ORIGINAL ARTICLE

A Comparative Study of Waist Circumference, Waist-Hip Ratio and BMI in Diabetics and Non-Diabetics

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ABSTRACT

Objective: To determine the pattern of fat distribution in Diabetics as compared to Non-Diabetics.

Study Design: Descriptive cross-sectional comparative study.

Place and Duration: This study was conducted at Khan Research Laboratory (KRL) Hospital, Islamabad from September to November 2016.

Methodology: Present study consisted of 200 candidates out of which half were Diabetics and half were Non-Diabetics. This was a Descriptive cross-sectional comparative study. All statistical analysis was done using statistical package for social sciences (SPSS version 17).

Result: Significant association exists between BMI & Waist circumference and Waist circumference & WHR in male and female Diabetics (p-value <0.05), no association exists between BMI and Waist-hip ratio (WHR) among male and female Diabetics (p-value >0.05). Significant association was found among male and female Non-Diabetics in terms of BMI, Waist circumference and WHR. Cut off values for BMI in Diabetics was found to be 22.72 kg/m2 and 23.05 kg/m2 in males and females respectively. Cut off values for Waist circumference in Diabetics was found to be 34.5 inch and 34.5 inch in males and females respectively. Cut off values for WHR in Diabetics was found to be 0.89 and 0.87 in males and females respectively.

Conclusion: Cut off values for BMI, Waist circumference and Waist-hip ratio need to be revised in Pakistani population. In Diabetics distribution of fat is central as well as peripheral with an increment of BMI while in Non-Diabetics, with rising BMI, fat distribution becomes more central.

Key Words: Body Mass Index, Waist circumference, Waist-hip ratio, Diabetes Mellitus.

Introduction

The prevalence of type 2 diabetes is estimated at 6.4 % in adults worldwide, ranging from 3.8 to 10.2 % by regions and rates of undiagnosed diabetes may be as high as 50 % in some areas.[1] For more than 2000 years we know about the morbidity and mortality associated with being overweight (body mass index [BMI] of 25 to 29.9 kg/m^2) or obese (BMI of ≥30 kg/m^2).[2] Mean BMI is increasing worldwide. In developed countries, obesity rates were approximately 18 and 20 percent in men and women, respectively in 2013.[3] In a survey done in 2013, reported prevalence rates of obesity by country included 25 percent of men and women in the United Kingdom, 21 percent of men and 23 percent of women in Belgium, 20.6 percent of men and 33 percent of women in Mexico, 12.3 percent of men and 41 percent of women in South Africa, and 14 percent of men and women in Pakistan.[3,4] Obesity is associated with a significant increase in morbidity which includes diabetes mellitus, dyslipidemia,

hypertension, heart disease, sleep apnea, stroke, and cancer, among others and in mortality. Expenditures on health care are significantly higher for overweight and obese individuals.[5] The first step to determine the degree of overweight involves measurement of BMI which is easy to measure, reliable, and correlated with percentage of body fat and body fat mass.[6] BMI has proven to provide a better estimate of total body fat compared with body weight alone.[7] BMI is calculated from the weight and square of the height as follows: BMI = body weight (in kg) ÷ height (in meters square). The current cutoffs of BMI underestimate the risk factors which are associated with obesity, for example, for diabetes in the Asian population. In certain populations, the level of risk in terms of percent body fat is reached at a much lower BMI (South Asians) and in others, a higher BMI (blacks) compared with whites.[8] The mean BMI which was associated with the development of an adverse metabolic profile (as defined by markers of glucose and lipid metabolism) was 21 kg/m^2 in South Asians as compared to 30 kg/m^{2}in Europeans.[9] In addition to measuring BMI, measurement of waist circumference in overweight and obese adults is also recommended to assess abdominal obesity. A waist circumference of ≥40 in (102 cm) for men and ≥35 in (88 cm) for women is considered raised and is indicative of increased metabolic risk.[10] There is ethnic variability in waist circumference values that predict increased risk. As an example, Japanese Americans and Indians from South Asia have a total fat and visceral fat and therefore may be at higher risk of developing type 2 diabetes for a given BMI than whites. In Asian males, a value ≥35 in (90 cm) and in Asian females a waist circumference ≥31 in (80 cm) are considered abnormal.[11] Waist-hip ratio is another measuring tool that is used to predict metabolic risk factors among people and is calculated by dividing Waist circumference by Hip circumference.[12] A comparison needs to be made among Diabetics and non-Diabetics in terms of the association between Waist Circumference, Waist-Hip Ratio and BMI in Pakistani population. This would provide us information regarding difference in cutoff values and association of obesity with risk factors and among Waist circumference, WHR and BMI and determining which is the better predictor of obesity among Pakistani population.

Methodology

200 candidates from Islamabad region were selected via non-probability convenience sampling. This was a Descriptive cross-sectional comparative study. Duration of this study was 3 months from September to November 2016. This study was conducted at Khan Research Laboratory (KRL) Hospital, Islamabad after approval from an Ethical review board of the hospital. Informed consent was taken from all subjects.

Standard techniques were applied in the measurement of Height in centimeters and Weight in Kilograms. BMI (weight in Kg ÷ height in m^2), Waist circumference (in inches, measured as a circumference from midpoint between iliac crest and lowest rib), Hip circumference (in inches, measured as a circumference from level of maximal gluteal protrusion) and Waist-hip ratio (Waist circumference ÷ Hip circumference) were measured.

Half of the subjects included were Diabetics and the rest half were non-Diabetics.

Data analysis was done according to gender on statistical package for social sciences (SPSS version 17). Statistical significance was indicated if the p-value was <0.05. The clinical data of the subjects studied was stated as Mean ± SD. The difference between two groups were examined by t-test or ANOVA for continuous variables and by c2-test for categorical variables. Chi-square test was also applied to check for an association between two categorical variables. Receiver operating characteristic (ROC) curve was used for calculation of cut-off values.

Results

Our study comprised of 200 candidates out of which 100 candidates were Diabetics and 100 candidates were Non-Diabetics. Out of 100 Diabetic candidates, 34 were males and 66 were females. Out of 100 Non-Diabetic candidates, 70 were males and 30 were females. According to Table 1, In Diabetic males 2 (6%) had a BMI of less than 18.5 kg/m^2, 7 (21%) had BMI between 18.5 and 24.9 kg/m^2, 18 (52%) had BMI between 25 and 29.9 kg/m^2 and 7 (21%) had BMI of equal to or more than 30 kg/m^2. In Diabetic females 0 (0%) had a BMI of less than 18.5 kg/m^2, 24 (36%) had BMI between 18.5 and 24.9 kg/m^2, 15 (23%) had BMI between 25 and 29.9 kg/m^2 and 27 (41%) had BMI of equal to or more than 30 kg/m^2. In male Diabetics 6 (18%) had waist circumference less than 35 inch and 28 (82%) had waist circumference equal to or more than 35 inches. In female Diabetics 2 (3%) had waist circumference less than 31 inches and 64 (97%) had waist circumference equal to or more than 31 inches. In male Diabetics Waist Hip Ratio (WHR) of 5 (15%) candidates were less than 0.90, 20 (59%) had WHR between 0.90 and 0.99 and 9 (26%) had WHR equal to or more than 1.0. In Female Diabetics Waist Hip Ratio (WHR) of 1 (2%) candidate was less

than 0.80, 4 (6%) had WHR between 0.80 and 0.84 and 61 (92%) had WHR equal to or more than 0.85.

Table: 1 Numbers and Percentages of Diabetic candidates falling into different cutoff values of BMI, Waist circumference and Waist Hip Ratio (WHR)

Male			Female		
	No.	**%**		**No.**	**%**
BMI<18.5 (kg/m^2)	02	06%	BMI < 18.5 (kg/m^2)	0	0%
BMI 18.5 – 24.9 (kg/m^2)	07	21%	BMI 18.5 – 24.9 (kg/m^2)	24	36%
BMI 25 – 29.9 (kg/m^2)	18	52%	BMI 25 – 29.9 (kg/m^2)	15	23%
BMI >=30 (kg/m^2)	07	21%	BMI >=30 (kg/m^2)	27	21%
Waist < 35 (inch)	06	18%	Waist < 31 (inch)	02	03%
Waist >=35 (inch)	28	82%	Waist >=31 (inch)	64	97%
WHR<0.90	05	15%	WHR<0.80	01	02%
WHR 0.90-0.99	20	59%	WHR 0.80-0.84	04	06%
WHR >=1	09	26%	WHR >=0.85	61	92%

According to Table II, In Non-Diabetic males 4 (6%) had a BMI of less than 18.5 kg/m^2, 38 (54%) had BMI between 18.5 and 24.9 kg/m^2, 22 (31%) had BMI between 25 and 29.9 kg/m^2 and 6 (9%) had BMI of equal to or more than 30 kg/m^2. In Non-Diabetic females 2 (7%) had a BMI of less than 18.5 kg/m^2, 12 (40%) had BMI between 18.5 and 24.9 kg/m^2, 8 (27%) had BMI between 25 and 29.9 kg/m^2 and 8 (27%) had BMI of equal to or more than 30 kg/m^2. In male Non-Diabetics 26 (37%) had waist circumference less than 35 inches and 44 (63%) had waist circumference equal to or more than 35 inches. In female Non-Diabetics 11 (37%) had waist circumference less than 31 inches and 19 (63%) had waist circumference equal to or more than 31 inches. In male Non-Diabetics Waist Hip Ratio (WHR) of 27 (39%) candidates were less than 0.90, 34 (49%) had WHR between 0.90 and 0.99 and 9 (13%) had WHR equal to or more than 1.0. In Female Non-Diabetics Waist Hip Ratio (WHR) of 7 (23%) candidate was less than 0.80, 5 (17%) had WHR between 0.80 and 0.0.84 and 18 (60%) had WHR equal to or more than 0.85.

Table III & IV shows characteristics of candidates included in the study. Mean weight of males in Diabetics and Non-Diabetics group was 79 kg and 72 kg respectively. Mean BMI of males in Diabetics and Non-Diabetics group was 29 kg/m^2 and 24.3 kg/m^2 respectively. Mean waist circumference of males in Diabetics and Non-Diabetics group was 39 inch and 35 inch respectively. Mean waist hip ratio (WHR) of males in Diabetics and Non-Diabetics group was 0.95 and 0.91 respectively. Mean weight of females in Diabetics and Non-Diabetics group was 75 kg and 63 kg respectively. Mean BMI of females in Diabetics and Non-Diabetics group was 27.5 kg/m^2 and 26.5 kg/m^2 respectively. Mean waist circumference of females in Diabetics and Non-Diabetics group was 39 inch and 34 inch respectively. Mean waist hip ratio (WHR) of females in Diabetics and Non-Diabetics group was 0.91 and 0.86 respectively.

Table II: Numbers and Percentages of Non-Diabetic candidates falling into different cutoff values of BMI, Waist circumference and Waist Hip Ratio (WHR)

Male			Female		
	No.	**%**		**No.**	**%**
BMI<18.5 (kg/m^2)	04	06%	BMI < 18.5 (kg/m^2)	02	07%
BMI 18.5 – 24.9 (kg/m^2)	38	54%	BMI 18.5 – 24.9 (kg/m^2)	12	40%
BMI 25 – 29.9 (kg/m^2)	22	31%	BMI 25 – 29.9 (kg/m^2)	08	27%
BMI >=30 (kg/m^2)	06	9%	BMI >=30 (kg/m^2)	08	27%
Waist < 35 (inch)	26	37%	Waist < 31 (inch)	11	37%
Waist >=35 (inch)	44	63%	Waist >=31 (inch)	19	63%
WHR<0.90	27	39%	WHR<0.80	07	23%
WHR 0.90-0.99	34	49%	WHR 0.80-0.84	05	17%
WHR >=1	09	13%	WHR >=0.85	18	60%

All values are in Mean ± S.D.

Table III: Characteristics of study Population (Diabetics)

	Total	**Male**	**Female**	**P value**
No of Subjects	100	34	66	
Patient Age	52.41±11.75	56.26±13.148	50.42±10.53	<0.05
Weight (kg)	76.37±16.07	78.79±17.56	75.12±15.24	0.224
Height (cm)	163.90±6.38	161.09±5.47	169.35±4.08	<0.01
BMI (kg/m^2)	28.51±6.23	29.03±6.28	27.49±6.08	<0.05
Waist (inch)	39.22±5.35	39.13±5.25	39.27±5.43	0.973
Hip (inch)	42.28±5.50	42.74±5.72	41.36±4.99	0.183
WHR	0.93± 0.05	0.95±0.05	0.91±0.05	0.730

Table IV: Characteristics of study Population (Non-Diabetics)				
	Total	**Male**	**Female**	**P value**
No of Subjects	100	70	30	
Patient Age	35.67±13.27	34.57±12.140	38.23±15.54	<0.01
Weight (kg)	69.22±14.06	71.71±12.53	63.40±15.86	<0.05
Height (cm)	166.68±10.56	171.83±6.38	160.90±3.32	<0.01
BMI (kg/m^2)	24.99±5.22	24.31±4.28	26.58±6.75	0.124
Waist (inch)	34.84±5.32	35.29±4.55	33.78±6.78	<0.01
Hip (inch)	38.60±4.34	38.44±3.65	39.00±5.69	<0.05
WHR	0.90±0.07	0.91±0.06	0.86±0.08	0.146

All values are in Mean ± S.D.

Table V and Figure 1a & 1b shows an association between male Diabetics and Non-Diabetics. BMI and Waist circumference among male Diabetics has a significant association as p-value <0.01. BMI and Waist Hip Ratio (WHR) among male Diabetics does not have a significant association as p-value = 0.069. Waist circumference and Waist Hip Ratio (WHR) among male Diabetics has a significant association as p-value <0.05. BMI and Waist circumference among male Non-Diabetics has a significant association as p-value <0.01. BMI and Waist Hip Ratio (WHR) among male Non-Diabetics has a significant association as p-value <0.01. Waist circumference and Waist Hip Ratio (WHR) among male Non-Diabetics has a significant association as p-value <0.01.

Table 5: Association of BMI, Waist and Waist Hip Ration among Male Diabetics and Non-Diabetics:						
	Male Diabetics			**Male Non-Diabetics**		
	BMI (29.03 ±6.28)	BMI (29.03 ±6.28)	Waist (39.13 ±5.25)	BMI (24.31 ±4.28)	BMI (24.31± 4.28)	Waist (35.29 ±4.55)
	Waist (39.13 ±5.25)	WHR (0.95± 0.05)	WHR (0.95± 0.05)	Waist (35.29 ±4.55)	WHR (0.91±0 .06)	WHR (0.91± 0.06)
P Value	<0.01	0.069	<0.05	<0.01	<0.01	<0.01

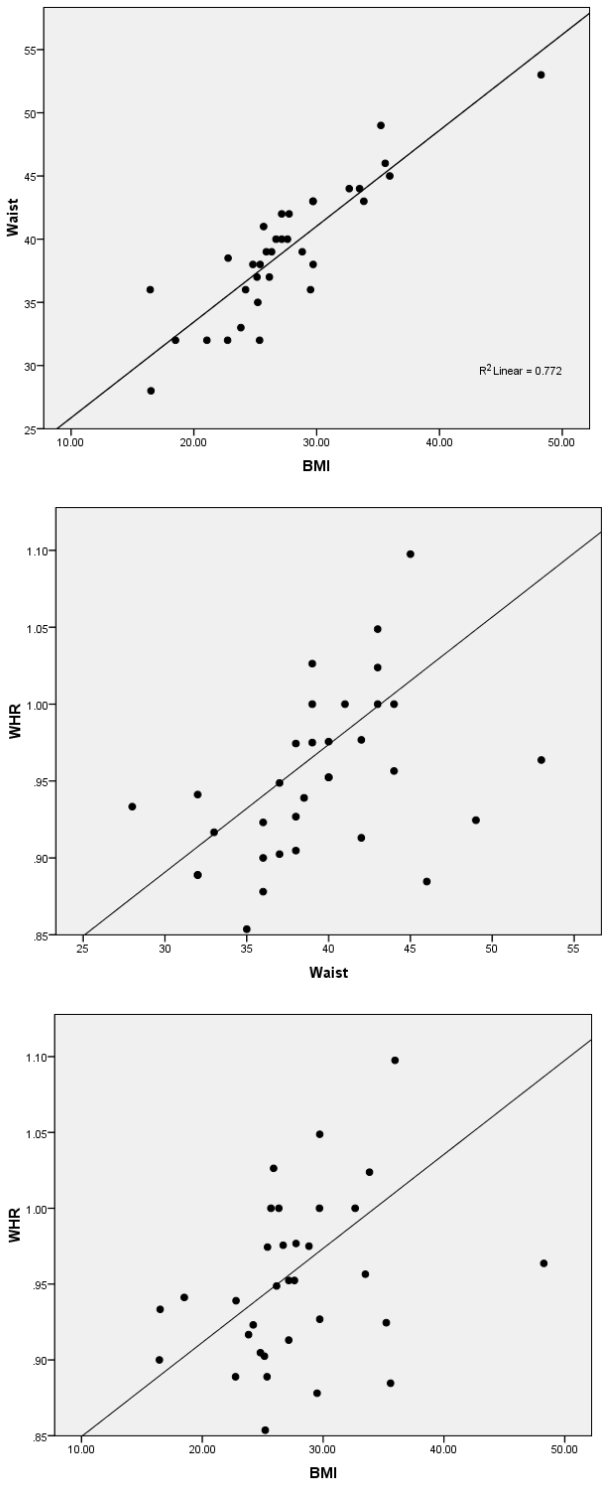
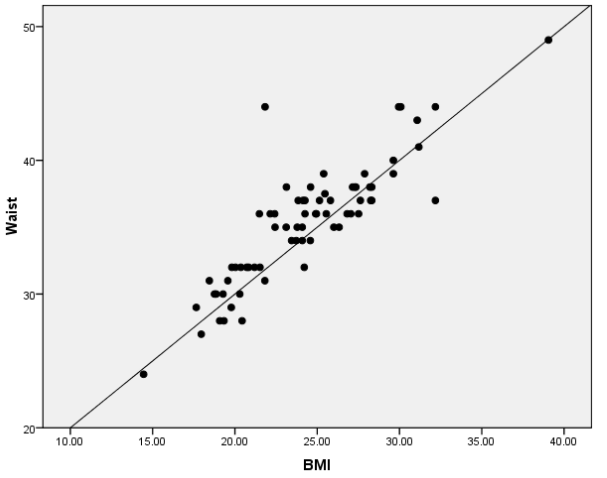
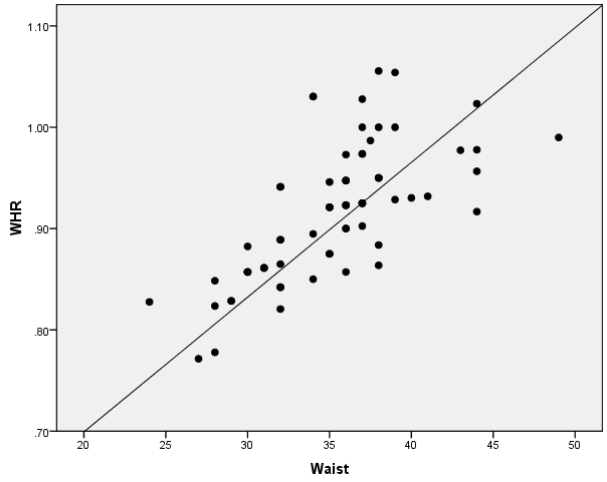


Figure 1a: Association of BMI (kg/m2), Waist circumference (inch) and WHR in male Diabetics





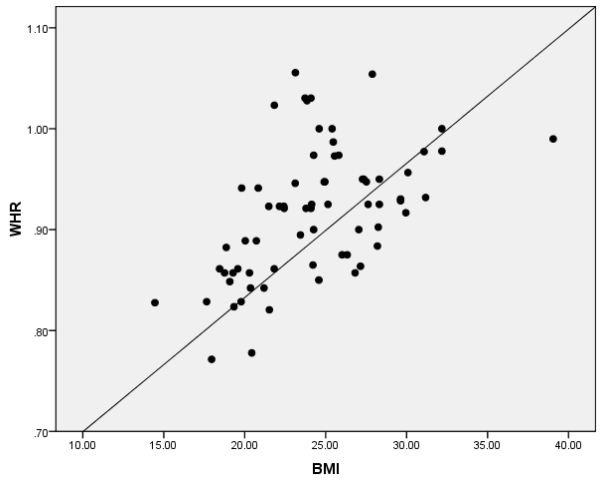


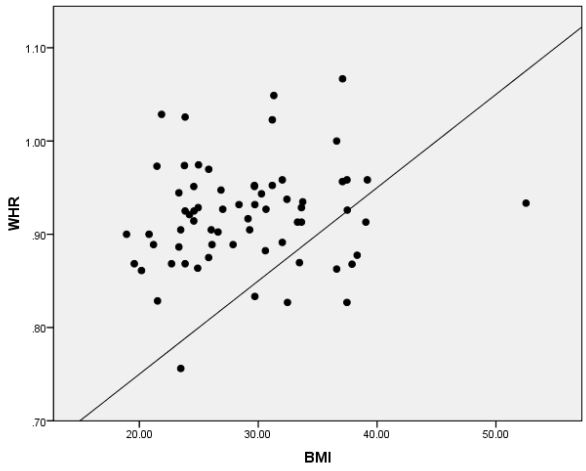
Figure 1b: Association of BMI (kg/m2), Waist circumference (inch) and WHR in male Non-Diabetics

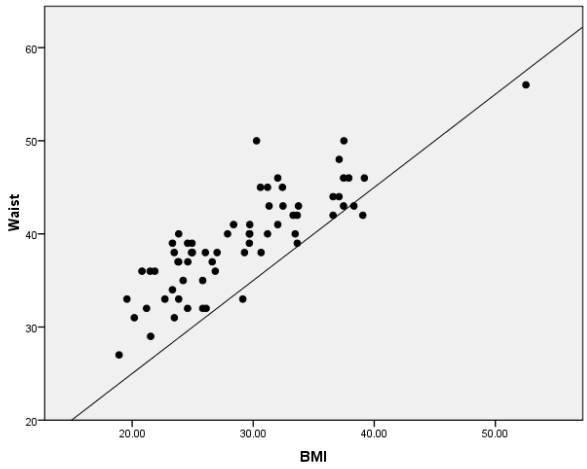
Table VI and Figure 2a & 2b shows association between female Diabetics and Non-Diabetics. BMI and Waist circumference among female Diabetics has significant association as p-value <0.01. BMI and Waist Hip Ratio (WHR) among female Diabetics does not have significant association as p-value = 0.282. Waist circumference and Waist Hip Ratio (WHR) among female Diabetics has a significant association as p-value <0.05. BMI and Waist circumference among female Non-Diabetics has a significant association as p-value <0.01. BMI and Waist Hip Ratio (WHR) among female Non-Diabetics has a significant association as p-value <0.05. Waist circumference and Waist Hip Ratio (WHR) among female Non-Diabetics has a significant association as p-value <0.01.

Table VI: Association of BMI, Waist and Waist Hip Ration among Female Diabetics and Non-Diabetics

	Female Diabetics			**Female Non-Diabetics**		
	BMI (27.49 ±6.08)	BMI (27.49 ±6.08)	Waist (39.27 ±5.43)	BMI (26.58±6 .75)	BMI (26.58± 6.75)	Waist (33.78 ±6.78)
	Waist (39.27 ±5.43)	WHR (0.91± 0.05)	WHR (0.91± 0.05)	Waist (33.78±6 .78)	WHR (0.86±0 .08)	WHR (0.86± 0.08)
P Value	<0.01	0.282	<0.05	<0.01	<0.05	<0.01

All values are in Mean ± S.D.





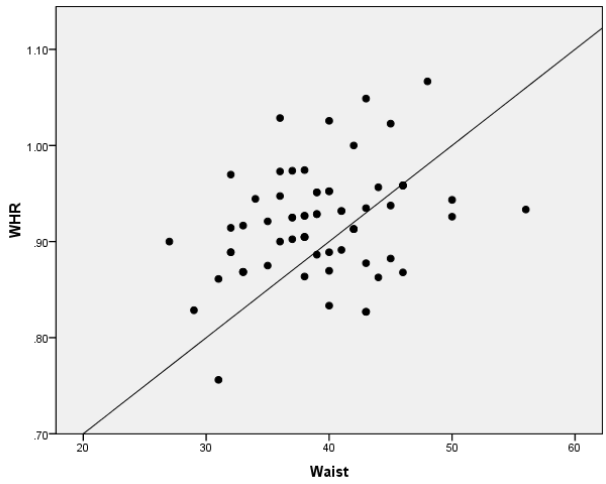


Figure 2a: Association of BMI (kg/m2), Waist circumference (inch) and WHR in Female Diabetics

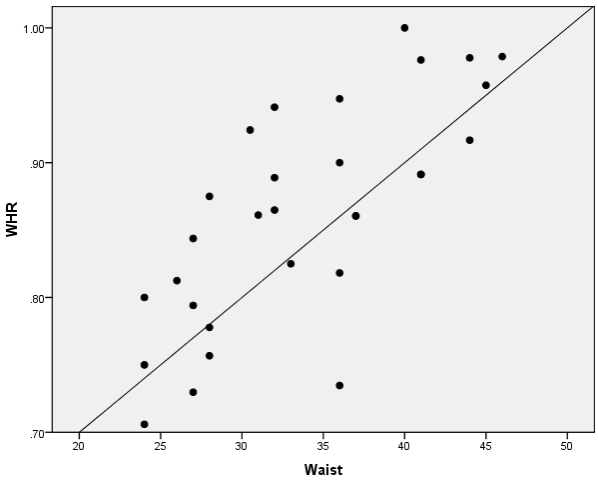
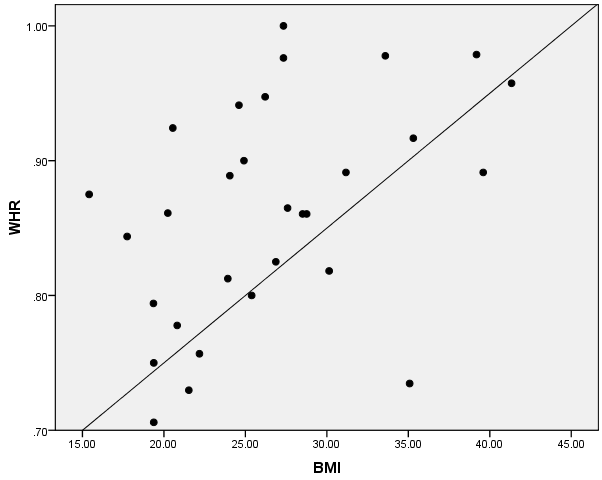
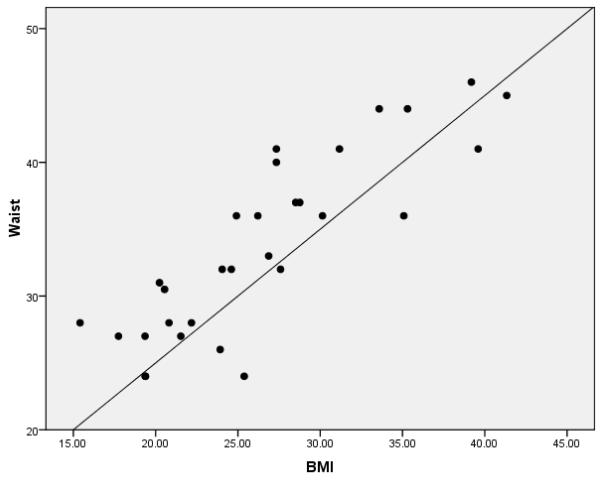


Figure 2b Association of BMI (kg/m2), Waist circumference (inch) and WHR in Female Non-Diabetics





Discussion

The present study indicates that there are different cutoffs of BMI for Diabetics and Non-Diabetics. It further illustrates that in Diabetic male and female population, there is a Positive or direct association between BMI and Waist circumference and Waist circumference and Waist Hip Ratio (WHR), however, no association is present between BMI and WHR. This study also demonstrates that in Non-Diabetic males and females there is only positive or direct association between BMI and Waist circumference, BMI and WHR & Waist circumference. These findings indicate that in Diabetics the distribution of fat is not just central but peripheral as well as disparate from Non-Diabetics in which case, the fat distribution is more in the center.

In a prospective study, it is postulated that larger Hip circumference is associated with reduced odds of developing Diabetes.[13] In another study, Waist-hip ratio has been found to be a good predictor of Diabetes. [14] It has also been observed in studies that more peripheral fat may be related with advantageous metabolic profile and it has also been suggested that femoro-gluteal fat may have a protective role as it acts as a basin for circulating free fatty acids. [15,16,17] The association of Diabetes with BMI, Waist circumference and Wait-hip ratio was also confirmed in a study and it was found that Waist circumference is superior to BMI which is superior to Waist-hip ratio.[18] Waist-hip ratio is one of the most common obesity-associated predictor of Diabetes but has a weak association with BMI as compared to BMI and waist circumference.[19] In a study conducted in China cut-off values of BMI for metabolic risk were 22.85 kg/m^2

and 23.30 kg/m^2 in males and females respectively. For waist circumference cut-off values were 39.5 inch and 34.3 inches in males and females respectively.[20]

In the present study, cutoff values for BMI in Diabetics was found to be 22.72 kg/m^2 and 23.05 kg/m^2 in males and females respectively. Cut off values for Waist circumference in Diabetics was found to be 34.5 inches and 34.5 inches in males and females respectively. Cut off values for WHR in Diabetics was found to be 0.89 and 0.87 in males and females respectively.

In present study majority of Diabetic population i.e.; 82% males and 97% females fell into the category of obesity as per waist circumference cut-off values while this was not followed as per BMI cut-off values monitored worldwide. This suggests that in Pakistani population BMI cut-off values need to be revised and corrected.

Lower values of BMI cut off in the diabetic group was found in present study which indicates that risk of developing Diabetes is high at even lower BMI values as opposed to what was previously thought. These observations guide us to modify our lifestyles, including diet modification and regular exercise be added to our routine in order to prevent certain diseases including Diabetes. There is a need for promotion of health education. Guided programs should be launched that would aid in weight reduction and thus prevent the occurrence of certain diseases.

Present study also suggests an association of an increase in overall body fat distribution with an increment of BMI as opposed to the concept of only central fat distribution increase with raising BMI in Diabetic population. These findings suggest early screening for Diabetes at a lower BMI level and screening with the even absence of central fat distribution, in Pakistani population.

Conclusion

The present study suggests that cut off values for BMI, Waist circumference and Waist-hip ratio needs to be revised and corrected in Pakistani population. This study also suggests that in Diabetics BMI is directly or positively correlated with Waist circumference but no association exists between BMI and WHR. While in Non-Diabetics, a Positive association exists between BMI, Waist circumference and WHR which indicates that in Diabetics distribution of fat is central as well as peripheral with an increment of BMI while in Non-Diabetics, with rising BMI, fat distribution becomes more central.

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