in type 2 diabetes mellitus.

KEYWORDS: Neck circumference; Type 2 diabetes mellitus; Glycated haemoglobin; Triglycerides; Anthropometry.

INTRODUCTION
Type 2 diabetes mellitus is one of the largest public health problems of the present era, and about 828 million adults were living with diabetes worldwide in 2022[1]. Pakistan carries a heavy share of this burden, with affected adults rising from around 5.2 million in 2000 to nearly 33 million in 2021[2]. Long-standing hyperglycaemia drives microvascular and macrovascular damage, so early detection of poor metabolic control is a central goal of care. Body mass index and waist circumference are the usual anthropometric tools, yet both are affected by measurement error and reflect upper-body fat poorly. Neck circumference indicates upper-body subcutaneous fat, a depot tied to insulin resistance, and has been linked to incident diabetes in community cohorts[3].
Several studies have examined neck circumference against biochemical markers, with results that are not fully consistent. In hypertensive adults, neck circumference correlated positively with HbA1c and triglyceride level alongside other cardiometabolic risk factors[4]. An Indian study reported a correlation between neck circumference and triglyceride that was stronger in women ($r = 0.320$) than in men ($r = 0.172$), while the link with fasting glucose ran the other way [5]. Among Korean adults, a larger neck circumference raised the odds of uncontrolled diabetes by about 10% per centimetre [6]. The size and even the direction of the association therefore shift with sex and setting.
Local work points in the same direction but stops short of the diabetic population. In young Pakistani adults, neck circumference was the strongest predictor of prediabetes, ahead of triglyceride level and waist circumference [7].

General-population studies have proposed neck circumference cut-offs for metabolic syndrome [8]. Most available evidence comes from general, hypertensive, or pre-diabetic groups rather than established type 2 diabetes, and data from Pakistani diabetic patients are scarce.

The rationale of the current study is to provide locally grounded evidence on whether a single, inexpensive tape measurement can flag diabetic patients with poorer glycaemic and lipid control. Many clinics in resource-limited settings cannot offer repeated biochemical monitoring to every patient, so a bedside marker of higher metabolic risk would carry real clinical worth. Confirmation that neck circumference tracks HbA1c and triglyceride level in a defined diabetic population would support its addition to routine assessment, help target patients who need closer follow-up, and guide earlier lifestyle and drug treatment. The study was therefore designed to measure these correlations in patients with type 2 diabetes at a tertiary care hospital in Lahore.

METHODS

This cross-sectional correlational study was conducted in the Department of Medicine, Shaikh Zayed Hospital, Lahore, from March 27, 2026 to June 27, 2026, after approval from the hospital ethics review committee vide letter no. 02-TERC/NHRC-SZH/INT-SC/59 dated: 26/03/2026. Written informed consent was taken from every participant after the purpose and procedure of the study had been explained. All records were kept confidential and were stored without personal identifiers.

Patients were enrolled through non-probability consecutive sampling. Adults between 30 and 70 years of age of either sex with type 2 diabetes mellitus were eligible. Patients were not enrolled if they had type 1 or gestational diabetes, thyroid disease, chronic kidney disease, liver failure, or acute hepatitis, or any condition or treatment that alters fat distribution, such as long-term steroid use, Cushing syndrome, or acromegaly. Those with neck masses, neck deformity, or earlier neck surgery were also excluded, as were pregnant women and patients with an acute infection or a hospital admission within the previous four weeks. These restrictions were applied to ensure that the measured neck circumference reflected habitual upper-body fat rather than a temporary or structural change.

The sample size of 193 was calculated for a correlation analysis with a two-sided alpha of 0.05, β of 0.1 and a power of 80%, using the formula $n = [(Z1-\alpha/2 + Z1-\beta) / C]^2 + 3$, where $C = 0.5 \times \ln[(1 + r) / (1 - r)]$. An expected correlation coefficient of $r = 0.231$ between neck circumference and triglyceride level was drawn from a previous study reporting a comparable association[9].

Type 2 diabetes mellitus was taken as present when a patient met the American Diabetes Association criteria, that is a fasting plasma glucose of 126 mg/dL or higher, an HbA1c of 6.5% or higher, a two-hour plasma glucose of 200 mg/dL or higher on an oral glucose tolerance test, or a random glucose of 200 mg/dL or higher with classic symptoms [10]. HbA1c reflects average blood glucose over the preceding two to three months and was measured from a venous sample by high-performance liquid chromatography. Triglyceride level was estimated from a venous sample by an automated enzymatic colourimetric assay and recorded in milligrams per decilitre. Neck circumference was taken in centimetres at the upper border of the laryngeal prominence while the patient stood upright with the head in the Frankfurt plane, and the mean of two readings from a non-stretchable tape was used. Body mass index was grouped by World Health Organization criteria into underweight, normal weight, overweight, and obese categories. Age, duration of diabetes, body mass index, neck circumference, HbA1c, and triglyceride level were handled as continuous variables, while sex, hypertension, ischaemic heart disease, and type of antihyperglycaemic therapy were treated as categorical variables.

Each eligible patient was approached during the clinic visit, and demographic and clinical details were entered on a predesigned proforma. The proforma covered age, sex, duration of diabetes, height, weight, comorbid hypertension and ischaemic heart disease, and the current antihyperglycaemic regimen. Height and weight were recorded to derive body mass index. After the anthropometric readings, a venous blood sample of 3 to 5 mL was drawn under aseptic conditions from the antecubital vein and sent at once to the hospital laboratory for estimation of HbA1c and triglyceride level.

Data were analysed in SPSS version 27, and statistical significance was set at $p \leq 0.05$. The Shapiro-Wilk test was applied first to check the distribution of the continuous variables, because the choice between parametric and non-parametric methods depends on normality; all continuous variables followed a normal distribution. Continuous variables were therefore summarised as mean and standard deviation, while categorical variables were expressed as frequencies and percentages. The Pearson correlation coefficient was used to measure the relationship of neck circumference with HbA1c and with triglyceride level, since this test captures the strength of a linear association between two normally distributed continuous variables. The same coefficient was repeated after stratification by age, sex, duration of diabetes, and comorbidities to check whether the associations held within subgroups.

RESULTS

A total of 145 patients with type 2 diabetes were studied. The mean age was 52.80 ± 9.18 years, and 75 patients (51.7%) were women while 70 (48.3%) were men. The mean duration of diabetes was 7.39 ± 3.06 years and the mean body mass index was 23.95 ± 2.73 kg/m². Hypertension was present in 72 patients (49.7%) and ischaemic heart disease in 25 (17.2%). Oral hypoglycaemic agents were the commonest treatment, used by 87 patients (60.0%). The mean neck circumference was 35.66 ± 3.16 cm, the mean HbA1c was 8.14 ± 1.38%, and the mean triglyceride level was 164.90 ± 46.55 mg/dL. All continuous variables were normally distributed on the Shapiro-Wilk test ($p > 0.05$). The baseline characteristics are shown in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study patients (n = 145)

Variable	Value (n = 145)
Age (years), mean ± SD	52.80 ± 9.18
Sex: Female, n (%)	75 (51.7)
Sex: Male, n (%)	70 (48.3)
Duration of diabetes (years), mean ± SD	7.39 ± 3.06
Height (cm), mean ± SD	163.16 ± 7.99
Weight (kg), mean ± SD	63.89 ± 9.26
Body mass index (kg/m²), mean ± SD	23.95 ± 2.73
Hypertension, n (%)	72 (49.7)
Ischaemic heart disease, n (%)	25 (17.2)
Oral hypoglycaemic agents, n (%)	87 (60.0)
Both oral agents and insulin, n (%)	34 (23.4)
Insulin only, n (%)	18 (12.4)
Lifestyle modification only, n (%)	6 (4.1)
Neck circumference (cm), mean ± SD	35.66 ± 3.16
HbA1c (%), mean ± SD	8.14 ± 1.38
Triglycerides (mg/dL), mean ± SD	164.90 ± 46.55

Most patients were within the normal weight range. Normal weight was recorded in 89 patients (61.4%), followed by overweight in 50 (34.5%), underweight in 4 (2.8%), and obesity in 2 (1.4%). The distribution differed between the sexes, with a higher proportion of women in the overweight and obese categories. The body mass index categories by sex are shown in Table 2.

Table 2. Distribution of body mass index categories by sex

Body mass index category	Male, n (%)	Female, n (%)	Total, n (%)
Underweight (<18.5)	1 (1.4)	3 (4.0)	4 (2.8)
Normal weight (18.5–24.9)	47 (67.1)	42 (56.0)	89 (61.4)
Overweight (25.0–29.9)	22 (31.4)	28 (37.3)	50 (34.5)
Obese (≥30.0)	0 (0.0)	2 (2.7)	2 (1.4)

Neck circumference showed a significant positive correlation with both metabolic markers. The correlation with HbA1c was moderate ($r = 0.349$, 95% CI 0.197 to 0.484, $p < 0.001$), and the correlation with triglyceride level was also significant ($r = 0.288$, 95% CI 0.131 to 0.431, $p < 0.001$). Neck circumference was further correlated with body mass index ($r = 0.396$, 95% CI 0.249 to 0.525, $p < 0.001$). The correlation of neck circumference with HbA1c and with triglyceride level is given in Table 3, and the patterns are shown in Figures 1 and 2.

Table 3. Pearson correlation of neck circumference with HbA1c and triglyceride level

Variable pair	r	95% CI	p-value
Neck circumference vs HbA1c	0.349	0.197 to 0.484	<0.001*
Neck circumference vs triglycerides	0.288	0.131 to 0.431	<0.001*

*CI: confidence interval. * Statistically significant at $p \leq 0.05$.*

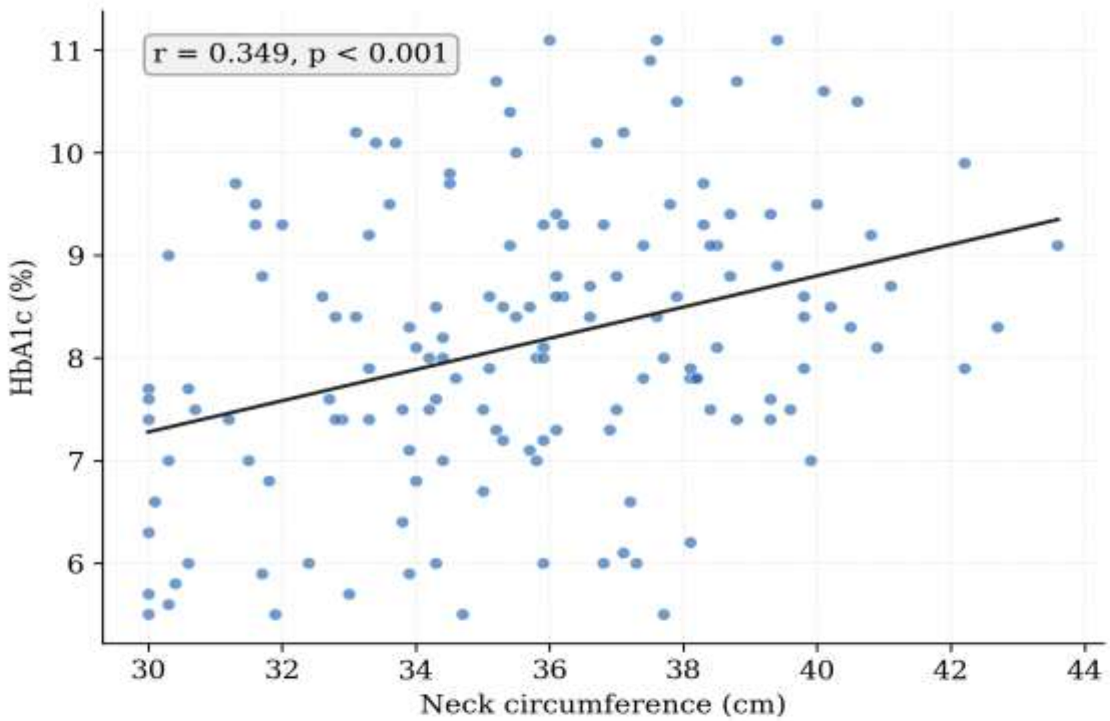

Figure 1. Scatter plot of neck circumference against HbA1c, with the fitted regression line.

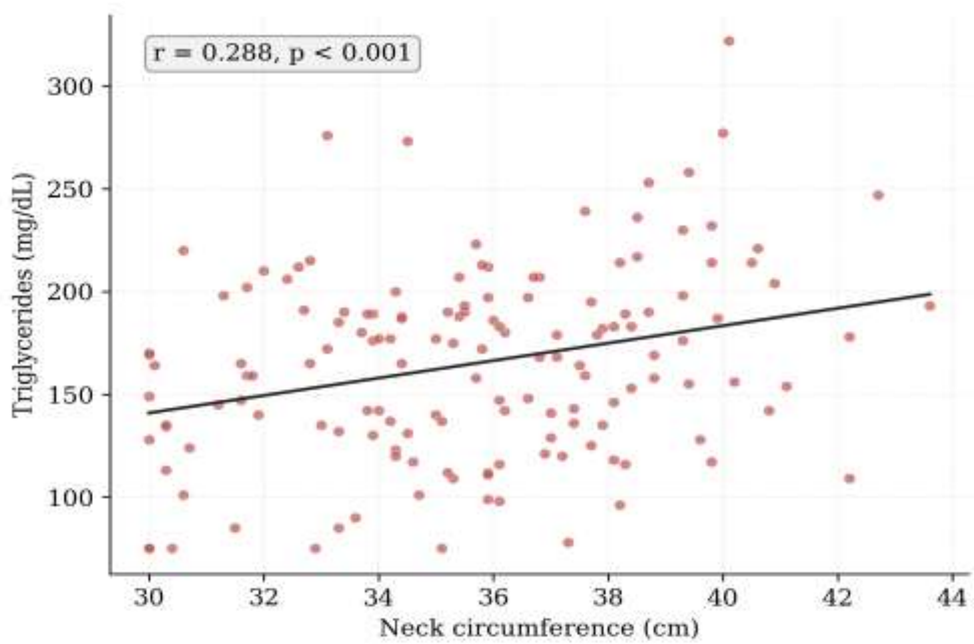

Figure 2. Scatter plot of neck circumference against triglyceride level, with the fitted regression line.

The associations were examined within subgroups defined by age, sex, duration of diabetes, and comorbidities. The correlation of neck circumference with HbA1c stayed significant in both men ($r = 0.383$, $p = 0.001$) and women ($r = 0.451$, $p < 0.001$), while the correlation with triglyceride level was stronger in men ($r = 0.476$, $p < 0.001$) than in women ($r = 0.320$, $p = 0.005$). Both correlations remained significant across the age groups, the diabetes duration groups, and the presence or absence of hypertension. In the smaller subgroup with ischaemic heart disease, neither correlation reached significance (HbA1c r = 0.320, p = 0.119; triglyceride r = 0.099, p = 0.638). The stratified results are shown in Table 4.

Table 4. Stratified Pearson correlation of neck circumference (NC) with HbA1c and triglyceride level

Subgroup	n	NC vs HbA1c, r (p)	NC vs triglycerides, r (p)
Male	70	0.383 (0.001)*	0.476 (<0.001)*
Female	75	0.451 (<0.001)*	0.320 (0.005)*
Age ≤50 years	55	0.389 (0.003)*	0.395 (0.003)*
Age >50 years	90	0.318 (0.002)*	0.227 (0.032)*
Diabetes duration ≤5 years	41	0.396 (0.010)*	0.321 (0.041)*
Diabetes duration >5 years	104	0.311 (0.001)*	0.279 (0.004)*
Hypertension present	72	0.392 (0.001)*	0.328 (0.005)*
Hypertension absent	73	0.304 (0.009)*	0.243 (0.038)*
Ischaemic heart disease present	25	0.320 (0.119)	0.099 (0.638)
Ischaemic heart disease absent	120	0.360 (<0.001)*	0.327 (<0.001)*

*NC: neck circumference. * Statistically significant at p ≤ 0.05.*

DISCUSSION

The present study found a significant positive association between neck circumference and both HbA1c and triglyceride level in patients with type 2 diabetes. A larger neck circumference was tied to higher HbA1c (r = 0.349) and higher triglyceride level (r = 0.288), and the relationship held across most subgroups of age, sex, and comorbidity. The mean neck circumference of 35.66 cm in a group whose body mass index sat mainly within the normal range suggests that upper-body fat carries metabolic information that body mass index alone can miss.

The link between neck circumference and glycaemic control agrees with several reports. In hypertensive adults, neck circumference was positively correlated with HbA1c and fasting glucose [11]. Among Korean adults, each additional centimetre of neck circumference raised the odds of uncontrolled diabetes by about 10% [12], and a neck-to-waist ratio moved together with fasting glucose, insulin, and HbA1c in the same population [13]. The moderate strength seen here matches these findings and supports neck circumference as a marker of poorer glycaemic control rather than a precise replacement for laboratory testing.

The association with triglyceride level fits the known biology of diabetic dyslipidaemia. Insulin resistance increases hepatic output of triglyceride-rich very-low-density lipoprotein and raises circulating triglyceride concentrations [14]. Because upper-body subcutaneous fat is an active source of free fatty acids, a larger neck circumference may mark the same metabolic state that drives the lipid disturbance. An Indian study reported a neck circumference correlation with triglyceride of 0.320 in women and 0.172 in men [15], and neck circumference has outperformed body mass index and waist circumference as a correlate of insulin resistance in severe obesity [17]. The triglyceride correlation in the current sample lies within this reported range.

A sex difference appeared in the subgroup analysis. The correlation with triglyceride level was stronger in men (r = 0.476) than in women (r = 0.320), while the correlation with HbA1c was a little stronger in women (r = 0.451) than in men (r = 0.383). A comparable sex-dependent pattern, with neck circumference relating more closely to lipids in men and to glucose in women, has been described before [18]. Differences in fat distribution and hormonal influence between the sexes may account for part of this variation, though the present subgroups were modest in size.

A notable feature of the sample was that most patients had a normal body mass index, yet the neck circumference association with metabolic markers persisted. South Asian populations tend to develop type 2 diabetes at a lower body mass index and with a higher proportion of central and upper-body fat [19]. In non-obese diabetic patients, neck circumference has predicted high visceral fat even when body mass index was normal, with reported cut-off values near 37.8 cm in men and 34.8 cm in women [20]. This pattern strengthens the case for an upper-body fat marker in lean-appearing diabetic patients who would be missed by body mass index alone.

Local evidence supports the relevance of these findings. Among apparently healthy adults in Karachi, neck circumference was one of the anthropometric indices able to screen for metabolic syndrome [21]. Pakistani diabetic cohorts also show a high burden of dyslipidaemia, with raised triglyceride, total cholesterol, and low-density lipoprotein in patients with poor glycaemic control [22]. A related Pakistani study confirmed disturbed lipid profiles and their link with glycaemic index in type 2 diabetes [23]. These reports place the current correlations within a familiar local pattern of combined glycaemic and lipid disturbance.

Larger anthropometric studies reinforce the wider link between neck circumference and metabolic risk. Above-normal neck circumference was associated with diabetes prevalence in older Chinese adults, and neck-based indices of insulin resistance were higher in patients with type 2 diabetes. Anthropometric indices that include neck circumference have predicted prediabetes in large cohorts, and neck circumference has contributed to diabetes prediction models alongside the lipid accumulation product. The consistency of these results across populations adds weight to the associations found here.

The clinical value of neck circumference rests on its simplicity. It needs only a tape, takes a few seconds, and avoids the privacy and clothing problems of waist measurement. Population studies have proposed neck circumference cut-offs of about 36 to 39 cm in men and 33 to 35 cm in women for metabolic syndrome, and similar values have been reported in other Asian groups. A raised neck circumference has further been associated with incident diabetes, cardiovascular events, and left ventricular hypertrophy in diabetic patients. Adding neck circumference to routine diabetes review could help identify patients who need tighter glycaemic and lipid monitoring, and future Pakistani studies should test locally derived cut-off values in larger multicentre samples.

This study has limitations. The cross-sectional design records association at a single point and cannot show that upper-body fat causes the metabolic changes. The data came from a single tertiary care hospital in Lahore, so the findings may not extend to the wider population or to primary care. Neck circumference was analysed as a continuous variable without a locally validated cut-off, and other influences on triglyceride level, such as diet and lipid-lowering treatment, were not recorded. The smaller subgroup with ischaemic heart disease reduced the power to detect a correlation within that group. Larger multicentre studies with longitudinal follow-up are needed to confirm these associations and to set practical cut-off values for Pakistani patients.

CONCLUSION

Neck circumference showed a significant positive association with HbA1c and triglyceride level in patients with type 2 diabetes mellitus. As a quick and low-cost bedside measurement, it may be a useful adjunct for flagging patients with poorer glycaemic and lipid control. Its addition to routine diabetes assessment could support earlier and more focused care in resource-limited settings.

REFERENCES

1. American Diabetes Association Professional Practice Committee. 2. Classification and diagnosis of diabetes: Standards of Care in Diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S20-S42. doi:10.2337/dc24-S002.
2. American Diabetes Association Professional Practice Committee. 6. Glycemic targets: Standards of Care in Diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S111-S125. doi:10.2337/dc24-S006.
3. Li D, Zhao Y, Zhang L, You Q, Jiang Q, Yin X, et al. Association between neck circumference and diabetes mellitus: a systematic review and meta-analysis. *Diabetol Metab Syndr*. 2023;15:133. doi:10.1186/s13098-023-01111-z.
4. Altun HK, Suna G. Is neck circumference related to other anthropometric measurements and biochemical parameters in type 2 diabetes? *Cureus*. 2022;14(10):e30750. doi:10.7759/cureus.30750.
5. Fojas EGF, Buckley AJ, Lessan N, et al. Associations between neck circumference and markers of dysglycemia, non-alcoholic fatty liver disease, and dysmetabolism independent of body mass index in an Emirati population. *Front Endocrinol (Lausanne)*. 2022;13:929724. doi:10.3389/fendo.2022.929724.
6. He ZY, Gu X, Du LJ, Hu X, Zhang XX, Yang LJ, et al. Neck-to-height ratio is positively associated with diabetic kidney disease in Chinese patients with type 2 diabetes mellitus. *Front Endocrinol (Lausanne)*. 2023;13:1100354. doi:10.3389/fendo.2022.1100354.
7. Li X, Bai L, Niu Z, Lu Q. Correlation between neck circumference and gestational diabetes. *Diabetes Metab Syndr Obes*. 2023;16:4179-4185. doi:10.2147/DMSO.S439413.
8. Pandey T, Khanal J, Gautam R, Pokhrel S. Study of neck circumference as a new anthropometric indicator for prediction of diabetes mellitus. *J Lumbini Med Coll*. 2024;11(1). doi:10.22502/jlmc.v11i1.503.
9. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes since 1990: pooled analysis of population-based studies. *Lancet*. 2024;403:1780-1792. doi:10.1016/S0140-6736(24)00801-4.
10. Chatterjee S, Khunti K, Davies MJ. Type 2 diabetes in South Asians: epidemiology and clinical implications. *Lancet Diabetes Endocrinol*. 2025;13(1):45-57. doi:10.1016/S2213-8587(24)00256-1.
11. Feng Y, Wang H, Liu X, et al. Neck circumference and prevalence of diabetes among older adults: a community-based study. *BMC Public Health*. 2023;23:1854. doi:10.1186/s12889-023-16672-0.
12. Jiao Y, Zhang X, Li H, et al. Neck circumference predicts visceral obesity in non-obese adults with type 2 diabetes. *Nutr Metab Cardiovasc Dis*. 2025;35(2):312-320. doi:10.1016/j.numecd.2024.10.008.

13. Lee KR. Neck-to-waist circumference ratio and insulin resistance in adult Korean population under 50 years. *J Prim Care Community Health*. 2025;16:21501319251379854. doi:10.1177/15578518251379854.
14. Hirano T. Pathophysiology of diabetic dyslipidemia. *J Atheroscler Thromb*. 2022;29(11):1545-1562. doi:10.5551/jat.RV17023.
15. Sanchez E, Gomez A, Perez R, et al. Anthropometric indices including neck circumference predict prediabetes in adults. *Nutrients*. 2022;14(9):1826. doi:10.3390/nu14091826.
16. Li Y, Chen X, Wang P, et al. Lipid accumulation product and neck circumference improve prediction of type 2 diabetes. *Front Endocrinol (Lausanne)*. 2024;15:1378642. doi:10.3389/fendo.2024.1378642.
17. Adil M, Khan S, Ahmed N, et al. Neck circumference as a screening tool for metabolic syndrome in Pakistani adults. *J Pak Med Assoc*. 2023;73(8):1623-1628. doi:10.47391/JPMA.8067.
18. Arif M, Shahid R, Ali A, et al. Dyslipidemia and glycemic control among patients with type 2 diabetes mellitus. *Pak J Med Sci*. 2022;38(7):1845-1851. doi:10.12669/pjms.38.7.5620.
19. Zaidi SA, Ahmed F, Khan MA, et al. Relationship of lipid profile with glycemic status in patients with type 2 diabetes mellitus. *Cureus*. 2023;15(6):e40158. doi:10.7759/cureus.40158.
20. Somdee T, Chaisomboon C, Wattanakit K, et al. Sex-specific neck circumference cut-off values for metabolic syndrome in Asian adults. *Sci Rep*. 2023;13:15984. doi:10.1038/s41598-023-43188-0.
21. Yang GR, Yuan SY, Fu HJ, et al. Neck circumference and cardiovascular disease risk: an updated prospective cohort study. *Nutr Metab Cardiovasc Dis*. 2022;32(10):2314-2322. doi:10.1016/j.numecd.2022.06.018.
22. Barutta F, Gruden G, Bruno G, et al. Neck circumference and left ventricular hypertrophy in patients with type 2 diabetes mellitus. *Cardiovasc Diabetol*. 2025;24:52. doi:10.1186/s12933-025-02552-7.
23. World Health Organization. Classification of diabetes. 2023 update. *World Health Organization*. Geneva: WHO; 2023. doi:10.2471/BLT.23.290347.