ORIGINAL ARTICLE

Cut-off values of anthropometric indices to determine insulin resistance in Pakistani adults

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Abstract

Objective: To determine the cut-off values of anthropometric indices to indicate insulin resistance and correlation of these indices with insulin resistance in Pakistani adults.

Methods: The cross-sectional study was conducted at the Military Hospital and Army Medical College, Rawalpindi, Pakistan, from June 2010 to November 2011. The study measured 209 adults for body mass index, waist circumference, waist-to-hip ratio, waist-to-height ratio and conicity index. Receiver operating characteristics curve analyses were done to determine the predictive values of these anthropometric measures and their cut-off values for insulin resistance by triglyceride/high density lipoprotein ratio.

Results: Overall mean age was 51.5±1.16 years (range: 28-73) and there were 136 (65%) males and 73 (35%) females. Body mass index had the maximum predictive value for insulin resistance followed by waist circumference and waist-to-height ratio in males ($p < 0.0001$), sensitivity and specificity being 68% and 62% respectively with cut-off value of 25.04kg/m^2. ROC curve analyses showed the maximum predictive value of conicity index for insulin resistance followed by waist circumference and waist-to-height ratio in females ($p < 0.08$), sensitivity and specificity being 65% and 50% respectively with cut-off value of 1.39.

Conclusion: In Pakistani male adults, BMI is the best indicator of insulin resistance, while in female adults, conicity index is the best indicator. This is the first study in Pakistan reporting predictive values of anthropometric indices as a non-invasive method in determining insulin resistance.

Keywords: Receiver operating characteristics curve, Anthropometry, Metabolic syndrome. (JPMA 63: 1220; 2013)

Introduction

According to World Health Organization (WHO) studies, incidence of obesity is increasing worldwide. The total number of adult obese persons globally in 2008 was 1.5 billion.[1] Metabolic parameters like blood glucose levels, lipid profile and insulin resistance as well as incidence of type 2 diabetes mellitus (T2DM) have been correlated with anthropometric indices. These include body mass index (BMI), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and conicity index [WC (in m)/0.109 x square root of weight (in kg)/height (in m)]. WHO studies reveal that there is ethnic-specific cut-off values for different anthropometric parameters. The pathophysiology and statistical relations of these parameters with risk of metabolic syndrome are not questioned. Instead the utility and best suited one or more anthropometric parameters need to be established for various ethnic groups. Recent studies have identified ethnic specific cut-off values for BMI, WC, HC, WHR and WHtR for Asians, North Americans, South Americans, Africans, Hispanic, Middle-Eastern, Aboriginals and Pacific-inlanders.[2] WHO has set the cut-off value of BMI for obesity at <25kg/m^2 for South-Asians. It is logical that WC and WHR values, which are the most common anthropometric indices studied for metabolic risks, should be lower in Asians.[3-6]

According to WHO, cut-off points for waist circumference are >94cm for males and >80cm for females for increased risk of metabolic complications, whereas this risk is substantially increased with WC of >102cm in males and >88cm in females.[1] Similarly, WHO cut-off values for WHR for substantially increased metabolic complications risk are >0.9 in males and >0.85 in females. According to the International Diabetic Federation (IDF), the cut-off points for WC in different ethnic groups are >94cm and >80cm for males and females respectively in Europids, >90cm and >80cm for males and females respectively in South Asians, Chinese and Japanese.[7] No study has been carried out so far to determine the cut-off values of anthropometric indices for the risk of metabolic complications in Pakistani population.

The present study was planned to carry out the receiver operating characteristic (ROC) analyses of BMI, WC, WHR,

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WHtR and conicity index as indicators of insulin resistance determined by Triglyceride/High density lipoprotein (TG/HDL) ratio in Pakistani adults, and to reach a cut-off value for each anthropometric index based on ROC curves analyses.

Subjects and Methods

After approval from the Ethical Committee of Army Medical College, National University of Sciences and Technology (NUST), the study was conducted in accordance with the current 'Good Clinical Practices' and the Declaration of Helsinki. The cross-sectional study was carried out at the Military Hospital and Army Medical College, Rawalpindi, Pakistan, from June 2010 to November 2011. A total of 209 patients were selected for the study by non-probability convenience sampling technique. Inclusion criteria were healthy adult Pakistani of 'Punjabi Rajput ethnic origin' of either gender. Exclusion criteria consisted of presence of any acute or chronic disease, hypertension or diabetes mellitus diagnosed on the basis of history, physical examination, and laboratory tests including blood complete picture (CP), erythrocyte sedimentation rate (ESR), blood sugar fasting (BSF) and high sensitivity C-Reactive Protein (hs-CRP). Persons taking lipid-lowering drugs were also excluded from the study. Written and informed consent was obtained.

After obtaining complete demographic information, anthropometric measurements of height, weight, waist and hip circumference were measured according to the WHO STEP-wise Approach to Surveillance (WHO STEPS) protocol.[7] BMI was calculated by the formula: Weight (kg)/height (m)^2. WHR and WHtR were calculated. Conicity index was calculated with the following formula; [WC (in m)/0.109 x square root of weight (in kg)/height (in m)].

The subjects fulfilling the inclusion criteria were screened for dyslipidaemia and insulin resistance by TG/HDL ratio (cut-off value=1.8).[8] Serum total cholesterol was measured by cholesterol oxidase method, Serum TG by enzymatic calorimetric method, and Serum high-density lipoprotein (HDL) was measured by direct enzymatic method. Serum low-density lipoprotein (LDL) was calculated by Friedwald formula.[9]

Data was entered in SPSS 19. Mean ± SD of age, BMI, WC, WHR, WHtR, conicity index, S.TC, S.TG, S.LDL, S.HDL and TG/HDL ratio was determined by descriptive analysis. Frequency of obesity and insulin resistance was determined gender-wise. Correlation between all anthropometric indices and TG/HDL ratio was determined by regression analysis. P value and regression coefficient were noted. ROC curve analysis was used as the method of defining the points of maximum sum of sensitivity and specificity of each anthropometric variable as a predictor of insulin resistance. Area under the curve (AUC) and anthropometric index with maximum AUC was noted. Anthropometric index with maximum AUC was labelled as index with highest predictive value separately for males and females.

Results

The age range of 209 normal healthy adults was 28-73 years, with a mean of 51.5±1.16 years. There were 136 (65%) males and 73 (35%) females. Out of 136 males, 77 (56.6%) had BMI>25kg/m^2 and 59 (43.38%) had BMI <25kg/m^2. Among the 73 females, 59 (80.8%) had BMI >25kg/m^2 and 14 had BMI <25kg/m^2. Insulin resistance (IR) was measured by TG/HDL ratio. Among 136 males, 71 (52.2%) had IR whereas 65 (47.7%) did not have it. Among 73 females, 31 (42.46%) had IR and 42 (57.53%) did not have insulin resistance. BMI and IR were significantly associated with weak positive correlation ($p < 0.02$; r= 0.152). WC and IR had highly significant association with weak positive correlation ($p < 0.001$; r= 0.219). A significant positive correlation was also found

Table-1: Demographic features and biochemical parametres' values in Pakistani adults.

Parametre	Mean ± SD (range) Male n = 136	Female n = 73
Age (years)	51.6±12.1 (28 - 73)	51.16±10.62 (30 - 70)
BMI (kg/m^2)	25.35±3.72 (15.69 - 35.6)	29.1±5.14 (18 - 39.4)
WC (m)	0.95±0.1 (0.7 – 1.17)	1.02±0.11 (0.76 - 1.3)
WHR	0.95±0.04 (0.77 - 1.07)	0.97±0.04 (0.86 - 1.14)
WHtR	0.55±0.05 (0.39 - 0.69)	0.65±0.07 (0.39 - 0.69)
Conicity index	1.32±0.07 (1.04 - 1.51)	1.4±0.08 (1.21 - 1.6)
S. TC (mg/dl)	167.44±37.12 (76.56 - 261.79)	184.04±36.34 (104.79 - 264.5)
S. TG (mg/dl)	183.34±147.74 (43.61 - 528.66)	240.3±72.09 (53.4 - 357.78)
S. LDL (mg/dl)	94.59±28.57 (27.8 - 164.48)	104.25±31.27 (23.17 - 155.21)
S.HDL (mg/dl)	39.77±8.11 (18.92 - 64.86)	46.72±23.17 (30.12 – 66.8)
TG/HDL ratio	1.95±0.86 (0.57 - 4.44)	1.89±0.93 (0.02 - 4.29)

BMI: Body Mass Index. WC: Waist Circumference. WHR: Waist-to-Hip ratio. WHtR: Waist-to-Height ratio. S.TC: Serum Total Cholesterol. S.TG: Serum Triglycorides. S.LDL: Serum Low-density lipoprotein. S.HDL: Serum High-density lipoprotein. TG/HDL: Triglycorides/High-density lipoprotein.

Table-2: Cut-off values of anthropometric indices by Receiver Operating Characteristics (ROC) Curve Analysis in Pakistani adults.

Anthropometric index	Area under curve (AUC)		P value		Sensitivity %		Specificity%		Cut-off Value	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
BMI kg/m^2	0.69	0.543	0.0001	0.5	68	71	62	53	25.04	28.05
*WC (cm)	0.67	0.594	0.001	0.17	70	67	50	50	94.37	95.5
**WHR	0.62	0.53	0.01	0.6	69	71	50	45	0.95	0.97
†WHtR	0.67	0.57	0.001	0.2	70	71	56	45	0.54	0.64
Conicity index	0.56	0.62	0.02	0.08	56	65	52	50	1.32	1.39

*WC - Waist circumference. **WHR - Waist to hip ratio. †WHtR - Waist to height ratio. BMI: Body Mass Index.

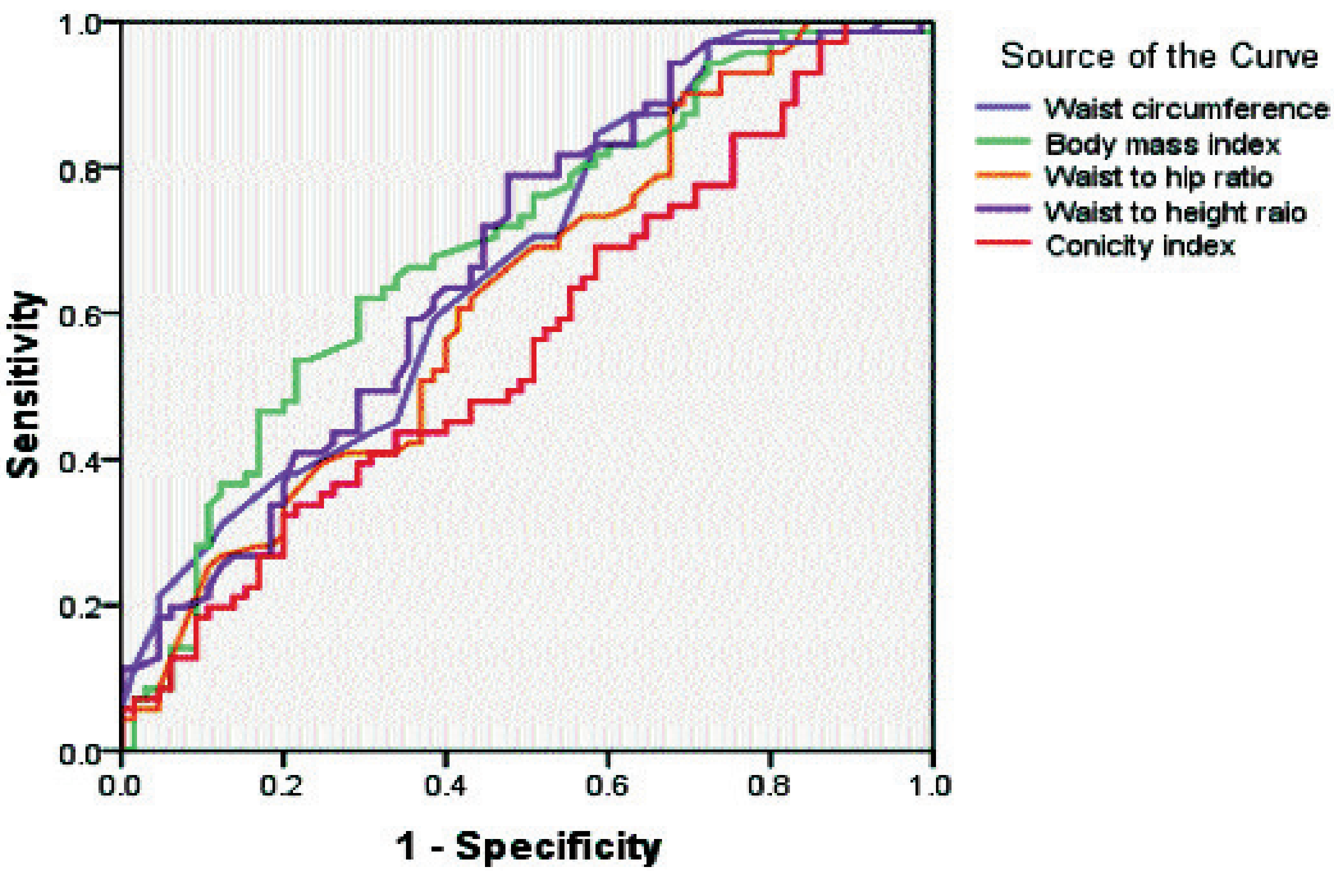

Figure-1: Receiver Operating Characteristics (ROC) Curve of WC, BMI, WHR WHtR and conicity index in males.

between HC and IR ($p < 0.02$; r= 0.153). WHR and IR also had highly significant association with weak positive correlation ($p < 0.002$; r= 0.212) and so was the case between WHtR and IR ($p < 0.03$; r = 0.148) and conicity index and IR ($p < 0.02$; r= 0.16).

Demographic and biomedical parameters (Table-1) and ROC curve analyses in both males and females (Table-2; Figure-1 and 2) were separately worked out. The maximum predictive value is of BMI for IR in males with cut-off value of 25.04kg/m^2. The predictive values of WC and WHtR in males were also closer to BMI with cut-off value of 94.37cm and 0.54 respectively. ROC curve analyses in females showed different results than those in males. ROC curve analyses showed the maximum predictive value of conicity index for insulin resistance in females with cut-off value of 1.39 which was slightly higher than that in males (1.32). The predictive values of WC and WHtR in females were also closer to BMI with cut-off value of 100.5 cm which was greater than that of males (94.37cm) and 0.64 (0.54 in males) respectively. The BMI in

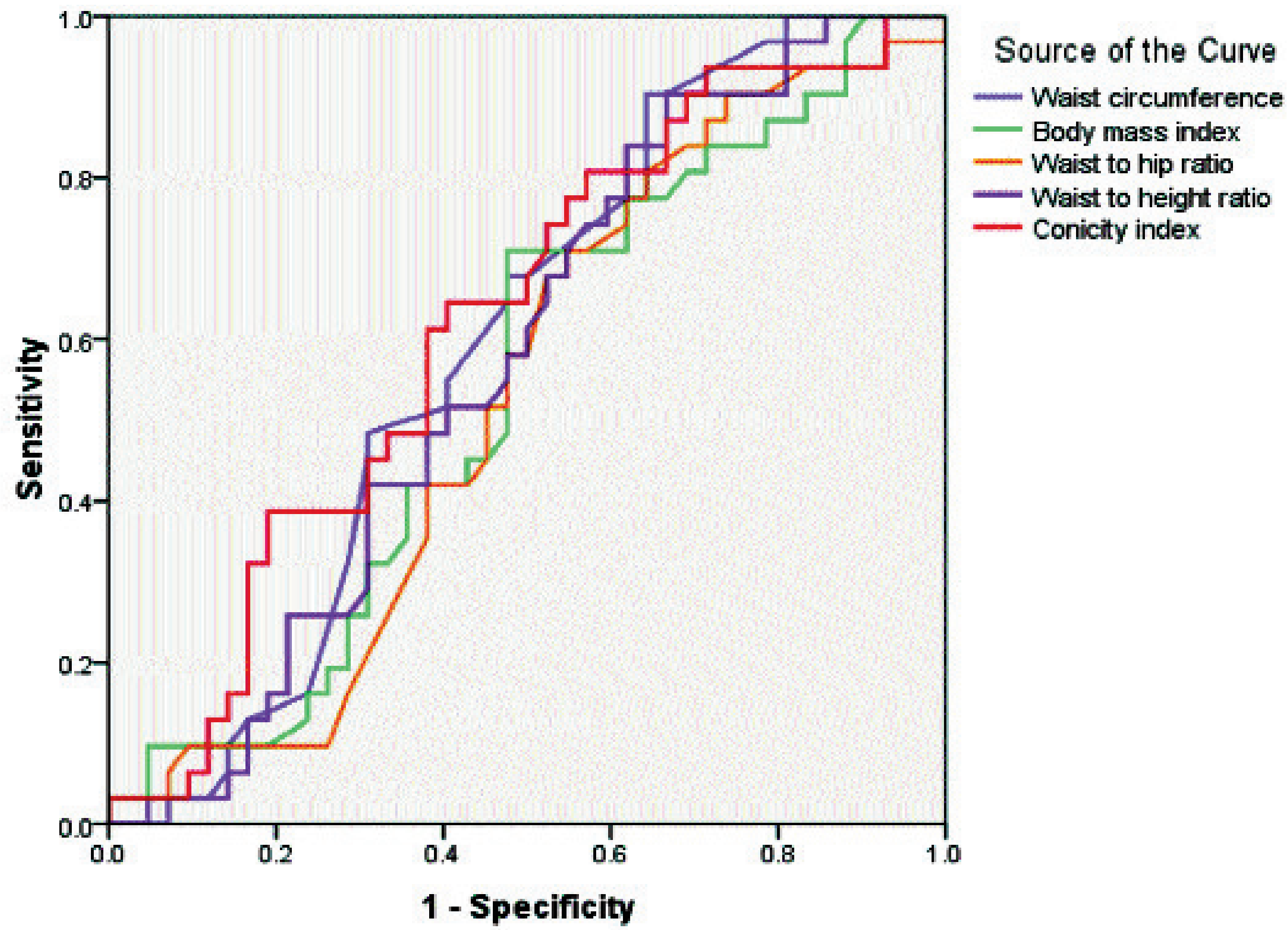

Figure-2: Receiver Operating Characteristics (ROC) Curve of WC, BMI, WHR WHtR and conicity index in female.

females had least predictive with cut-off value of 28.05kg/m^2.

Discussion

Obesity has been strongly associated with metabolic syndrome and T2DM. Various pre-screening tools are studied for selection of best possible one or more parameters to determine the high-risk individuals. Obesity is defined and classified by WHO using BMI as the most reliable anthropometric index. Measures of central obesity have been studied for positive predictive value in different populations with varying results. Our study is the first one todate in Pakistani population to determine the cut-off values of anthropometric indices.

In our study, statistically significant association with weak positive correlation was found between all six anthropometric indices and IR. ROC analyses revealed that in males, the best predictor of insulin resistance is BMI. This finding is supported by a number of studies.[8-12] In Northern Chinese, the metabolic risk was better indicated by BMI than WC in males as in our study, but no difference in predictive values of BMI and WC were found in females.[9] In French adult males, BMI had higher sensitivity than that of WC or WHR for detection of both dyslipidaemia and T2DM as in our study. In French diabetic women, WC was more sensitive than WHR and BMI.[11] In Indian-American adults, BMI in overweight range was strongly associated with metabolic syndrome as in our study.[12]

Varying results have also been reported. The predictive value of BMI, WC and WHtR was almost the same in Brazilian males against BMI in our study. In Brazilian females, WHtR had highest predictive value against conicity index in our study, but conicity index was not calculated in the Brazilian study.[13] In Iranian women, the predictive value of WHtR for T2DM was highest followed by that of BMI, WC and WHR.[14] In Mauritian ethnic group, no difference was found in the predictability of T2DM by BMI, WC, WHR and WHtR.[15] In Lithuanian subjects, there are higher cut-off values for BMI, WC and WHR for predicting metabolic syndrome.[16] None among BMI, WC, WHR and WHtR was found to be an effective tool to predict metabolic factors in Chinese adults.[17] The reason for varying results is not known, but variable sample size and variation in metabolic risk factors predicted by anthropometric indices can be one contributing factor. Moreover, most studies determined that measures of central obesity are better indicators of metabolic syndrome than BMI.

WHO cut-off values of BMI are $\geq$30kg/m^2 for Europeans and $\geq$25kg/m^2 for Asians.[18] In our study, by ROC analyses, the cut-off value of BMI in Pakistani subjects is 25.04kg/m^2 in males and 28.05kg/m^2 in females. In Iranians, the cut-off values of BMI as predictor of dyslipidaemia are 25kg/m^2 in males and 26-28kg/m^2 in females which are almost identical to our study.[19] In our study, the cut-off values of all five anthropometric parameters are higher in females as compared to males as in Iranian subjects. In Brazilian males, cut-off value of BMI is 33.3 kg/m^2 which is quite high compared to our study.[13] Similarly, in the Chinese, BMI cut-off value for metabolic syndrome is 24kg/m^2 in both males and females,[17] while in French subjects, BMI values as indicator of metabolic risk factors are 27kg/m^2 and 26kg/m^2 in males and females respectively.[11]

In our study, the cut-off values of WC in Pakistani subjects is 94.37cm in males and 95.5cm in females, whereas WHO cut-off points for WC as a predictor of metabolic syndrome are >94cm for males and >80cm for females. For Asians, WC cut-off is lower i.e. 85/80 cm in males and females respectively.[4-6,20-21] In our study, WC cut-off values are higher; the probable cause being the small sample size. WC cut-off values are 100cm in Brazilian males,[13] 97-99cm in White males and 85cm in White females; 94/80cm in European males and females,[22] 90/84cm in South Americans men and women,[2] 90/85cm in Hispanic males and females,[23] 88-89/90cm in Iranian men and women,[19] 86.5/82.1 in Chinese men and women[9] and 96/83cm in French males and females respectively.[11] The WC cut-off values are lower in Africans. For Nigerians, it is 75.6/71.5cm and in those with Cameroon origin; 80.5/81.5cm in males and females respectively.[24,25] In studies on Japanese patients of metabolic syndrome, cut-off value of WC was 85/82[26] and 87/83cm[27] in males and females, whereas in Korean patients WC cut-off value was 86.5cm in both grnders.[28]

WHO cut-off values for WHR for increased metabolic complications risk are $\geq$0.9 in males and $\geq$0.85 in females, whereas in our study it was 0.95 for males and was found to be higher in females (0.97). Other studies revealed WHR cut-off values 0.9 in males and 0.8 in females of Asian origin,[4-6,20] 0.9 and 0.84-0.86 in Hispanic males and females respectively[22] and 0.95 in male and 0.79-0.85 in female Whites.[20] The probable reason for within WHO range WHR value in males but higher WHR cut-off value in females in our study could be relatively small sample size of females than for males.

In our study, cut-off value is 0.54 in males and 0.64 in females for WHtR and 1.32 and 1.39 for conicity index respectively. In a review of 78 studies[29] conducted during 1950-2008, WHtR and WC were found to be better predictors of diabetes and cardiovascular diseases than BMI although meta-analysis was not performed. The cut-off value for WHtR was found to be 0.5 in most of the studies as was the case in our study. A review of 16 cross-sectional studies on Asians revealed that diabetic risk in males was indicated better by WHtR than BMI, while in females; both WC and WHtR had better predictive value than BMI.[15] Limited studies have determined the predictive role of conicity index in metabolic syndrome.

Our study is the first on Pakistani subjects to determine the predictive values of anthropometric parameters for metabolic risk factors by ROC. By the year 2030, Pakistan will be the fifth country with largest number of diabetic patients; so it is imperative to find non-invasive methods to determine high-risk cases in Pakistani population. The limitation of our study is its small sample size. Moreover, only insulin resistance; and not the other metabolic risk factors, could be predicted by anthropometric parameters using ROC curve analyses. Studies with larger sample size and more metabolic risk factors estimation are recommended to be done in Pakistani subjects.

Conclusion

In Pakistani male adults, BMI is the best indicator of insulin resistance, while in female adults, conicity index is the best indicator. This is the first study in Pakistan reporting predictive values of anthropometric indices as a non-invasive method in determining insulin resistance.

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