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Original Research Article

Correlation of wrist circumference with waist circumference and body mass index in adults with early-onset type 2 diabetes mellitus

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ABSTRACT

Background: Recent studies have shown that wrist circumference is correlated with insulin resistance, obesity and new onset diabetes. Being easy to measure, it may be useful in identifying individuals at risk for cardio- metabolic disorders.
Methods: 112 consecutive subjects with new onset type 2 diabetes in the age group 18-44 years were included in the study. Socio demographic characteristics, anthropometric and biochemical measurements were carried out using standard techniques. Pearson product movement Correlation Coefficient was used to find out correlation with other measures of obesity and ROC curve to determine its cut off values.
Results: Wrist circumference showed moderate positive correlation with BMI (r+0.389) and waist circumference (r+0.443). The cut off value of wrist circumference when compared with BMI in defining obesity was 16.5cm in male and 15.7 cm in female. The cut off value of wrist circumference with waist circumference in male was 16.2cm.
Conclusions: Measurement of wrist circumference may supplement in assessing obesity especially when other measures of obesity like BMI or Waist circumference measurements are difficult or not feasible.

Keywords: Body mass index, Correlation, Early onset, Type 2 diabetes, Waist circumference, Wrist circumference

INTRODUCTION

The incidence of type 2 diabetes mellitus (T2DM) in the young is rising in parallel with the incidence of overweight and obesity. The fall in age of onset of T2DM is driven by increasing obesity in the younger age group. This is supported by the inverse relationship between obesity and age of diagnosis of T2DM.[1] Of concern is the fact that obesity has increased by 70 % in adults aged between 30 and 39 years, thus, making younger adults the fastest growing group for obesity and T2DM.[2] According to WHO, obesity is one of the most common, yet among the most neglected public health problems in both developed and developing countries [World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation (1-253)].

According to WHO, when the BMI is greater than or equal to 25 kg/m^2 it is overweight and ≥30 Kg/m^2, is obesity. A technical report of WHO for South Asians define a BMI >23 Kg/m^2as increased risk and

>27.5Kg/m^2 as high-risk population. India specific consensus guideline developed by MOH& FW, ICMR, NIN and others reduced the diagnostic cut offs to 23-24.9 as overweight and ≥25 as obesity (October 2008).

Body Mass Index (BMI) and waist circumference (WC) are considered as the traditional measures of generalized and abdominal obesity respectively. Recently, it has been shown that in addition to the pancreatic β-cells and the hepatocytes, bones may also be involved as an endocrine organ in the regulation of whole-body glucose metabolism.[3,4] Wrist circumference (WrC) is a tool to detect measures of skeletal frame size without being severely confounded by body fat variation.[5] Studies have shown that, wrist circumferences a significant predictor of diabetes in both genders of adult population. However, its predictability is independent of BMI or WC only among females.[6] Differences between the two genders regarding the association between wrist girth and diabetes occurrence could be explained by the effects of sex steroid hormones and their interaction with bone metabolism and glucose homeostasis.[7,8] Because of its simple and easy-to-detect nature, and can be assessed with only minimal action from patients, wrist circumference could be considered as a new anthropometric assessment for prediction of type 2 diabetes and metabolic syndrome.[9] It has recently been suggested as a clinical marker associated with insulin resistance in obese children and adolescents in a cross-sectional study.[10,11]

In an AHA study, researchers analysed how wrist size and BMI correlated with levels of insulin resistance. While BMI only accounted for 1 percent of variation in insulin resistance, the wrist measurement accounted for between 12 and 17 percent. Its easy measurement without the need of calculation ratios might make it as a routine measurement in daily clinical practice and in large epidemiological studies. The objectives of the current study was to evaluate the association of wrist circumference with generalized and abdominal obesity and to determine its sex- and age-specific optimal cut off points in association with generalized and abdominal obesity in a sample of young adults with incident type 2 diabetes.

METHODS

Inclusion Criteria

Adult men and women aged between 18-44 years who fulfil the American Diabetes Association criteria for diagnosis of type 2 diabetes mellitus.

Exclusion Criteria

Type 1 diabetes, Gestational Diabetes, other specific types of diabetes, unclear types of diabetes and subjects with incomplete data as well as those who were pregnant or had a chronic disease that may affect the metabolic status or body composition (e.g., thyroid or hypothalamic disease, chronic hepatitis, and cirrhosis), participants with bilateral wrist deformity, bed ridden and those not willing to give consent were excluded from the study.

Study Period

January 2016 to January 2019.

Study Population

All consecutive subjects (adult men and women) aged between 18-44 years who have visited General Medicine & Diabetology departments of Sree Gokulam Medical College & Research Foundation with FPG >126 mg/dL. Fasting is defined as no caloric intake for at least 8h.In the absence of unequivocal hyperglycemia, result was confirmed by repeat testing.

Data collection Methods

After identification of eligible study participants, informed consent was taken and those who gave written informed consent were interviewed using a structured performa. Socio demographic characteristics, anthropometric and biochemical measurements were carried out using standard techniques.

112 consecutive subjects with new onset type 2 diabetes in the age group 18-44 years (early-onset type 2 diabetes) who visited a tertiary care hospital outpatient department were included in the study. The cases were ascertained using internationally accepted American Diabetes Association criteria. The measurements were done by a qualified, trained, single investigator.

Height was measured with the commercial fixed stadiometer corrected to 0.1cm with the subject standing with arms at the sides, heels touching the rod with head held erect and the plane passing through the lower border of orbit and Frankfurt plane parallel.

Digital scale weighing machine corrected to 0.5 Kg was used to measure body weight. Machine was checked for zero error prior to each measurement. BMI was calculated by dividing body weight in kg by height in meters squared. Waist circumference in centimeter was measured in horizontal plane midway between the inferior margin of the ribs and the superior border of the iliac crest, using a standard inelastic measuring tape at the end of gentle expiration. Measurements were taken thrice and the median was taken in all cases.[12]

Wrist circumference was measured with subjects in a seated position with their wrist anterior up, using a tension-gated tape measure positioned over the Lister tubercle of the distal radius and over the distal ulna on the right arm without the tape is too tight or too loose and with lying flat on the skin.[13] The Lister tubercle, a dorsal tubercle of the radius, can be easily palpated at the dorsal aspect of the radius around the level of the ulna head, about 1 cm proximal to the radio carpal joint space.[14-17] A tension-gated tape measure was used to ensure equivalent tape pressure between subjects. Wrist circumference was measured to the nearest 0.1 cm. In the case of any deformity, left wrist was used for the measurement.

Statistical Analysis

Data were entered in MS Excel spread sheet. The data was cleaned and completeness of data was checked. Continuous variables are represented as arithmetic mean+standard deviation and categorical data as percentage. By considering the area under the curve (AUC) of the receiver operator characteristic (ROC) curves, the association of wrist circumference with obesity indices were evaluated and determined its sex- and age-specific optimal cut off points in association with obesity. AUC:0.5, AUC:0.5-0.65 and AUC:0.65-1.0 were interpreted as equal to chance, moderately and highly accurate tests, respectively. To determine an appropriate cut off point of wrist circumference to predict incidence of obesity, a receiver-operator curve analysis was done regarding the subjects' BMI as the outcome variable and wrist circumference as the exposure. The appropriate cut off of wrist circumference was defined by calculating Youden's J statistics (sensitivity+specificity-1) for each cut off measure of wrist circumference and a cut off wrist circumference measure with the maximum value of Youden's index was taken as the appropriate cut off value. All analyses were performed using IBM SPSS for Windows version 20. A two-tailed P value <0.05 was considered significant in all analyses.

RESULTS

In the present study, 68(60.7%) of the study participants were males and 44(39.3%) were females. Mean age of male and female participants were 35.4±6.3 years and 37.6±5.9 years respectively. Males developed type 2 diabetes at an earlier age than females. The mean waist circumference was 97.6 cm (male 97.1 cm, female 98.6 cm). The mean wrist circumference was 16.1 cm (male 16.3 cm, female 15.7 cm). 80.9% males and 100% females were having abdominal obesity.

Table 1: Distribution of BMI, waist circumference and wrist circumference according to gender.

Variable	Male N=68(60.7%)		Female N=44(39.3%)	
	Mean	SD	Mean	SD
BMI (Kg/m^2)	26.47	3.489	28.46	4.704
Waist circumference(cm)	97.1	9.046	98.56	12.521
Wrist circumference(cm)	16.35	0.938	15.70	0.966

Table 2: Distribution of Generalized and Abdominal obesity according to gender.

Variable	Male		Female	
	No.	%	No.	%
BMI 18.5-22.9 kg/m^2	10	14.7	6	13.6
BMI 23-24.9 kg/m^2	14	20.6	7	15.9
BMI ≥25 kg/m^2	44	64.7	31	70.4
WC ≥90 cm	55	80.9	-	-
WC ≥80 cm	-	-	44	100

BMI 18.5-22.9 Kg/m^2 - Normal Weight
BMI 23-24.9 Kg/m^2 - Overweight
BMI ≥25 Kg/m^2 - Obesity
WC ≥90 cm (in male) & ≥80cm (in female) - Abdominal obesity

The mean BMI of the participants was 27.25 Kg /m^2 (male 26.5Kg/m^2, female 28.5Kg/m^2). 18.75% were overweight (male 20.6%, female 15.9%) and 67% were obese (male 64.7%, female 70.5%). Only 10 (14.7%) males and 6 (13.6%) females had normal BMI (18.5-22.9 Kg/m^2).

Only 13 (19.1%) of males had normal waist circumference (<90 cm). All the female participants irrespective of BMI status had abdominal obesity (WC ≥80cm).

Male participants had larger wrist size than females 16.3 cm (minimum 14.5 maximum 19.5 range 5.0) versus 15.7±4 cm (maximum 18 minimum 14 range 4.0).

Female participants had relatively higher BMI and waist circumference

Table 3: Waist circumference and wrist circumference according to BMI categories in both genders.

BMI (kg/m^2)	Male		Female	
	WC (Cm)	WRC (Cm)	WC (Cm)	WRC (Cm)
18.5-22.9	88.50	15.85	87.58	14.83
23-24.9	90.65	15.79	87.37	15.00
≥25	100.62	16.59	101.03	16.13

Anthropometric measurements according to BMI are summarized in Table 3. Waist and wrist Circumference among different BMI categories shows that, Overweight-obese subjects had a higher waist and wrist circumference compared with normal weight subjects.

Pearson product movement Correlation Coefficient (r) of wrist circumference with BMI after controlling the effect of age was+0.389(95% Confidence Interval 0.225-0.525 p value <0.001).

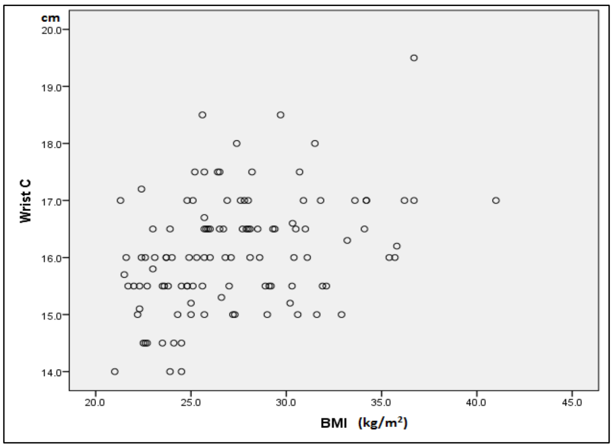


Figure 1: Correlation between BMI and Wrist Circumference.

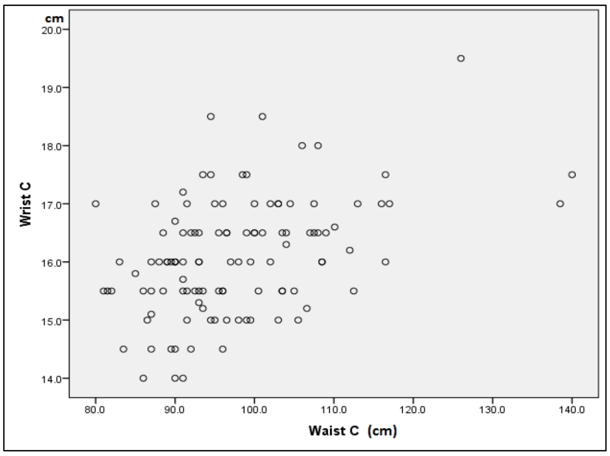
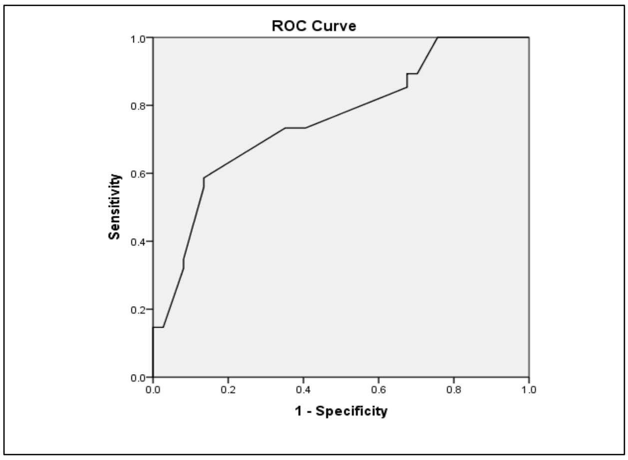


Figure 2: Correlation between Waist circumference and Wrist Circumference.

The Correlation Coefficient of wrist circumference with waist circumference was+0.443 (95%CI 0.290-0.567 p-value <0.001).



AUC .756 (95 % CI .664-.849) p value <0.001

Figure 3: Obesity Vs Wrist Circumference.

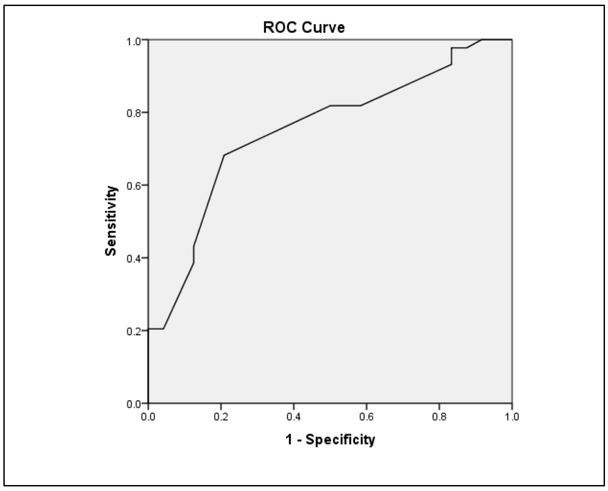


Figure 4: Obesity Vs Wrist Circumference -Male.

The cut off value of wrist circumference when compared with Body Mass Index in male was 16.55cm (sensitivity 60, specificity 72.4, Youden's J statistic 0.324). Area Under Curve (AUC) 0.750. 95% CI 0.631-0.870 p value 0.001.

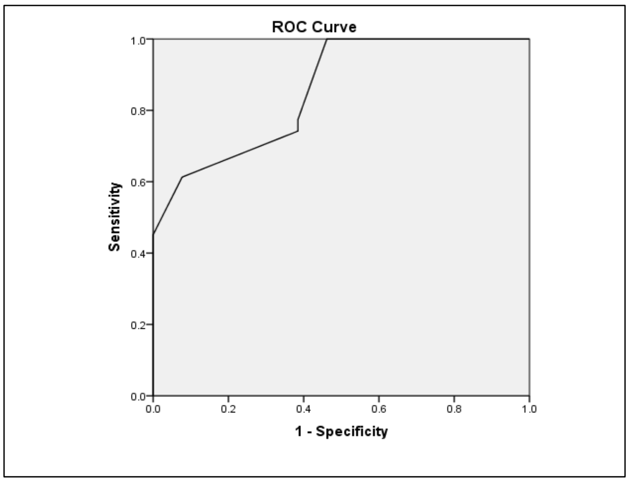


Figure 5: Obesity Vs Wrist Circumference -Female.

The cut off value of wrist circumference in female when compared with BMI was 15.75cm (sensitivity 70.6 Specificity 70.4 Youden's J statistic 0.41) Area Under Curve 0.756 95% CI 0.631-0.870, p value 0.001).

The cut off value of Wrist circumference with waist Circumference in male was 16.25cm (sensitivity 57.1 Specificity 76.9 Youden's J statistic 0.341) Area Under Curve 0.635 95% CI 0.491-0.779 p value 0.131.

In females all participants were having abdominal obesity. Wrist circumference had significant positive correlation with BMI and waist circumference.

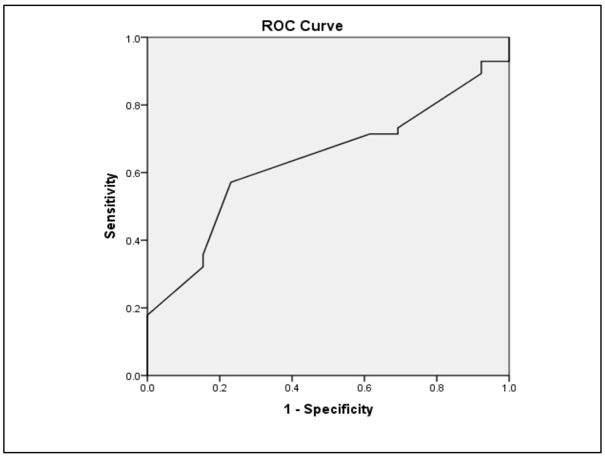


Figure 6: Waist C Vs Wrist Circumference - Male.

DISCUSSION

In the present study, wrist circumference showed moderate positive correlation with BMI (r+0.389) and waist circumference (r+0.443). Restriction of range of age to young adults may have reduced the correlation because of not including all age range.

A study from Pakistan also showed significant correlation of wrist circumference with indexes of generalized and abdominal obesity, i.e. BMI and waist circumference, respectively.[18] This finding proposes that in large population-based studies, measuring wrist size can be useful as an easy-to-detect clinical marker to identify individuals at risk of cardio metabolic disorders.[19] In a study among obese children and adolescents in Italy, a statistically significant association was documented between wrist circumference and insulin levels or homeostasis model assessment of insulin resistance. These associations were stronger than those between body mass index and insulin levels or homeostasis model assessment of insulin resistance. In this study, nuclear magnetic resonance imaging revealed that the relationship between wrist circumference and insulin levels or homeostasis model assessment of insulin resistance reflected the correlation with bone tissue-related areas but not with the adipose tissue ones.[10] In contrary, another study by Shokoufeh et al showed, although correlated with METs-type lipid profile, WrC may not be a valuable index for predicting the presence of CAD or METs.[20]

In another study from Ghana, the optimal cut-off value of WrC to identify individuals at increased cardio metabolic risk was between 17.5 and 17.8 cm for men and 16.0 and 16.7 cm for women.[21] A study from Nepal also showed positive Pearson correlation of wrist circumference with waist circumference(r=0.58 in male and 0.64 in female) and with weight (r=0.64 in male and 0.86 in female).[22] In CASPIAN-IV study wrist circumference performed relatively well in classifying individuals into overweight (AUC: 0.67–0.75, p<0.001), generalized obesity (AUC: 0.81-0.85, p<0.001) and abdominal obesity (AUC: 0.82-0.87, p<0.001).[23]

Wrist circumference is a simple, easy-to-detect anthropometric measure, and it is not subject to measurement problems involved in assessment of other anthropometrics like waist and hip circumference; clothing is one major perturbing factor complicating the measurement of waist and hip circumferences. Several studies have shown that hyperinsulinemia is associated with increased bone mass. They propose that the overall circumference of the wrist could be a good measure of how the bones within have grown in response to insulin levels in the blood, and assume that this measure of skeletal frame size is not confounded by body fat variation.[10] The high intra and inter-observer reproducibility demonstrated by Campagna G et al suggests that wrist circumference measurement, being safe, non-invasive and repeatable can be easily used in out-patient settings to identify youths with increased risk of insulin-resistance.[15] This can avoid testing the entire population of overweight or obese children for insulin resistance parameters. They found that wrist circumference, in particular its bone component, is highly correlated with measures of insulin-resistance in a population of overweight/obese children and adolescents.

Apriori there is no strong basis for choosing any single measure of obesity as a gold standard. Obesity calculated by BMI can misclassify a significant number of individuals because of its relatively high specificity and low sensitivity. BMI is the most common anthropometric index of adiposity used in clinical practice. In the present study, wrist circumference is compared against BMI, which is generally considered as reference standard for assessing obesity. But BMI also has some limitations. BMI is used to describe secular changes in adiposity at the population level, has less discriminatory power at individual level for chronic disease. Disadvantages of BMI is that being an overall anthropometric index it does not give any idea about distribution of body fat, which is found to affect morbidity patterns. Although the utility of BMI has been borne out in epidemiological data, there are limitations to the use of BMI alone to assess for adiposity in clinical practice, particularly among adults with BMI $\leq$30 Kg/m^2. It does not distinguish between lean and fat mass. Distribution of body fat is more important than absolute degree of fatness. BMI has a pooled sensitivity of 50 % to identify excess adiposity and a pooled specificity of 90%, which demonstrates that half of the individuals with excess body fat were not identified as obese. But still BMI is considered as the primary screening tool for the initial assessment of body fatness in clinical practice because of its global acceptance and relative ease of calculation.

The wrist circumference parameter is easily obtainable and measurable by the operator, reducing the cooperation needed by the subjects. The easy and simple way of measuring wrist circumference is a considerable advantage in everyday clinical practice compared to the classical anthropometrical measurement such as BMI or waist circumference. Another advantage of using wrist circumference compared to the common anthropometric measures is that reflecting a skeletal frame size, it changes slightly through time. Differently from waist circumference, wrist circumference measurement is not affected by clothing, respiration or by postprandial state which can interfere with the determination of waist circumference.[24,25] Measurement of wrist circumference may supplement in assessing generalised and abdominal obesity (and indirectly insulin resistance), when valid weighing machine is not easily available in the field for measuring BMI or accurate measurement of waist circumference is not possible in communities because of lack of privacy for removing cloths especially in women.

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