Original Article

Neck Circumference as an Anthropometric Measure of Obesity in Diabetics

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Abstract

Background: Obesity is a risk factor for type 2 diabetes mellitus. Insulin resistance is associated with visceral subcutaneous fat content. Neck circumference (NC) is a marker of upper body subcutaneous adipose tissue distribution. **Aim:** The aim of this study is to compare NC in diabetics and non-diabetics and to correlate NC with other anthropometric measures. **Materials and Methods:** A cross-sectional study was conducted in 350 type 2 diabetics and 350 non-diabetics of >30 years of age. Anthropometric parameters like body mass index (BMI), waist circumference (WC), hip circumference, and NC were measured. Independent *t*-test and Pearson's correlation were the tests of significance done to analyze quantitative data. **Results:** There was positive correlation of NC, BMI, and index of central obesity. The NC in diabetics was significantly higher than in non-diabetics ($P < 0.001$). NC >36 cm in diabetics and >37 cm in non-diabetics was the best cutoff value to determine subjects with central obesity. **Conclusion:** The findings indicated that NC may be used both in clinical practice and in epidemiologic studies as a straightforward and reliable index. It is an economical easy to use test with less consumption of time and correlates well with other standard anthropometric parameters.

Keywords: Diabetes mellitus, Neck circumference, Obesity

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Introduction

Diabetes mellitus (DM) is a syndrome of impaired carbohydrate, fat, and protein metabolism either by lack of insulin secretion (DM type I) or by decrease in sensitivity of tissues to insulin (DM type II).[1] According to World Health Organization (WHO), the number of people with diabetes in the world will reach 300 million by 2025.[2] There has been a dramatic increase in the prevalence of DM type II in India in recent times. Obesity is a major risk factor for the development of type 2 DM. Overweight decreases the insulin usage of muscles, as it decreases the number of insulin receptors on cell surfaces. Obesity is not only the most common cause of insulin resistance, but also a growing health concern in its own right. The trends in the prevalence of obesity documented over the last few decades in our country have been alarming, with morbid obesity affecting 5% of Indian population.[3] Insulin resistance is associated with visceral and subcutaneous fat content.[4]

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International criteria for body mass index (BMI) suggest the following: 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).[5] But the revised guidelines for diagnosis of obesity in Asian Indian populations 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. The healthy waist circumference (WC) limits are 90 cm for men and 80 cm for women.[4] Diabetes and its complications pose a major public health concern worldwide and are a major challenge to patients, health-care systems, and national economies. Usually, BMI has been used as a measure to diagnose obesity. Other types of anthropometric measures like WC, waist to hip ratio (W/H), and index of central obesity (ICO) have all been associated with increased body fat and have predicted the distribution of body fat.

Neck circumference (NC) is a relatively new method of differentiating between normal and abnormal fat distribution. It is a marker of upper body subcutaneous (SC) adipose tissue distribution. Adipose tissue is found in specific locations, which are referred to as adipose depots. Adipose tissue contains several cell types, with the highest percentage of cells being adipocytes, which contain fat droplets. Upper body obesity characterized by upper body SC fat is related to metabolic disorders like glucose intolerance, diabetes, hypertriglycerdemia, etc., Free fatty acid release from this upper body SC fat was reported to be larger than that from lower body SC fat.[6] As a result of insulin resistance in adipose tissue, lipolysis and free fatty acid flux from adipocytes are increased, leading to increased lipid [very low density lipoprotein (VLDL) and triglyceride] synthesis in hepatocytes. This lipid storage or steatosis in the liver may lead to nonalcoholic fatty liver disease and abnormal liver function tests. This is also responsible for the dyslipidemia found in type 2 DM.[7] It has been shown that NC >37 cm in men and NC >34 cm in women are probably the best cutoff points to determine subjects with central obesity.[8]

The aim of this study is to compare the NC in diabetics and non-diabetics and to correlate the NC with other anthropometric measures.

Materials and Methods

A community-based cross-sectional study was conducted in 700 subjects, which included age-matched 350 type 2 diabetics and 350 non-diabetics of >30 years of age in Kolar District. Ethical clearance was obtained from institutional ethical committee and informed consent was taken from all subjects prior to the study. Anthropometric parameters like BMI, WC, hip circumference (HC), and NC were measured. Weight was measured with light clothing and without shoes. Height was measured without shoes. BMI was calculated by dividing weight (kg) with the square of height (m). WC (cm) was taken horizontally to within 1 mm, using plastic tape measure at midpoint between the costal margin and iliac crest in the mid-axillary line, with the subject standing and at the end of a gentle expiration. HC was measured in centimetres, at the level of greater trochanters, with the legs close together. ICO was calculated by dividing WC with height (m).

NC 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. In men with a laryngeal prominence (Adam's apple), it was measured just below the prominence. While taking this reading, the subject was asked to look straight ahead, with shoulders down, but not hunched. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement. Subjects with any thyroid disorder or Cushing's disease, and pregnant and lactating women were excluded from the study.

Statistical analysis

Epi info 7 software was used for data analysis. Independent *t*-test and Pearson's correlation were the tests of significance done to analyze the quantitative data. Receiver operating characteristic (ROC) analysis was done to find the optimal, maximal sensitivity and specificity for NC against WC. A P value of ≤0.05 was considered significant.

Results

The study sample of 700 subjects consisted of 350 type 2 diabetics and 350 non-diabetics. Table 1 shows the results of independent *t*-test comparing the anthropometric parameters in diabetics and non-diabetics.

Mean NC among 350 diabetics was 36.4 ± 6.18 cm and among 350 non-diabetics was 34.9 ± 6.01 cm. The NC in diabetics was significantly higher than in non-diabetics ($P < 0.001$), as shown in Table 1.

There was statistically significant positive correlation between NC and other anthropometric measurements in diabetic and non-diabetic groups (BMI, WC, W/H, and ICO) as shown in Table 2.

ROC analysis showed that area under the curve (AUC) for NC and central obesity was 0.853 for diabetics. NC of >36 cm was the best cutoff point for determining the central obesity with positive likelihood ratio of 4.85 [Figure 1].

ROC analysis showed that AUC for NC and central obesity was 0.809 for non-diabetics. NC of >37 cm was the best cutoff point for determining the central obesity with positive likelihood ratio of 4.73 [Figure 2].

Table 1: Independent *t*-test comparing anthropometric measures in diabetics and non-diabetics

Parameters	Diabetics Mean±SD	Non-diabetics Mean±SD	*P* value
Age (years)	56.09±11.24	54.93±10.16	0.153
Weight (kg)	67.23±11.09	65.05±13.42	0.019
Height (m)	1.623±0.088	1.627±0.552	0.552
BMI (kg/m^2)	25.52±4.52	24.67±4.71	0.016
WC (cm)	90.56±12.23	88.74±9.00	0.025
HC (cm)	90.08±7.90	91.42±8.39	0.030
W/H	1.00±0.09	0.97±0.07	<0.001
NC (cm)	36.40±6.18	34.91±6.01	0.001
IOC	55.86±8.52	54.82±6.31	0.067

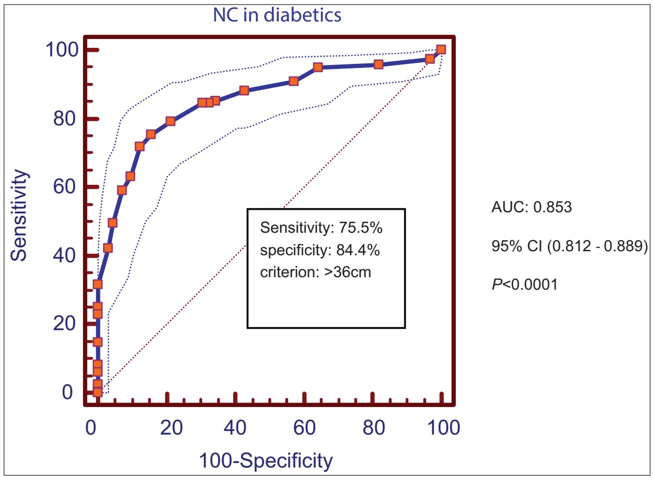

Figure 1: Receiver operating characteristic curves related to neck circumference and central obesity (waist circumference >90 cm/80 cm) in diabetics

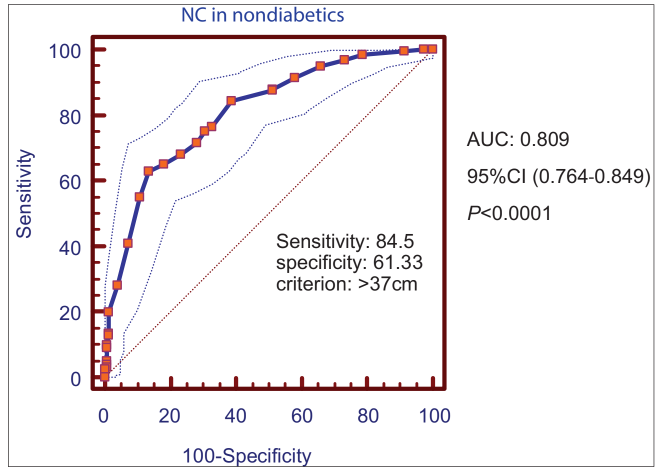

Figure 2: Receiver operating characteristic curves related to neck circumference and central obesity (waist circumference >90 cm/80 cm) in non-diabetics

Table 2: Pearson's correlation between neck circumference and other anthropometric measures in diabetics and non-diabetics

Parameters	Non-diabetics		Diabetics	
	r	*P*	*r*	*P*
Age (years)	−0.007	0.898	−0.015	0.785
Height (metres)	0.123	0.021*	0.009	0.868
Weight (Kg)	0.608	0.000**	0.031	0.0563
BMI (Kg/m^2)	0.768	0.000**	0.668	0.000**
WC (cm)	0.708	0.000**	0.773	0.000**
HC (cm)	0.656	0.000**	0.032	0.546
W/H	0.164	0.002	0.483	0.000**
ICO	0.557	0.000**	0.675	0.000**

**Correlation is significant at 0.01 level (two-tailed), *Correlation is significant at 0.05 level (two-tailed). BMI: Body mass index; WC: Waist circumference; W/H: Waist to hip ratio; NC: Neck circumference; ICO: Index of central obesity

Discussion

Central obesity has been shown to be associated with an increased risk of diabetes. Various anthropometric measurements like BMI, WC, W/H, and ICO have been related to metabolic complications.[9] The purpose of this analysis was to study the role of NC as a measure of obesity and to compare it between diabetics and non-diabetics.

The present study has shown a significant increase in NC in diabetics compared to non-diabetics. NC is reported to be positively associated with glycemic status, W/H, and BMI.[10] The present study showed positive correlation of NC with BMI, WC, W/H, and ICO ($P < 0.01$). Studies have also shown that NC has surpassed other anthropometric measurements as a powerful marker of both visceral adipose tissue (VAT) and insulin resistance.[11]

In our study, NC of >36 cm in diabetics and >37 cm in non-diabetics was the best cutoff value to determine subjects with central obesity. Another study reports that large NC is related to the presence of sleep apnea, diabetes, and hypertension.[12]

Upper body SC fat, as estimated by NC, may confer risk above and beyond VAT. Anatomically, upper body SC fat is a unique fat depot located in a separate compartment, compared with VAT. Various studies indicate that diabetics have a relative preponderance of adipose tissue in various regions of the upper body. Upper body SC fat is responsible for a much larger proportion of systemic free fatty acid release than visceral fat, particularly in obese individuals, and is lipolytically more active than lower body adipose tissue. Lipolytic activity of upper body fat may mediate this relationship with lipid metabolism and glucose homeostasis. Insulin resistance relates better with SC truncal fat compared to intraperitoneal fat.[13] Central obesity, particularly high levels of upper body fat, is associated with adverse metabolic outcomes such as insulin resistance, diabetes, hypertension, and elevated triglycerides, whereas individuals with lower body obesity tend to have lower levels of these adverse metabolic outcomes. SC fat plays a major role in obesity-related insulin resistance in men.[14]

As there is a high correlation between NC and BMI, WC, ICO, and W/H, and also NC is more in diabetics, which indicates more of regional adiposity is present, the diabetic subjects require a comprehensive evaluation of their overweight and obesity. Upper body SC fat is a novel, easily measured adipose depot, which is an important predictor of diabetic risk. The study of this depot may lead to a better understanding of the differential effects of adiposity in an individual.

Other anthropometric measures have their own limitations. BMI does not account for factors such as body fat distribution, specifically abdominal obesity, and cannot distinguish between lean and fat body mass.[15] WC has its own disadvantages as subjects are required to wear thin clothes during the measurement, so that the thickness of clothing does not influence the result. The measurement is typically conducted before eating and after emptying bladder. Subjects should be asked to breathe normally and at the time of the measurements asked to breathe out gently. So, it involves discomfort to the subject. W/H and ICO are dependent on WC.

Thus, NC is a better potential clinical screening tool for predicting overweight and obesity; it can be used as an inexpensive straightforward test with less consumption of time.

Conclusion

High correlations between NC and BMI, WC, ICO, and W/H may point to NC as a reliable index for obesity. These findings indicate that NC may be used both in clinical practice and in epidemiologic studies as a straightforward and reliable index for obesity. NC is more in diabetics, which indicates more of regional adiposity is present. The risk of central obesity is more in diabetics at a lesser NC (>36 cm) compared to non-diabetics (>37 cm). Thus, diabetic subjects require a comprehensive evaluation of their obesity.

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