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Comparison of Waist Circumference in Type 2 Diabetes and Non - Diabetic Population

Latha Sannasi, MBBS, MD[1]

[1]Department of Physiology, Panimalar Medical College and Research Institute, Chennai, Tamil Nadu, India.

***Corresponding author:**
Latha Sannasi,
Associate Professor,
Department of Physiology,
Panimalar Medical College and Research Institute, Chennai,
Tamil Nadu, India.

drlathu@gmail.com

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ABSTRACT

Objectives: Diabetes mellitus has a great association with obesity. Obesity is a risk factor for diabetes mellitus. Obesity can be measured clinically with waist circumference (WC), which is an indirect measurement of obesity in humans. The association between WC and plasma glucose in type 2 diabetes mellitus (T2DM) was studied in a population in the suburban population of Tamil Nadu. The objectives of this study were to study and compare the WC in diabetic and non-diabetic populations and to study the relation of WC with plasma glucose in T2DM.

Materials and Methods: WC, post-prandial plasma glucose (PPPG), and fasting plasma glucose (FPG) were measured for 125 diabetic participants and 120 non-diabetic participants who formed the control group.

Results: WC was considerably higher in type 2 diabetes than non-diabetic population. The male T2DM WC was higher compared with the female T2DM. The WC and the plasma glucose across the three BMI groups were statistically different. The WC showed a positive correlation with FPG and PPPG in T2DM.

Conclusion: The waist circumference in T2DM was high compared with NDM group. Among T2DM, the plasma glucose was high in participants with higher waist circumference than in participants with WC less than the cut off values. WC can be used as a marker to screen for diabetes and to detect plasma glucose control among different BMI groups in T2DM.

Keywords: Fasting plasma glucose, Obesity, Post-prandial plasma glucose, Type 2 diabetes mellitus, Waist circumference

INTRODUCTION

The global prevalence of diabetes mellitus is 10.5% and will reach 12.2% by 2045.[1] Diabetes mellitus is the most common non-communicable disease in India. As the incidence of type 2 diabetes mellitus (T2DM) is increasing, there is a concomitant increase in the incidence of obesity.[2] T2DM influences obesity in increasing the incidence of both.[3] The risk factors for diabetes include obesity, increasing age, unhealthy diet, and overweight.[1] T2DM patients who are obese are at greater risk of complications and poor plasma glucose control.[3] Obesity is a risk factor for mortality and morbidity in T2DM and is associated with many complications.[4] Obesity can be measured with body mass index (BMI) and WC but WC is more concerned with central obesity which is more associated with T2DM.[5] The majority of Asians are lean phenotype diabetics where the BMI may be low but WC is significantly raised.[6] Increased body fat is the most common characteristic of this phenotype deposited in the visceral and central compartment.[7] BMI cannot be used as an indicator of obesity because it does not account muscle distribution, bone density, and fat mass.[8] The obese or the overweight individuals have the same BMI but

some have cardiovascular complications and some may have a bone joint problem.; therefore, a high BMI may not be a predictor of complications in obesity.[1] Central obesity means excess fat above the hips; this is different from having excess fat in hips and thighs. Central obesity is measured with waist circumference (WC) and waist–hip ratio. Central obesity is more common in Indians when compared with other population.[9] WC measurement is the best indicator of total body fat and body adiposity.[2] WC is the sum of visceral abdominal adipose tissue and subcutaneous adipose tissue and can be used as a marker of obesity.[10] WC as a marker of obesity is a strong predictor of mortality and morbidity.[3] As we screen for diabetes, there should be an easy method to screen obesity so that both can be handled simultaneously and diabetes can be managed in a significant way. The association between obesity and T2DM indicates that the WC as a marker of obesity can be used as an alternative method to screen for diabetes and plasma glucose control in T2DM. T2DM diagnosis is delayed up to middle adulthood in Asians[11] so WC can also be used as a screening method for early diagnosis of T2DM, the test being a simple measurement.

MATERIAL AND METHODS

This is a cross-sectional study. The ethical committee of the institute approved the study. The study place was at a tertiary care hospital in a suburban area. About 125 T2DM subjects visiting the general medicine department for regular health check-ups participated in the study. About 120 non-diabetic participants (NDM) who visited the hospital for other medical treatment were the controls. The T2DM participants were diagnosed as T2DM using the American Diabetes Association guidelines as fasting plasma glucose (FPG) >126 mg/dL with post-prandial plasma glucose (PPPG) >200 mg/dL glycated hemoglobin (HbA1C) measured using ion exchange chromatography (DS5 Analyzer, Drew Scientific Limited, Cumbria, U.K).[12] The participants were under treatment for T2DM with oral hypoglycemic medications. Height: Height recorded with the patient standing erect in a stadiometer. The height of the subjects was measured at the vertex of his skull. The height was measured in centimeters up to two points WC: Measured with a non-stretchable measuring tape, patients were asked to stand erect with feet close to each other. The measuring tape was placed around the waist, at the level of the umbilicus, and measurement was recorded in centimeters. The WC was measured using tape which is stretch-resistant and provides a 100 g constant tension with an anatomical midpoint between the top of the iliac crest and the lower margin of the last rib. The subject feet should be close together, the weight of the body evenly distributed, with arms by the side with little clothing, and measured at the end of expiration. The measurement was repeated twice, and the average was calculated.[13] Weight: Weight was measured with an electronic weighing machine. Subjects were asked to stand in the center of the platform with hands at their sides and looking straight ahead. The weight measurement was recorded in kilograms. BMI of the participants was calculated using the formula, BMI = Wt (Kg)/Ht (m^2). We used the World Health Organization (WHO) criteria of obesity definition: BMI 18.5–24.9 for normal, 25–29.9 for overweight, and ≥30 as obese.[13] Abnormal WC was diagnosed according to ATP (adult treatment panel III for metabolic syndrome) criteria as ≥102 for men and ≥88 cm in women.[6] A written informed consent was obtained from all participants before study enrollment. Statistical Package for the Social Sciences version 17 software was used for data analysis. Continuous variables were compared using the Student's t-test and expressed as mean ± Standard deviation. $P < 0.05$ was taken as the level of significance. Pearson's correlation was used to find the influence of WC on FPG and PPPG.

RESULTS

One hundred and twenty-fivediabetic subjects participated in the study. Age-matched controls without complications of diabetes were included in the study. The age and height of both groups were almost identical. The average BMI of diabetic participants was 26.60 and that of non-diabetic was 23.93. About 44% of participants in the diabetic group were obese with BMI >30 compared with NDM. The WC in T2DM was of a greater value when compared with NDM and it was statistically significant. The mean waist circumference of T2DM was higher than NDM as given in Table 1. The difference between WC and BMI was statistically significant between T2DM and NDM as shown in Table 1. The WC is positively co related with FPG, PPPG and HbA1c as given in Table 2. When compared between different BMI groups among T2DM, the waist circumference in <25 group was 87.29 cm, in 25 - 29 BMI group it was 95.71 cm and in >30 BMI group it was 103.35 cm and the differences were statistically significant as given in Table 3. The male T2DM had a higher mean WC of 98 cm compared with females, which was 90.42 cm and it is statistically significant $P < 0.05$ as shown in Table 4. this was comparatively higher than NDM in which the mean WC of NDM male is 83 cm and female is 80 cm. In the present study, according to ATP criteria, 49% of women with T2DM had WC >88 cm and 42% of men had WC >102 cm.

DISCUSSION

This study is the first of its kind in Chennai suburban area to find the association between WC and plasma glucose levels. WC is comparatively higher in diabetic subjects in the present study than in non-diabetics as was demonstrated in a study

done in Ludhiana in India.[14] The WC between different BMI groups was a statistically significant difference with a greater than cutoff value. According to the WHO, WC is the most important risk factor for diabetes and cardiovascular incidents than BMI.[13] The WC was statistically different in the different BMI groups, suggesting most of the T2DM participants had central obesity. Higher WC is associated with glucose intolerance. Asians with high WC were associated with more incidence of diabetes. In a study done with Asians, WC showed a strong association with T2DM.[5] Padaki *et al.* demonstrated a strong association between WC and diabetes in the Indian population; the present study demonstrated a positive correlation between WC and plasma glucose.[5] According to Jackson's heart study in America, WC is a stronger predictor of incident diabetes[15] The FPG and PPPG are considerably elevated in T2DM with increased WC than in T2DM with normal WC, this proves that WC influences the plasma glucose.[2] Central obesity is an important factor causing insulin resistance and the etiological factors contributing to this are obesity and inflammation[3] A Korean study conducted with 31,118 individuals showed men with WC of 90.1 cm and women with WC of 69.9 cm had a 4.5 fold and 8.3 fold higher risk, respectively, to develop diabetes.[16] In the present study, it was proved that a higher WC had more incidence of diabetes as the T2DM group WC was statistically greater when compared with the non-diabetic group. The etiology for increased WC in diabetes has been attributed to a modern lifestyle with decreased physical activity and increased consumption of high glycemic foods.[3] The present study was also conducted in a suburban area where the population may have the same characteristics. WC is the sum of visceral abdominal obesity and subcutaneous adipose tissue. The etiology of diabetes mellitus has been attributed to the DAG of liver and muscle in obese individuals with decreased insulin signaling; thus, obesity is associated with the pathogenesis of T2DM.[3] Increased lipid derivatives cause fibrosis and some hypoxia in obesity that plays an inflammatory role in insulin sensitivity, insulin resistance, and deregulated energy metabolism.[3] In the present study, there is a significant difference in WC between men and women and also between diabetic and non-diabetic as studied by Ruze *et al.* where a significant difference in WC between both genders was demonstrated and WC was used as a cardiorespiratory efficiency marker in that study.[3] The higher WC in male T2DM participants than in NDM indicates that WC is a risk factor for diabetes and it

Table 1: Baseline characteristics of T2DM and non-diabetic (NDM).

Variables	T2DM	Non-diabetic	Significance
Age	46.82±7.06	46.72±7.03	0.094
Height cm	158.79±9.35	160.27±9.72	0.334
Weight kg	67.18±3.80	61.51±11.09	0.006
Body mass index	26.60±4.84	23.93±3.71	0.000*
Waist circumference	104.27±12.37	92.26±8.54	0.000*

All the data given are mean±standard deviation. All the comparisons were made with analysis of variance and Turkey's multiple comparisons with the level of significance (P<0.05).* - denotes significant difference. BMI – Body mass Index in kg/m^2. Waist circumference in cm. T2DM: Type 2 diabetes mellitus

Table 2: Person's Chi-square test - level of significance of plasma glucose, HbA1c with waist circumference in Type 2 diabetes mellitus.

Variables	Value	P<0.05*
Age	0.033	NS
Height cm	0.279	NS
Weight kg	0.740	0.000**
HbA1c	0.782	0.002*
FPG g/dL	0.745	0.000**
PPPG g/dL	0.722	0.000**

**: Significant two-tailed,
FPS: Fasting plasma sugar, PPBS: Post-prandial prandial sugar, NS: Not significant, HbA1c: Glycated Hemoglobin, PPPG: Post-prandial plasma glucose, FPG: Fasting plasma glucose

Table 3: Comparison of waist circumference among different BMI groups in T2DM.

Variable	Different BMI in T2DM			Sig.
	<25	25–29	30 or >	
Age	44.06±11.69	47.25±11.21	47.20±10.69	0.493
Height cm	159.26±10.35	158.54±8.25	158.35±9.38	0.935
Weight kg	55.74±9.04	69.67±8.04	81.95±9.11	0.000*
Waist measurement cm	87.29±11.82	95.71±10.39	103.35±8.69	0.000*
FPG g/dL	130.59±12.20	186.86±06.94	210.05±09.89	0.000*
PPPG g/dL	220.13±12.22	299.52±11.23	389.68±10.52	0.000*

All the data given are mean±standard deviation. All the comparisons were made with analysis of variance and Turkey's multiple comparisons with the level of significance (P<0.05).* - denotes significant difference. BMI: Body mass index in kg/m^2 FPS – Fasting plasma sugar, PPPG: Post-prandial plasma glucose, T2DM: Type 2 diabetes mellitus

Table 4: Baseline characteristics of male and female type 2 diabetes mellitus.

Variable	Male	Female	Sig.
Age	45.19±11.35	46.63±11.23	NS
Height cm	165.27±6.19	152.47±7.38	0.000**
Weight kg	71.45±12.24	63±14.11	0.007*
Body mass index	26.22±4.59	26.98±5.11	NS
Waist circumference cm	102.22±10.38	90.42±13.05	0.000*

All the data given are mean±standard deviation. All the comparisons were made with analysis of variance and Turkey's multiple comparisons with the level of significance (P<0.05).* - denotes significant difference. **Significant two-tailed. BMI: Body Mass Index in kg/m^2

is only the diabetic male group which had WC greater than cutoff point of >102 cm. In the female group, both T2DM and NDM had WC >88 above the cutoff value but was not greater than men's value as in a South African study where women had greater WC than men.[10] The high WC in male T2DM is strongly associated with diabetes as shown in an Iranian study. The high WC was considered abdominal obesity resulting in cardiovascular disorders[17] Framingham's heart study showed a high WC in male than female in Americans and the blood pressure was also high in male than female[18] as proved in our study. In a study done in Tamil Nadu, the prevalence of abdominal obesity was 49.5% in women and 15.7% in men;[17] in the present study, the prevalence of abdominal obesity is 49% in women and 42% in men. Our study shows a positive correlation between WC and PPPG in T2DM as demonstrated in a cross-sectional study of the Indian, Chinese, and Malaysian populations; the Indians had a strong association with the WC, the incidence of diabetes, and high plasma glucose.[19] The high plasma glucose in obesity associated with T2DM can be explained as proved by Bai *et al*. that obese people's fat diet can cause dysfunctional mitochondria and dysfunctional endoplasmic reticulum present in the hypothalamus which changes leptin signaling resulting in insulin resistance.[1] The high plasma glucose value in T2DM with high WC and its positive correlation proved that WC is a positive predictor of deranged glucose homeostasis as shown in a study.[6] In a study, WC in both men and women was used as a cardiorespiratory fitness[4] marker; hence, it can used for that purpose in the future. T2DM with increased WC is associated with increased complications, increased mortality, and obstructive sleep apnea.[10] Obesity is also associated with osteoarthritis.[20] Abdominal obesity is an important cause of cardiac failure in diabetes as proved in a study.[21] WC is a single risk factor and could replace the waist–hip ratio for all-cause mortality.[13] To maintain normal plasma glucose values and to prevent obstructive sleep apnea and complication of obesity such as cardiovascular complication, the WC in T2DM should be less than the cut-off values.

CONCLUSION

The WC in T2DM was high compared with non-diabetic subjects. The male T2DM had greater WC than the female T2DM. The persons with high WC had a higher value of plasma glucose than persons with a weight circumference less than the cutoff values. Thus, WC above the cutoff values in both genders is positively associated with plasma glucose. WC can be used as a marker to screen for diabetes and for blood glucose control across different BMI groups.

Ethical approval: The research/study was approved by the Institutional Review Board at Chettinad Medical College Hospital, number 043-12/CARE/AR-Research/2017, dated 28th July, 2017.
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