Original research article

A Cross Sectional Study to Assess and Compare the Efficiency of Older Anthropometric Measurements with Newer Parameters in Predicting the Risk of Diabetes Mellitus among the Urban Population of Mandya City in Karnataka, India.

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Abstract

Background & Objectives: Obesity is a major risk factor for Diabetes Mellitus(DM). Older anthropometric measurements like Body Mass Index(BMI), Waist Circumference(WC), Waist Circumference Height ratio(WHt ratio) etc and newer ones like A Body Shape Index(ABSI) and Body Roundness Index(BRI) are used to detect obesity. This study was undertaken to determine the utility of newer and older anthropometric measurements in predicting the risk of DM among urban population of Mandya city.

Methods: Fasting Blood Sugar(FBS) and anthropometric measurements like BMI, WC, WHt ratio, BRI and ABSI were measured. Correlation analysis, Odds Ratio and ROC curves were analyzed to know the ability of each anthropometric measurement in predicting the risk of DM.

Results: Overall prevalence of DM in the study population was 23.4%. All anthropometric measurements except ABSI were significantly high in subjects with DM. According to OR value, WHt ratio(2.254) was the best predictor of DM, followed by BMI(Asia Pacific classification) with 2.16.Older anthropometric measurements such as BMI(r=0.252;p=0.000*), WC(r=0.230;p=0.000) showed a significantly positive correlation with FBS compared to BRI and ABSI. According to ROC curves, the highest AUC was found with older methods such as WC(0.617) and BMI(0.616) followed by WHt ratio(0.595) and newer methods such as BRI(0.595) and ABSI(0.542).

Conclusion: Older anthropometric measurements have better discriminatory powers and significant strength of association with DM compared to newer ones. Establishing newer reference ranges of FBS for Asian population and incorporation of Asia Pacific Guidelines of BMI classification at all levels of health care in India is needed for better risk stratification and the prevention of DM.

Key Words: Anthropometric measurements, A Body Shape Index, Body Mass Index, Body Roundness Index, Waist Circumference, Waist Height Ratio, Diabetes mellitus

Introduction

Diabetes mellitus(DM) is a major public health concern(s) worldwide. Prevalence of DM is rapidly increasing in low and middle-income countries compared to high income countries. In 2019, DM was considered as the ninth leading cause of overall global deaths. accounting to 48%.[1] Prevalence of DM has increased drastically with the proportionate increase of obesity, unhealthy diet, sedentary lifestyle, decreased physical activity, greater longevity, urbanization and aging of population. Considering this trend towards the emergence of DM cases, International Diabetes Federation(IDF) predicted that, by 2040 about 642 million people would have developed DM.[2]

DM is polygenic and multifactorial. Genetic factors play a major role in DM with marked differences in susceptibility among different ethnic groups.[2] Age, sex and ethnic background are the important factors for DM. Type-2 DM is more commonly seen in individuals above 40years of age. The disease is due to decreased response to insulin or otherwise termed insulin resistance(IR), characterized by relative insulin deficiency. About 60% of patients with type-2 DM are obese. Abdominal obesity in combination with IR or reduced glucose tolerance are the classical features of metabolic syndrome(MS).[3] The risk for metabolic disease is determined by the distribution of fat rather than the amount of fat. Hence, both central and visceral type of abdominal obesity has been labelled as the major factor towards the causation of DM, hypertension, MS and cancer.[4]

Obesity is the excess bodily adipose tissue status, which is expressed as BMI. High BMI is a sole contributor towards the development of DM in India. It is mainly associated with unhealthy eating habits such as shift from nutritious diet to calorie rich diet, nutrient poor high carbohydrate diets and increased sedentary occupation due to inculcation of urban lifestyles. [5,6] Anthropometric measurements such as BMI, WC, WHt Ratio etc, were considered as the predictors of obesity in earlier days.[7] Currently, newer anthropometric measurements such as ABSI and BRI are in the spotlight.

BMI is the most commonly used anthropometric measurement towards the assessment of obesity. It is a simple index, which classifies the population as underweight, normal, overweight and obese. The major disadvantage associated with this method is, it only serves as the measurement of excess body weight instead of excess body fat and its distribution.[8] According to World Health Organization(WHO) Expert Consultation, the association between excess body weight and morbidity is different among individuals with same BMI and different ethnic backgrounds.[9]. BMI can be classified in two different ways; one by the incorporation of universally used categorization by WHO Expert Committee and the other method based on Asia Pacific Guidelines by Indian Consensus group. In 1997, WHO expert committee, suggested the classification of BMI as underweight($<18.5kg/m^2$), normal($18.5-24.9kg/m^2$), over weight($25.0-29.9kg/m^2$) and obese($\geq30kg/m^2$). This method of BMI classification was universally considered. Whereas, in 2009, based on Asia Pacific Guidelines by Indian Consensus group, a new cut-off of BMI was suggested exclusively for Asian population, as, $23-24.9\ kg/m^2$ and $\geq25kg/m^2$ for overweight and obese respectively.[10]

WC and WHt ratio are the other older methods of anthropometric measurements. WC is an easy and practical method for evaluation of adult visceral fat.[11] According to WHO, the presence of central obesity was graded with the help of WC measurements, with the cut-offs of ≥90cm and ≥80cm for males and females respectively. WC serves as the major component to diagnose MS. Higher WC values have increased risk towards the development of DM and cardiovascular risk. The major drawback of this method is that, there exists no differentiation between subcutaneous and visceral type of fat. [12]

WHt ratio is also known as the Index of central obesity. WHt ratio is the measure of body fat distribution with a cut-off of 0.5. The fact that there is no cut off for children, makes the usage of this ratio limited among the younger population. It is found to be a better predictor of metabolic risk as compared to BMI and WC.[13]

Recently, two new anthropometric measurements such as ABSI and BRI have been developed. Krakauer and Krakauer came up with ABSI in 2012. This index is age and gender dependent, and independent of height, weight and BMI. ABSI mainly focuses on concentration of body volume and body shape. ABSI was also considered as a predictor of premature mortality across BMI categories that aids in making clinical decisions and its relationship between lifestyles and other risk factors towards health outcomes.[14]

Thomas et al. developed BRI in 2013, the main purpose of this index is to quantify individual shape in a height independent manner. BRI values range from 1 to 16, and rounder individuals tend to have larger values. The merits of this index is to predict the IR, DM and cardiovascular risk factors.[15]

Hence, this study was undertaken to determine the utility of newer and older anthropometric measurements among the urban population of Mandya city. The study also assessed Fasting Blood Sugar(FBS) levels of the participants and its association with the anthropometric measurements and also evaluated the ability of these anthropometric measurements to predict the risk of DM.

MATERIALS AND METHODS:

This cross-sectional study was conducted for a period of 2years from 2013 to 2015. Consenting urban population of Mandya city of age 25-64years were included for the study. The study was initiated after obtaining ethical clearance from the Institutional Scientific committee and Institutional Ethics Committee: No-MIMS/IEC/01-05/2012-13 dated 20/11/2012.

In a study conducted by Mohan V et al, in 2007 the prevalence of DM in Bangalore city was 12.4%. Considering this, the sample size of this study was 707 using the formula, "Sample size = $4pq/l^2$" keeping 20% as margin of error.[16] To this a non-response rate of 10% was added which brought the sample size to 777. This was rounded off to 800 participants.
Consent was taken from the subjects and prior brief information regarding the objectives and the procedures related to the study were provided. Participants who did not fulfil the age criteria and non-consenting subjects were excluded from the study.

Study procedure:

After obtaining the consent from the subjects, assurance regarding the confidentiality of their data was ensured and they were informed regarding their liberty to walk out of the study at any point of time. A participant proforma was used to collect the information regarding the personal history including name, age, address and lab number. Family history of DM, hypertension, dyslipidemia, other endocrine disorders and cardiovascular dysfunction.

Anthropometric measurements such as height, weight and WC were performed on the participants. For the measurement of height and weight, stadiometer and analogue weighing scale were used respectively. A non-stretchable measuring tape was snug around the midpoint between the lower margin of last palpable rib and the top of iliac crest towards the measurement of WC.

Using these values, the calculated parameters like BMI, WHt, ABSI and BRI were determined. BMI was calculated using the formula; BMI= Weight(kg)/Height(m^2). The calculation of WHt ratio was done by; WC(cms)/ Height(cms). ABSI was calculated using formula; ABSI= WC/(BMI2/3 * Height1/2) and BRI by the formula; BRI= 364.2-365.5 *√1-[WC/$(2\pi)^2$/(0.5 Height)^2].[14,15] The calculations of all these parameters were performed using Microsoft Excel Spreadsheet.

Collection of blood samples for biochemical investigations was performed. Under aseptic precautions, 3mL of venous blood was drawn into a plain tube after confirming 10-12 hours of overnight fasting for the estimation of FBS by using glucose oxidase peroxidase method in the Clinical Biochemistry Section, Central Diagnostic Laboratory, Mandya. These tubes were allowed to stand for about 10-15minutes and subjected to centrifugation at 3500rpm for 15-20minutes. The serum was processed after ensuring both internal and external quality control checks. According to WHO/ American Diabetic Association(ADA) criteria, subjects with FBS values of ≥126mg/dL were considered as DM.

Statistical Analysis:

Data entered into Microsoft Excel worksheets were analysed using Statistical Package for the Social Sciences(SPSS) version 21. Descriptive and inferential statistical analysis was used to calculate Mean±Standard Deviation. Odds Ratio(OR) was calculated to study the association between different anthropometric measurements and DM. The strength of association between FBS and anthropometric measurements such as, BMI, WC, WHt ratio, ABSI and BRI was analysed by using Spearman ranking correlation. ROC curve analysis using 95% confidence Intervals was performed to assess discriminatory power of each anthropometric measure to assess the risk for DM. Probability value(p) of <0.05 was considered statistically significant.

RESULTS:

The present study included 800 subjects belonging to urban population of Mandya City. Out of which 323(40.37%) were males and 477(59.63%) were females. The baseline characteristics of the subjects are depicted in

Table 1: The mean age of male and female subjects was 44.4 years and 46.6 years respectively.

Variables	**Number (out of 800) (%)**
Males	323 (40.37%)
Females	477 (59.63%)
Age in years	44.4 years (Males); 46.6 years (Females)
Table-1: The baseline characteristics of the subjects.	

Out of 800 subjects, 187 of them had FBS levels in the diabetic range bringing the overall prevalence of DM to 23.4% amongst which 52.4% and 47.6% was contributed by males and females respectively. There was no statistically significant difference with regards to gender and DM. Considering the status of DM, participants were categorized into two groups such as Group I (without DM) and Group II (with DM). Mean±SD of all the anthropometric measurements among Group I and Group II are depicted in

Table 2: Significant differences were found between Diabetic and Non-diabetic subjects in case of BMI, BRI, WC and WHt ratio, whereas ABSI did not show any significant difference.

Group I (Subjects without DM)		Group II (Subjects with DM)		
Variables	**Mean ± SD**	**Variables**	**Mean ± SD**	**T test (p-value)**
BMI (kg/m^2)	25.60±4.97	BMI (kg/m^2)	27.56±4.88	0.001*
WC (cm)	89.60±15.09	WC (cm)	95.23±13.84	0.001*
WHt Ratio	0.56±0.09	WHt Ratio	0.59±0.08	0.001*
ABSI	0.08±0.011	ABSI	0.08±0.010	0.701
BRI	4.88±2.18	BRI	5.45±2.01	0.001*

Table-2: Mean± Standard Deviation of all the anthropometric measurements among Group I and Group II.

(*Statistically significant difference)

Classification of obese participants on basis of BMI according to WHO expert committee reported only 18.6% of the subjects to have obesity. Whereas, Asia Pacific Guidelines by Indian Consensus group documented 56.8% of the subjects as obese. The anthropometric measurements such as BMI, WC, WHt ratio and BRI levels were found to be significantly high in group-II compared to Group-I subjects. No significant difference was seen with ABSI between both the groups.

On performing OR for risk prediction of DM, among all the anthropometric measurements, WHt ratio with 2.254 was found to be the best predictor of DM. With regards to BMI, usage of Asia Pacific Guidelines by the Indian Consensus group was found to have a predictive capacity with OR of 2.169. While WHO categorization for BMI, had the predictive capacity with OR of 1.947 as shown in **Table-3.** Odds Ratio could not be calculated for ABSI and BRI since globally accepted specific cut-offs for various categories are currently not available.[4]

Table 3: Odds Ratio (OR) for risk prediction of DM (n=800)

Variables	**Odds Ratio for Risk prediction of DM**	**95% Confidence Interval**	
		Lower	**Upper**
BMI (WHO)	1.947	1.322	2.867
BMI (Asia Pacific)	2.169	1.525	3.085
WC	1.905	1.301	2.789
WHt ratio	2.254	1.378	3.687

The strength of association between FBS and anthropometric measurements were analyzed by using Spearman ranking correlation. Among anthropometric measurements, the older methods such as, BMI(r=0.252;p=0.000*) and WC(r=0.230;p=0.000) showed a higher statistically significant positive correlation with FBS. ABSI(r=0.081;p=0.023) being a newer index had least correlation with FBS and was statistically not significant as depicted in

Table 4: Scatter plots are depicted in Figure 1.

Pair	Spearman correlation co-efficient (r-value)	p-value
FBS vs BMI	0.252	0.001*
FBS vs WC	0.230	0.001*
FBS vs WHt Ratio	0.207	0.001*
FBS vs ABSI	0.081	0.023
FBS vs BRI	0.206	0.001*
Table 4: Spearman ranking correlation between FBS and anthropometric measurements. (n=800) ***Significant at p<0.05**		

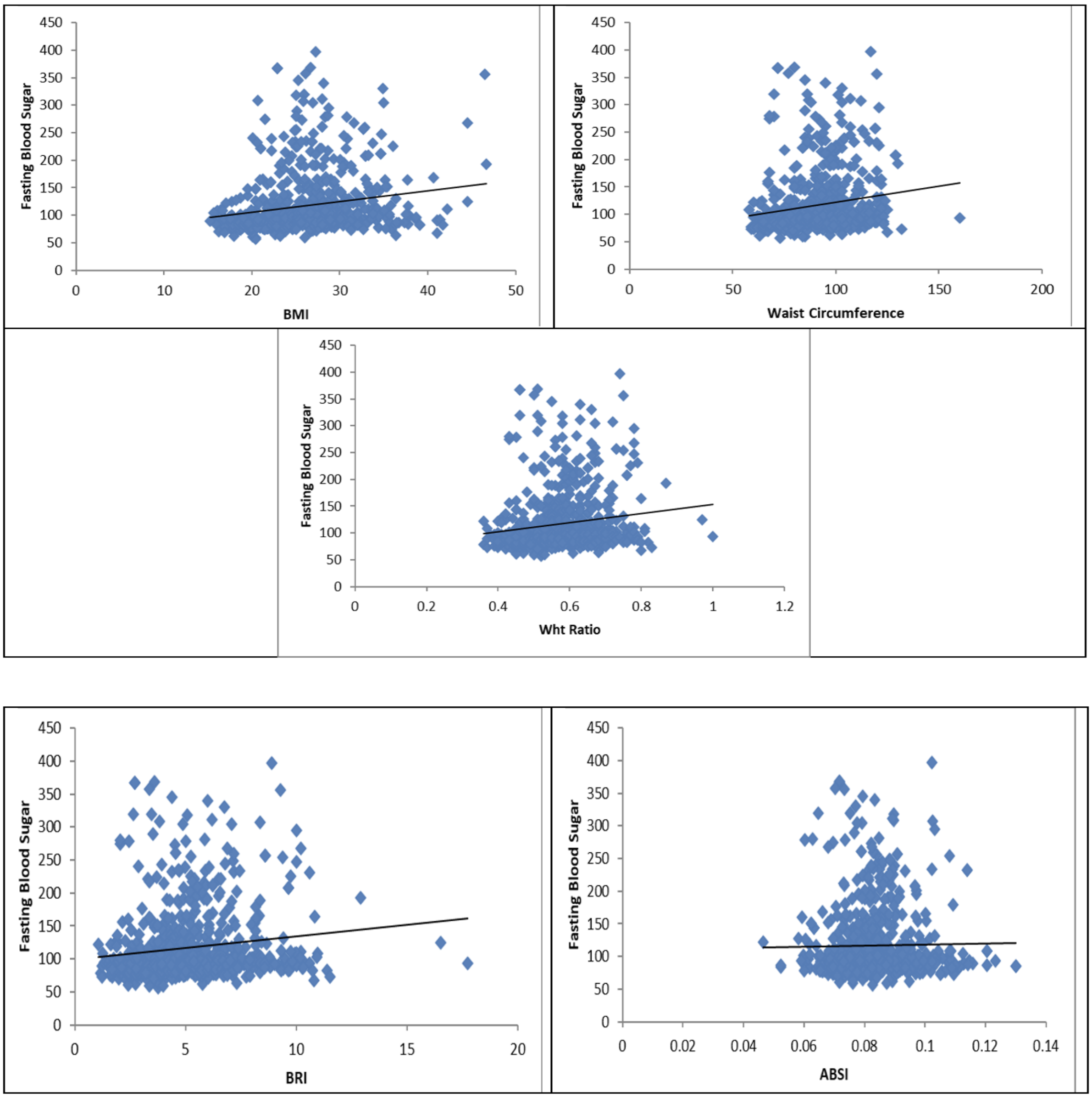

Figure 1: Scatterplots between FBS and all the anthropometric parameters.

ROC curve analysis was done to assess the ability of older and newer anthropometric measurements to predict the risk of DM among the subjects. According to **Table-5 and Figure-2,** the predictive capacity of different anthropometric measurements on considering the values of Area Under the Curve(AUC) showed the highest discriminatory power for older methods such as WC(0.617), BMI(0.616) and WHt ratio(0.595) and followed by newer methods such as BRI(0.595) and lastly ABSI (0.542).

Anthropometric Measurements	AUC
BMI	**0.616**
WC	**0.617**
WHt Ratio	0.595
ABSI	0.542
BRI	0.595

Table 5: ROC curve analysis of anthropometric measurements.

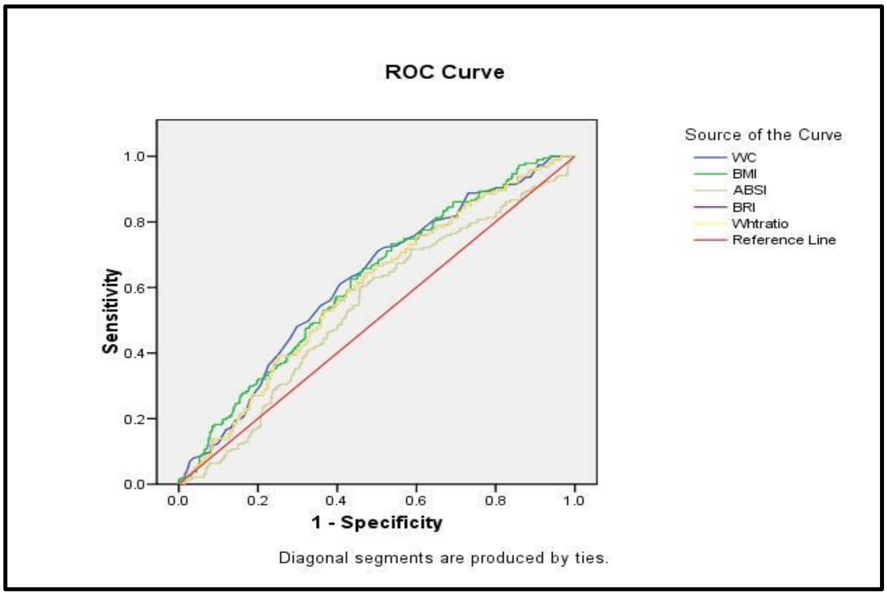

Figure 2: ROC curve analysis for different methods of anthropometric measurements.

Discussion:

DM is a disorder known for its morbidity and mortality, though these outcomes are not associated with the immediate effects of the disorder. The prevalence of DM is on the increasing trend worldwide and varies greatly within and between countries. Many patients with DM are usually asymptomatic and are diagnosed with the disease only when there exists an obvious derangement with blood investigations.

According to present study, the prevalence of DM was 23.4% i.e., among 800 subjects, 187 of them had FBS values of ≥126mg/dl. In a study conducted by a team from Bangalore headed by **Rajbhandari SM et al.,** the prevalence of DM among the population of Urban Bangalore was determined in 2020. According to their results, the overall prevalence of DM was contributed by 23.9%.[17] The prevalence of DM has been steadily increasing over the past few decades. Hence, the accurate prediction and early recognition of underlying disease may help in preventing life-threatening co-morbidities.

Numerous anthropometric measurements play a major role for diagnosing DM and its risk factors. Most commonly used anthropometric measurements are BMI, WC, WHt ratio, Waist Hip Ratio etc. Considering the disadvantages associated with older methods of anthropometric measurements, the ongoing quest for better indicators led to the development of newer indices. Recently, newer anthropometric measurements such as ABSI and BRI were introduced. Some studies showed that ABSI is closely associated with DM and hypertension.

The Mean±SD of the anthropometric measurements such as BMI, WC, WHt ratio, ABSI and BRI were compared between Group-I and Group-II subjects. It was found that, almost all the anthropometric measurements (BMI, WC, WHt ratio and BRI) were found to be significantly high among Group-II compared to Group-I subjects. However, ABSI did not show any statistically significant difference between both the groups as per **Table-2**. Present study results were consistent with the study conducted by **Fujitha M et al.,** in which, a total of 37,581 non-diabetic participants were monitored for disease incidence for 4years and concluded that higher values for BMI, WC and ABSI could increase the risk DM. They also observed that ABSI was found to be the weakest predictor of risk of DM.[18]

According to our results, among older anthropometric measurements, WHt ratio stood out as the best predictor of DM followed by BMI and WC. WHt ratio showed the highest OR value(2.254) as compared to other anthropometric measurements as per **Table-3**. Similar observations were made in a study conducted by **Mackay MF et al**., in which WHt ratio(1.79) had the best predictor of DM with the highest OR followed by BMI(1.76) and WC(1.75).[19]

The cut-off value for BMI to categorize a person as obese according to WHO (BMI≥30kg/m^2) and Asian Pacific guidelines(BMI ≥25kg/m^2) are different. According to estimates, it is said that incorporation of Asia Pacific classification segregates 10-15% more Indian population into overweight or obese group, which would have gone unnoticed by the usage of WHO classification. On usage of WHO BMI classification, present study reported only 150(18.6%) of them as obese. Whereas, on using Asia Pacific guidelines, the subjects with obesity increased to 454(56.8%). Out of 150 subjects classified as obese using WHO classification, 51 were found to have DM, whereas 132 out of 454 obese subjects as reported by Asian Pacific guidelines were known to have DM. Hence, by using the BMI categorization exclusively for Asian Pacific population the odds of predicting the risk of DM was 2.16 times compared to 1.94 times with WHO classification as depicted in **Table-3**. Our findings were consistent with the study conducted by **Verma et al.** wherein, out of 1080 total participants, they reported 34.6% and 49.6% of them as obese by using WHO classification and Asia Pacific Guidelines respectively. They concluded that, Asia Pacific guidelines classification for obesity categorized more subjects as obese than compared to WHO classification.[20]

In the year 2015, **Chang Ye et al**. came up with a study to predict the diagnostic outcome of newer anthropometric measurements over older anthropometric measurements. According to Spearman ranking correlation, WHt ratio and BRI showed the highest correlation coefficient for DM followed by WC, BMI and ABSI with the least correlation co-efficient. They concluded that ABSI was not superior to BMI, WC, or WHt ratio for predicting DM.[21] Similar findings were witnessed in our study, in which the highest association was observed with older measurements such as BMI, WC, WHt ratio. Least association was documented with the ABSI and BRI and the difference was statistically significant.

The assessment of a better tool for predicting the risk of DM among the older and newer anthropometric measurements was analyzed by ROC curve. The highest AUC was obtained for older anthropometric measurements such as WC(0.617) followed by BMI(0.616) and the least for ABSI(0.542). Same AUC values (0.595) were obtained for WHt ratio and BRI. Similar results were noticed in a study conducted by **Yang et al.,** in which the maximum AUC was witnessed for BMI(0.655) followed by WC, WHt ratio and BRI with AUC of 0.629. ABSI had the least AUC of 0.507. They concluded that newer anthropometric measurements did not improve the prediction of DM over the older methods of anthropometric measurements.[22]

At present, the absence of globally accepted cut-offs to categorize subjects for newer anthropometric measurements like ABSI and BRI limits the usage of the same. The ease of use of older anthropometric measurements like BMI, WC and WHt ratio also make these better than newer anthropometric other measurements.

Limitations:

Follow up of cases was not performed. If the follow-up of the cases was done during the study, more clarity regarding the causal relationship between anthropometric measurements and biochemical parameters towards the development of DM could be examined. Participants with high FBS values were not confirmed with glycated haemoglobin for type-2 DM. Specific cut-offs are not available for ABSI and BRI because of which OR could not be studied. A reference range for FBS similar to that of BMI for Asian Pacific population is currently not available for region specific categorization of subjects in relation to DM.

Conclusion:

To conclude, among the various anthropometric methods, older measurements such as BMI, WC, WHt ratio showed best discriminatory powers and significant strength of association with DM compared to newer methods such as ABSI and BRI. Among newer methods, BRI can be used as an alternative in obesity measurement. The incorporation of Asia Pacific Guidelines of obesity classification at all the levels of health care in India would enable better risk stratification and prevention of DM and its comorbidities at the earliest. Further studies to establish the reference ranges of FBS levels for Asian population to categorize them as subjects with and without DM would help in evaluating the efficacy of anthropometric measurements with newer cut-off values to improve the risk prediction and detection of DM early in the course of disease. This would greatly enable in taking preventive and corrective measures to reduce the risk of development of DM and also the long-term co-morbidities in the affected individuals.

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