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Original Research Article

Study of Neck Circumference as a New Anthropometric Indicator for Prediction of Diabetes Mellitus

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ABSTRACT:

Introduction: Overweight and obesity are the risk factors for metabolic syndrome. This study aimed to show that neck circumference is a simple tool to identify the overweight and obesity as a new anthropometric index and association with type 2 diabetes. **Methods:** This was a cross-sectional study with a total of 246 participants, 123 of whom had diabetes mellitus, and the same numbers were non-diabetics, adjusted for weight and height in both groups. Means with standard deviation were used for neck and waist circumferences, body mass index, and blood sugar, and the Pearson correlation test was applied to identify the association. A comparison of means was done by the student 't' test in parametric data within the two groups. **Results:** The mean neck circumference, body mass index of diabetes and non-diabetes participants were 38.0±3.0 cm, 28.5±2.6 and 36.6±3.2 kg/m^2, 27.4±3.1 kg/m^2 respectively. In diabetic patients, mean neck and waist circumference, blood sugar were higher than in nondiabetic patients and was significantly correlated with body mass index ($r=0.747$, $p<0.001$), waist circumference ($r=0.635$, $p<0.001$), systolic and diastolic blood pressure ($r=0.740$, $p<0.001$ and $r=0.619$, $p<0.001$ respectively), fasting and post prandial blood sugar ($r=0.275$, $p=0.002$ and $r=0.307$, $p<0.001$respectively) and glycated hemoglobin ($r=0.220$, $p=0.014$, $n=123$). In nondiabetic patients, glycated hemoglobin was negatively correlated. **Conclusion**: This study suggested that neck circumference is a simple, reliable, and appropriate new anthropometric tool to evaluate obesity, overweight, and the risk of metabolic disorders.

Keywords: Anthropometric; Body Mass Index; Diabetes Mellitus; Metabolic Disorders; Neck Circumference.

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INTRODUCTION:

Clinically, overweight and obesity have been assessed by body mass index (BMI), waist circumference (WC), and waist hip ratio. There are others markers which are less commonly used such as abdominal sagittal diameter and neck circumference (NC).[1]

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Body Mass Index is calculated as a ratio of body weight in kg divided by height in meter square. Overweight is defined as a BMI between 25 and 29.9 kg/m^2 and obesity as a BMI of 30 kg/m^2 or higher. Obesity has been shown to be positively correlated with increased incidence of type 2 diabetes mellitus (DM).[2]

Neck circumference is a simple and time-saving anthropometric measurement. It was identified as an index of central obesity and a promising potential predictor for cardio-metabolic syndrome. [3] It has been shown to have positive correlation with BMI and index of central obesity.[4]

Neck circumference is a simpler, more innovative and practical anthropometric parameter and has been shown to have positive correlation with systolic blood pressure (SBP), diastolic blood pressure (DBP) and fasting blood glucose.[5] Waist circumference is easily affected by being full or hungry, respiratory movements and wearing heavy clothes, whereas these problems can be avoided in the measurement of NC.[6] There are limited published literature exploring the relationship of NC with obesity in our region and hence this study was conducted to find out if NC could be the next valid anthropometric index to measure overweight and obesity, and thereby have a predictive role in diabetes.

METHODS:

This was a cross-sectional study conducted at Lumbini Medical College and Teaching Hospital, Pravas, Palpa, in the department of Internal Medicine from June 2022 to December 2022 for a duration of six months. The study was approved by the Institutional Review Committee of the institute (IRC-LMC-06|R-022), and written consent was obtained from all the participants. In our study, there were a total of 246 participants. They were divided into two groups: 123 participants with DM and the same number without DM who visited with diabetes participants. Mean NC and other anthropometric indices like BMI, waist circumference and metabolic components like blood sugar and BP were obtained from both the groups. After that, we studied the relationship between NC and conventional anthropometric indices and metabolic components in both groups.

All the necessary demographic, clinical, and laboratory parameters like age, sex, presence of DM, height, weight, NC, waist circumference, BMI, blood sugar, fasting and postprandial, and various lipid profiles were collected as per a preformed questionnaire-guided interview.

All diagnosed cases of DM, whether under medication or newly diagnosed type 2 DM were included in our study. The comparator group included healthy volunteers aged above 35 years whose height and weight were comparable to diabetic participants. The American diabetes association (ADA) criteria was considered for the diagnosis of DM. [4] Whereas, patients with severe disabilities, hepatic renal or thyroid failure, neck tumors, neck surgery, Cushing disease, pregnant and lactating women were excluded.

The sample size was calculated using the formula for estimating a correlation coefficient. Taking α (two-tailed) =0.05, β =0.20 and expected correlation coefficient (r) =0.25 from the study of Zhou et al, [6] the minimum sample size calculated was 123. Therefore, a targeted sample of 123 type 2 DM patients were studied.

Venous blood was collected into two vials, three milliliter blood in plain vial and two milliliter blood in potassium-EDTA vial.

Fasting blood sugar was labeled as per fasting for eight hours and postprandial blood sugar was assessed two hours after food intake. Glucose oxidase-peroxidase (GOD-POD) method was applied to measure fasting blood sugar and Nycocard Reader was used to estimate the glycated hemoglobin (HbA1c).
The international criteria for BMI suggested are underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obesity (>30 kg/m^2). Similarly, the revised guidelines for diagnosis of obesity in Asian Indian populations suggested are: A normal BMI of 18.0-22.9 kg/m^2, an overweight BMI of 23.0-24.9 kg/m^2, and obesity of BMI greater than or equal to 25 kg/m^2.[3] The healthy waist circumference limits were considered 90 cm for men and 80 cm for women. The NC >37 cm in men and NC >34 cm in women were reportedly the best cutoff points to determine persons with central obesity.[3]

In order to collect the sample, this study used the structure questionnaires covering the age, gender, height, weight, BMI, NC, waist circumference, waist-to-hip ratio and BP.
Neck circumference was measured in the midway of the neck, between mid-cervical spine and mid anterior neck, to within 1 mm, using non-stretchable plastic tape with the subjects standing upright. It was measured with head erect and eyes facing forward, horizontally just below the laryngeal prominence. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement. Waist circumference was measured at the level midway between the lower rib margin and the iliac crest. Blood pressure was measured twice after each participant had been seated for 10 minutes. The average BP was used for analysis.
Data was entered and analyzed using Statistical Package for Social Sciences (SPSS) software version 25. Afterward normally distributed data were figured in the form of mean and standard deviation, and correlation coefficient, wherever indicated. Independent t test was used to compare the means between the two groups. Pearson correlation test was done to identify the correlation between parametric data. A p value less than 0.05 considered significant.

RESULTS:

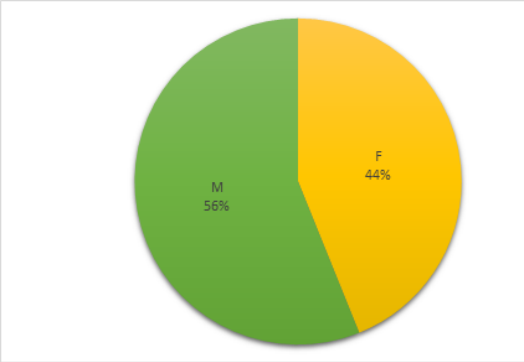
There were a total of 246 participants consisting of two groups:123 type 2 diabetics and 123 non-diabetics. Figures 1 and 2 show the gender wise distribution of diabetics and non-diabetics.

The mean NC of the diabetic group was 38.0±3.0 cm and that of non-diabetic group was 36.6±3.2 cm. The NC in diabetics was statistically significantly higher than in non-diabetics ($p<0.001$). All other metabolic parameters were statistically significantly higher in the diabetic group than in the non-diabetic group (Table 1)

Among various metabolic and anthropometric parameters, BMI, SBP, DBP and WC had moderate positive correlation with neck circumference in diabetic patients and mild positive correlation in BMI and waist circumference whereas as negative correlation in SBP and DBP in non-diabetic's participants. There was statistically significant positive correlation between NC and other anthropometric measurements in diabetic and non-diabetic groups (BMI, WC, FBS, and DBP) as shown in Table 2.

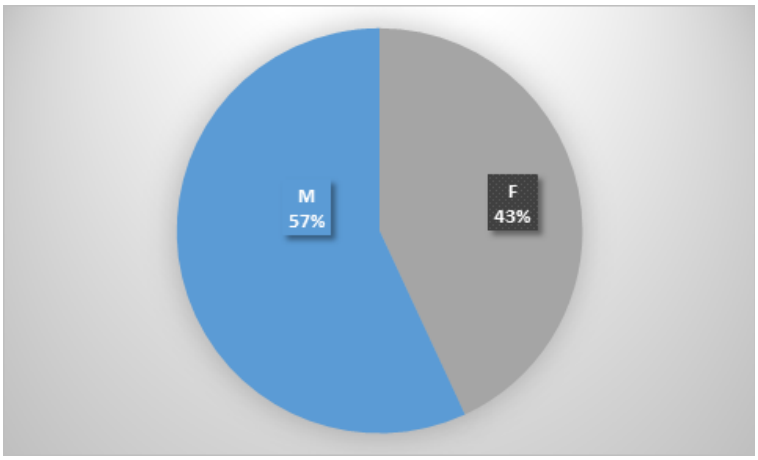
DISCUSSION:

In this study, male participants were more predominant than females in both the groups, which is also supported by the study of Kumar et al. [7] But, a few other studies disagreed with this finding. [8,9]



M= Male (69), F=Female (54)

Fig.1: Diabetic patients gender distribution



M= Male (70), F=Female (53)

Fig. 2: Non-diabetic patients gender distribution

Table 1: Comparison of various anthropometric and clinical parameters between the diabetic and non-diabetic groups (N=246).

Parameters (mean±SD)	**Diabetic group (n=123)**	**Non-diabetic group (n=123)**	**p-value[#]**
BMI	28.5±2.6 kg/m^2	27.4±3.1 kg/m^2	0.002
SBP	141±13 mm of Hg	131±9 mm of Hg	<0.001
DBP	84±11 mm of Hg	79±8 mm of Hg	<0.001
WC	90.04±5.8 cm	88.54±6.01cm	0.028
NC	38.0±3.0 cm	36.6±3.2cm	<0.001

BMI: body mass index, FBS: fasting blood sugar, PPBS: post prandial blood sugar, HbA1C: glycated hemoglobin, SBP: systolic blood pressure, DBP: diastolic blood pressure, WC: waist circumference, NC: neck circumference. [#] *Independent t test*

Table 2: Pearson's correlation between neck circumference and other anthropometric measures in diabetics and non-diabetics (N=246).

Parameters	Diabetic group		Non-diabetic group	
	R	p-value	R	p-value
Height(m)	-0.357	0.00	-0.122	0.182
Weight(kg)	0.179	0.047	0.140	0.124
BMI	0.747	<0.001	0.277	0.002
FBS	0.275	0.002	0.027	<0.001
PPBS	0.307	0.001	0.006	0.949
HbA1C	0.220	0.014	-0.031	0.739
SBP	0.740	<0.001	-0.173	0.057
DBP	0.619	<0.001	-0.269	0.003
WC	0.635	<0.001	0.472	<0.001

BMI: body mass index, FBS: fasting blood sugar, PPBS: post prandial blood sugar, HbA1C: glycated hemoglobin, SBP: systolic blood pressure, DBP: diastolic blood pressure, WC: waist circumference, NC: neck circumference.

Conventionally, waist circumference has been used to measure the central obesity and metabolic disorders assessment, but it has some demerits as compared to using NC. First, different studies have proposed different ways and sites to measure waist circumference, which might produce variable results. [10] Second, measuring waist circumference would not be easy in a large population during winter because of wearing more and warmer clothes. And third, waist circumference may be varied daily because the abdominal wall and cavity change with feeding and other activities. [10]

The mean NC was found higher in diabetic participants than in non-diabetes participants. However, mean NC in both groups was higher than the normal standard cut off value. Similarly, mean waist circumference and BMI were higher in diabetes than in the non-diabetes participants but above the normal cut off value in both groups[3] and the p value was found to be statistically significant. With these results, we assumed that neck circumference is proportionally increasing with the conventional anthropometrics parameters like BMI and waist circumference. A similar study done on Chinese diabetes patients by Yang et al.[11] reported that NC was positively related with BMI and waist circumference in type 2 diabetes and a neck circumference of ≥39 cm for men and ≥35 cm for women was the best cutoff point. Bao et al. also agreed with our study findings and reported that the neck circumference optimal cutoffs for identifying visceral obesity were 38.5 cm in men and 34.5 cm in women, suggesting that neck circumference may be used for identifying obesity.[12]

Our study indicated that increases above the optimal cut off level of NC are directly related

to overweight and obesity with an increased risk of diabetes. This finding was supported by the study of Aswathappa, which reported a significant increase in neck circumference in diabetics compared to non-diabetics.[3] Another large study done in Brazil has also shown a significant association between neck circumference and insulin resistance, which was supported by our study.[13]

This study also analyzed NC and systemic blood pressure (systolic and diastolic blood pressure) in both diabetes and non-diabetes groups. The results revealed that neck circumference and systolic blood pressure and diastolic blood pressure were found higher in diabetic patients as compared to non-diabetic patients. This finding was supported by other studies reporting larger NC being related to the presence of hypertension, diabetes and sleep apnea.[14] Another study has also reported the same result that the larger the neck circumference increases the risk of hypertension.[7]

In our study, the relationship of NC with conventionally used anthropometric indices like BMI and waist circumference to assess the central and peripheral fat as overweight and obesity was further studied. Neck circumference showed a significant high positive correlation with body mass index ($r=0.747$, $p<0.01$) and waist circumference ($r=0.635$, $p<0.01$) in diabetes patients and a mild positive correlation with BMI ($r=0.277$, $p=0.002$) and waist circumference ($r=0.472$, $p<0.01$) in non-diabetes participants.

This study also observed a significant positive correlation between neck circumference and fasting blood sugar, postprandial blood sugar, and HbA1c in diabetes patients and a significant negative correlation between HbA1c and non-diabetes participants. There was a significantly strong positive correlation of neck circumference with both systolic blood pressure and diastolic blood pressure in diabetes patients and a strong negative correlation in non-diabetes participants, as well as a similarly significant negative correlation with height in both diabetes and non-diabetes participants. With all these findings, it is valid to say that neck circumference is the next best anthropometric indices to evaluate overweight and obesity. There is a strong association between an increase in metabolic disorders like diabetes and hypertension and an increase in neck circumference. Various studies done by many authors supported our study with their findings.[3,7,9,10,15] Some authors reported that neck circumference was associated with metabolic syndrome more strongly than waist circumference.[16]

This observational study indicated that NC is an index that can be used to identify overweight and obese patients. It may be easier and helpful to monitor the risk of developing metabolic disorders.

CONCLUSION:

The current study observed a significant positive correlation between neck circumference and fasting blood sugar, postprandial blood sugar, and HbA1c in diabetes patients and a significant negative correlation between HbA1c and non-diabetes participants. This study also found a significantly strong positive correlation of neck circumference with both systolic blood pressure and diastolic blood pressure in diabetes patients and a strong negative correlation in non-diabetes participants. Neck circumference can therefore be considered a simple, easy, and a novel anthropometric index to evaluate overweight and obesity and hence predict type 2 diabetes mellitus.

Conflict of Interest: The authors declare that no competing interests exist.

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