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COMPARISON OF ANTHROPOMETRIC MEASUREMENTS IN NORMAL SUBJECTS WITH SUBJECTS HAVING DIABETES MELLITUS AND HYPERTENSION

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ABSTRACT

Background

Methods for direct assessment of abdominal fat include ultrasound, dual energy X-ray absorptiometry, magnetic resonance imaging and computerized tomography. However, these methods are expensive and, in case of computerized tomography, the subjects are exposed to ionizing radiation. The mass screening of population especially in rural areas of India require methods which can be adopted in health camps and OPD settings. Measurements of anthropometric variables such as sagittal abdominal diameter (SAD), waist circumference, hip circumference, waist to hip ratio (WHR) and different measures of skin fold thickness are simple, inexpensive and commonly used methods for indirect assessment of the body fat distribution. (4)

Objective

The present study aims to compare anthropometric measures such as SAD, waist and hip circumferences, WHR ratio, Body mass index, sub scapular skin fold measurements in healthy controls, subjects with diabetes mellitus and subjects with hypertension, in area in and around MGM medical college Kamothe Navi Mumbai

Methods

The conducted study is a cross sectional descriptive study performed in Department of Anatomy, MGM Medical College and Hospital, Kamothe, Navi Mumbai, as per the study design under the supervision of the Guide. The study was conducted in year 2011-12.The material consisted of 300 subjects (100 without diabetes mellitus and hypertension, 100 with diabetes, and 100 with hypertension), in the age group 25-65 years.

Ethical clearance was obtained from IERC (Institutional Ethical Review committee) before starting the study.

Informed consent of participants was taken. Age, sex, history of duration of diabetes mellitus and hypertension was noted.

Results

Anthropometric parameters where compared among controls, diabetics and hypertensive. WC, WHR and SAD were found to significantly higher in hypertensive and diabetics than in controls

Conclusions

The ethnic origin of the population studied influences the predictive power of various anthropometric indices. Hence, population specific anthropometric indices are needed to identify subjects at risk for hypertension and type2 diabetes. WC, WHR and SAD are simple, inexpensive anthropometric measurements. It is therefore suggested that WC, WHR and SAD are important markers to be used clinically for screening and to identify people with high risk of diabetes and hypertension.

KEYWORDS: SAD, Waist and Hip Circumferences, WHR Ratio, Body Mass Index, Sub Scapular Skin Fold, Body Fat Distribution**,** Diabetes Mellitus and Hypertension

INTRODUCTION

Anthropometry (Anthropos-human, Metric- measuring) is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. Measures of subcutaneous adipose tissue are important because individuals with large values are reported to be at increased risks for hypertension, adult-onset diabetes Mellitus, and cardiovascular disease. Anthropometric measurements such as skin folds and circumferences will allow cross-sectional analysis of the relationship between obesity and risk of disease. (4)

Methods for direct assessment of abdominal fat include ultrasound, dual energy X-ray absorptiometry, magnetic resonance imaging and computerized tomography. However, these methods are expensive and, in case of computerized tomography, the subjects are exposed to ionizing radiation. The mass screening of population especially in rural areas of India require methods which can be adopted in health camps and OPD settings. Measurements of anthropometric variables such as sagittal abdominal diameter (SAD), waist circumference, hip circumference, waist to hip ratio (WHR) and different measures of skin fold thickness are simple, inexpensive and commonly used methods for indirect assessment of the body fat distribution. (4)

The present study aims to compare anthropometric measures such as SAD, waist and hip circumferences, WHR ratio, Body mass index, sub scapular skin fold measurements in healthy controls, subjects with diabetes mellitus and subjects with hypertension, in area in and around MGM medical college Kamothe Navi Mumbai

MATERIALS AND METHODS

- The conducted study is a cross sectional descriptive study performed in Department of Anatomy, MGM Medical College and Hospital, Kamothe, Navi Mumbai, as per the study design under the supervision of the Guide. The study was conducted in year 2011-12. The material consisted of 300 subjects (100 without diabetes mellitus and hypertension, 100 with diabetes, and 100 with hypertension), in the age group 25-65 years.
- Ethical clearance was obtained from IERC (Institutional Ethical Review committee) before starting the study.
- Informed consent of participants was taken. Due permission from Head of department of Medicine was obtained. Age, sex, history of duration of diabetes mellitus and hypertension was noted.

Weight

INSTRUMENT – Weighing scale (Libra)

METHOD-Subject stands barefoot on the weighing scale with day to day clothing. The weight of the subject is distributed evenly on both feet. The arms hang freely by the sides of the trunk. Care was taken that both feet are equally spaced on the weighing scale and the feet don't project outside the scale. The subject stood erect looking straight without taking any support. Accuracy was ascertained by assuring that pockets were emptied and any jewellery articles whenever present were removed. Weight was taken to the nearest 0.5 Kg. All the recording were taken pre-lunch. Before every reading the scale was set to zeros. (37)

Height

INSTRUMENT- Measuring tape

METHOD Subject stands barefoot on a flat surface at right angles to the surface. The weight of the subject is evenly distributed on both feet and the head is positioned with the Frankfurt plane horizontally. The arms hang freely by the sides of the trunk while the palms face the thigh. The subject places the heels together with both heels touching the surface. The medial borders of the feet are at the angle of 60°. The subject is asked to inhale deeply and maintain a fully erect position without altering load on the heels. The scale at horizontal level is brought on to the superior point on the head (vertex) with sufficient pressure to compress the hair. The measurement is made to the nearest 0.1 centimeter. (38)

Waist Circumference

INSTRUMENT- Measuring tape

METHOD- The subject stands erect with abdomen relaxed, the arms at the sides and the feet together. The Measurement was taken standing facing the subject, with an inelastic tape placed at the level of the greatest extension of the abdomen in a horizontal plane. Generally it is found at a level about 1 centimeter above the highest point of iliac crest. The tape was held snug against the skin without compressing the tissues with its zero end below the value to be recorded. The measurement was made at the end of a normal expiration to the nearest 0.1 centimeter. (38)

Hip Circumference

INSTRUMENT- Measuring tape

METHOD- The hip circumference was taken with the subject in the same posture as when taking waist circumference. It was taken at the level of the maximum extension of the buttocks by an inelastic tape placed around the buttock in a horizontal plane without compressing the skin. An assistant helped positioned the tape on the opposite side of the subjects‟ body. Generally it is found at a level of greater trochanter. The measurement was made to the nearest 0.1 centimeter. (38)

Sagittal Abdominal Diameter

INSTRUMENT – Measuring tape and scale.

METHOD- For SAD measurements the subjects were made to lie down in supine position and measurements were taken with both the legs extended and with flexion at the knee joint. The perpendicular distance between the plane of support and the highest point of the abdomen is measured and read to the nearest 1mm. (18)

Subscapuar Fold Thickness

INSTRUMENT – Base line Caliper

METHOD- The subject was asked to stand erect with shoulders and arms relaxed at the side. The inferior angle (or triangle portion) of the right scapula. Was palpated. The (+) mark on the inferior angle of the scapula with the cosmetic pencil marker was made. The enough skin and adipose tissue was grasped to form a distinct fold that separates from the underlying muscle. The sides of the fold were roughly parallel. The fold of skin and subcutaneous adipose tissue was grasped directly below (1.0 cm) and medial to the inferior angle. The skin fold forms a line about 45 degrees below the horizontal extending diagonally toward the right elbow. The jaws of the caliper were placed perpendicular to the length of the fold about 2.0 cm lateral to the fingers with the top jaw of the caliper on the mark over the inferior angle of the scapula.

The skin fold thickness was measured to the nearest 0.1 mm while the fingers continue to hold the skin fold. The caliper was held in right hand and the measurement was read within 3 seconds (so that pressure does not compress the subcutaneous tissue). (37) Skin fold thickness was measured in millimeters. Measurements were taken for left scapula also.

BMI was calculated as body weight (in kg) without shoes and with light clothing, divided by height (in meters) squared. Waist hip ratio was calculated by weight in Kg divided by height in meter. To the data obtained suitable statistical tests (ANOVA) were applied, data was analyzed and results were drawn

RESULTS

Table 1: Comparison among Study Group for Waist Circumference (Cm)

Waist Circumferance(cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	84.47	13.47	13.860	o.ooo
Hypertension	100	84.39	8.45	Difference is significant	
Control	100	77.52	10.17		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean waist circumference in diabetics is 84.47, in hypertensive is 84.39 and in control is 77.52. The P value is 0.00, the difference is significant.

Table 2: Comparison among Male Group for Waist Circumference (cm)

Waist Circumferance(cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	88.47	16.755	6.015	0.003
Hypertension	45	87.29	6.747	Difference is significant	
Control	41	80.37	8.606		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean waist circumference in male, diabetics is 88.47, in hypertensive is 87.29 and in control is 80.37.The P value is 0.003, the difference is significant.

Table 3: Comparison among Female Group for Waist Circumference (cm)

Waist Circumferance(cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	81.33	9.180	7.725	0.001
Hypertension	55	82.03	9.002	Difference is significant	
Control	59	75.55	10.070		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean waist circumference in female, diabetics is 81.33, in hypertensive is 82.03 and in control is 75.55. The P value is 0.001, the difference is significant.

Table 4: Comparison among Study Group for Hip Circumference (cm)

Hip Circumferance(cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	84.10	12.46	1.535	0,217
Hypertension	100	83.25	11.83	Difference is not significant	
Control	100	81.28	10.61		

Mean hip circumference in diabetics is 84.10, in hypertensive is 83.25 and in control is 81.28. The difference is not significant.

Table 5: comparison among Male Group for Hip Circumference (cm)

Hip Circumferance(cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	75.36	11.356	1.940	0.148
Hypertension	45	71.72	5.315	Difference is not significant	
Control	41	73.58	8.526		

Mean hip circumference in male, diabetics is 75.36, in hypertensive is 71.72 and in control is 73.58. The difference is not significant.

Table 6: Comparison among Female Group for Hip Circumference (cm)

Hip Circumferance(Cm)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	90.97	8.326	9.661	0.000
Hypertension	55	92.69	5.645	Difference is significant	
Control	59	86.64	8.411		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean hip circumference in female, diabetics is 90.97, in hypertensive is 92.69 and in control is 86.64.The P value is 0.000, the difference is significant.

Table 7: Comparison among Study Group for WHR

WHR	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	1.02	0.16	5.354	0.005
Hypertension	100	1.03	0.18	Difference is significant	
Control	100	0.96	0.13		

All Pair wise Multiple Comparison Procedures (Tukey Test):		
Comparison	P<0.05	Only this group difference is significant
Hypertension vs. Control	Yes	
Diabetics vs. Control	Yes	

Mean WHR ratio in diabetics is 1.02, in hypertensive is 1.03 and in control is 1.01. The P value is 0.96. The P value is 0.005.The difference is significant.

Table 8: Comparison among Male Group for WHR

WHR	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	1.1724	0.11300	17.335	0.000
Hypertension	45	1.2198	0.08872	Difference is significant	
Control	41	1.0968	0.08776		
Comparison		P<0.05		Only this group difference is significant	
Hypertension vs. Control		Yes			
Diabetics vs. Control		Yes			

Mean WHR ratio in diabetics is 1.17, in hypertensive is 1.21 and in control is 1.09. The P value is 0.000. The difference is significant.

Table 9: Comparison among Female Group for WHR

WHR	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	0.8938	0.55650	2.354	0.098
Hypertension	55	0.9995	0.01830	Difference is not significant	
Control	59	0.8694	0.60980		

Mean WHR ratio in diabetics is 0.89, in hypertensive is 0.99 and in control is 0.86. The P value is 0.098. The difference is not significant.

Table 10: Comparison among Study Group for SAD (mm) (Extended)

SAGITTAL ABD DIA(mm) (Ext)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	20.87	3.90	6.335	0.002
Hypertension	100	20.88	4.74	Difference is significant	
Control	100	19.22	2.33		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetes vs. Control	Yes				

Mean Sagittal abdominal diameter (Knees extended) in diabetics is 20.87, in hypertensive is 20.88 and in control is 19.22. P value is 0.002 the difference is significant compared to control.

Table 11: Comparison among Study Group for SAD (mm) (Flexed)

SAGITTAL ABD DIA(mm) (Flex)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	22.31	4.27	8.096	0.000
Hypertension	100	22.48	5.00	Difference is significant	
Control	100	20.40	2.47		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean Sagittal abdominal diameter (Knees flexed) in diabetics is 22.31, in hypertensive is 22.48 and in control is 20.40. P value is 0.000 the difference is significant compared to control.

Table 12: Comparison among Male Group for SAD (mm) (Extended)

SAGITTAL ABD DIA(mm) (Ext)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	22.068	4.2479	5.999	0.003
Hypertension	45	22.213	4.3630	Difference is significant	
Control	41	19.668	2.2854		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean Sagittal abdominal diameter (Knees extended) in male, diabetics is 22.06, in hypertensive is 22.21 and in control is 19.66. P value is 0.003 the difference is significant compared to control.

Table 13: Comparison among Male Group for SAD (mm) (Flexed)

SAGITTAL ABD DIA(mm) (Flex)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	23.70	4.894	6.857	0.001
Hypertension	45	23.93	4.582	Difference is significant	
Control	41	20.91	2.470		
All Pair wise Multiple Comparison Procedures (Tukey Test):					
Comparison	P<0.05	Only this group difference is significant			
Hypertension vs. Control	Yes				
Diabetics vs. Control	Yes				

Mean Sagittal abdominal diameter (Knees flexed) in male diabetics is 23.70, in hypertensive is 23.93 and in control is 20.91. P value is 0.001 the difference is significant compared to control.

Table 14: Comparison among Female Group for SAD (mm) (Extended)

SAGITTAL ABD DIA(mm) (Ext)	N	Mean	Std. Dev.	F Value	P Value
Diabetis Mellitus	56	19.927	3.3468	1.348	0.263
Hypertension	55	19.784	4.7871	Difference is not significant	
Control	59	18.910	2.3345		

Mean Sagittal abdominal diameter (Knees extended) in female diabetics is 19.92, in hypertensive is 19.78 and in control is 18.91. The difference is not significant.

Table 15: Comparison among Female Group for SAD (mm) (Flexed)

SAGITTAL ABD DIA(mm) (Flex)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	21.21	3.368	2.018	0.136
Hypertension	55	21.29	5.060	Difference is not significant	
Control	59	20.04	2.425		

Mean Sagittal abdominal diameter (Knees flexed) in female, diabetics is 21.21, in hypertensive is 21.29 and in control is 20.04.The difference is not significant.

Table 16: Comparison among Study Group for Sub Scapular Fold Thickness (mm) (Rt)

Subscap Fold Thickness(mm) (Rt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	25.72	9.62	1.377	0.254
Hypertension	100	24.50	4.25	Difference is not significant	
Control	100	24.19	5.67		

Mean Sub scapular fold thickness (Right side) in diabetics is 25.72, in hypertensive is 24.50 and in control is 24.19. The difference is not significant.

Table 17: Comparison among Study Group for Sub Scapular Fold Thickness (mm) (Lt)

Subscap Fold Thickness(mm) (Lt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	25.28	9.60	1.015	0.364
Hypertension	100	24.47	4.31	Difference is not significant	
Control	100	23.90	5.66		

Mean Sub scapular fold thickness (Left side) in diabetics is 25.28, in hypertensive is 24.47 and in control is 23.90. The difference is not significant.

Table 18: Comparison among Male Group for Sub Scapular Fold Thickness (mm)(Rt)

Subscap Fold Thickness(mm) (Rt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	28.239	11.2365	1.982	0.142
Hypertension	45	25.531	3.4733	Difference is not significant	
Control	41	25.639	3.9616		

Mean Sub scapular fold thickness (Right side) in male, diabetics is 28.239, in hypertensive is 25.53 and in control is 25.63. The difference is not significant.

Table 19: Comparison among Male Group for Sub Scapular Fold Thickness (mm) (Lt)

Subscap Fold Thickness(mm) (Lt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	44	28.248	11.2318	1.976	0.143
Hypertension	45	25.540	3.4691	Difference is not significant	
Control	41	25.659	3.9688		

Mean Sub scapular fold thickness (Left side) in male, diabetics is 28.24, in hypertensive is 25.54 and in control is 25.65. The difference is not significant.

Table 20: Comparison among Female Group for Sub Scapular Fold Thickness (mm) (Rt)

Subscap Fold Thickness(mm) (Rt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	23.736	7.6684	0.130	0.878
Hypertension	55	23.653	4.6494	Difference is not significant	
Control	59	23.175	6.4417		

Mean Sub scapular fold thickness (Right side) in female, diabetics is 23.73, in hypertensive is 23.65 and in control is 23.17.The difference is not significant.

Table 21: Comparison among Female Group for Sub Scapular Fold Thickness (mm) (Lt)

Subscap Fold Thickness(mm) (Lt)	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	22.954	7.3930	0.316	0.729
Hypertension	55	23.593	4.7511	Difference is not significant	
Control	59	22.678	6.3403		

Mean Sub scapular fold thickness (Left side) in female, diabetics is 22.95, in hypertensive is 23.59 and in control is 22.67.The difference is not significant.

Table 22: Comparison among Study Group for BMI

BMI	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	100	24.43	4.40	2.760	0.065
Hypertension	100	24.77	4.80	Difference is not significant	
Control	100	23.28	4.88		

Mean BMI in diabetics is 24.43, in hypertensive is 24.77 and in control is 23.28. The P value is 0.065.The difference is not significant.

Table 23: Comparison among Male Group for BMI

BMI	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	43	23.7615	4.31081	2.966	0.055
Hypertension	45	24.6119	4.43578	Difference is not significant	
Control	41	22.2795	4.68022		

Mean BMI in male, diabetics is 23.76, in hypertensive is 24.61 and in control is 22.27. The P value is 0.055. The difference is not significant.

Table 24: Comparison among Female Group for BMI

BMI	N	Mean	Std. Dev.	F Value	P Value
Diabetes Mellitus	56	24.8996	4.42207	0.892	0.412
Hypertension	55	24.8400	5.09447	Difference is not significant	
Control	59	23.8386	4.85548		

Mean BMI in female diabetics is 24.89, in hypertensive is 24.84 and in control is 23.83. The P value is 0.412. The difference is not significant.

DISCUSSIONS

In the present study 300 volunteers comprising of equal number of controls, diabetic and hypertensive were analyzed for anthropometric variables (Table 1).

Waist Circumference (WC)

The mean WC of the control were 77.52 ±10.17cm, diabetics were 84.47±13.47 cm, hypertensive were 84.40±8.45 cm.There was a significant increase in WC in diabetics and in hypertensive ($P<0.05$). The difference was highly significant in both males ($P<0.001$) and females ($P<0.003$) (Table 5) WC is a simple measure of abdominal fat and a strong predictor of metabolic risk. It predicts the visceral adiposity, which conveys a significant health risk. Darren et al found that WC is a stronger predictor of cardio metabolic health. Increase in WC reflects increase fat accumulation and abdominal obesity, which in turn is related to increased lipolysis and lipogenesis of abdominal fat resulting in hyperlipidemia and insuln resistance. This increases the risk of diabetes and cardiovascular diseases. (36) Therefore the simple measure of waist circumference is recommended to identify the risk associated with CVD. Some men develop multiple metabolic risk factors when waist circumference is only marginally increased.

Hip Circumference

The mean hip circumference of the control, diabetic, hypertensive is 81.28±10.60cm, 84.10±12.46cm and 83.25 ±11.83 cm respectively. (Table 6) There was no significant increase in hip circumference in diabetic and hypertensive compared to the controls. There was significant increase in hip circumference in diabetic and hypertensive females as compared to controls. ($P<0.05$) (Table 6) There was no such difference found in male study group. In a study done by A Latiffah et al, there was a significant association between HC and hypertension. Hypertensive individuals significantly had higher HC ($P\leq 0.003$) compared to normotensive. (30)

Waist to Hip Ratio (WHR)

In present study WHR among control, diabetics and hypertensive was 0.96 ±0.135, 1.02±0.163and 1.03± 0.183).This difference was highly significant. ($P<0.005$). There was significant difference in WHR among males. (Controls 1.097±0.08, diabetic- 1.17±0.11, hypertensive-1.21±0.080.$P < 0.05$) (Table 7) Central obesity, measured as a waist to hip ratio is associated with an increased occurrence of diabetes independently of overall obesity. Bays HE et al suggested that WHR appeared to be the best anthropometric predictor of diabetes mellitus. (33) Fuchs D et al in his study compared the anthropometric indices with the incidence of hypertension. Waist- to- hip ratio was more tightly associated with the incidence of hypertension.(25) Latiffah A et al found that median for WHR was higher among hypertensive individuals compared to normotensive individuals(30). Waist to hip ratio measured as an index of upper body fat distribution is associated with cardiovascular risk factors independently of BMI.

Saggital Abdominal Diameter (SAD)

The mean SAD (knee extended) value for control was 19.22 ± 2.33cm, diabetic was 20.87 ± 4.2cm, hypertensive was 20.88 ± 4.73cm.($P<0.002$) The mean SAD (knee flexed) value for control was 20.40 ± 2.46cm, diabetic was 22.31 ± 4.27cm, hypertensive was 22.48 ± 5.00cm. This difference was statistically significant $p<0.005$. The difference was significant among the males but not in females. (Table 8, 9, 10) In a study done by Ohrall M et al, SAD was found to be the strongest measure of cardiovascular and metabolic risk in men and women. SAD was the best correlate to hypertension. SAD has been proposed as an alternative of WC as a surrogate of body fat distribution. It is highly correlated with visceral fat and is significantly related to fasting glucose and insulin and other cardiovascular risk factors. (17) Nordhamn K et al concluded that SAD with bent legs showed the highest reliability. They recommended the use of SAD with bent legs as a cheap and accurate assessment of metabolic and cardiovascular risk. (18)

Sub Scapular Skin Fold Thickness

In the present study there was an increase though not significant difference in the sub scapular skin fold thickness among controls, diabetes and hypertensive (24.19±5.67 mm, 25.72±9.62mm, 24.50±4.25mm on right side, 23.90±5.66 mm, 25.28±9.59mm, and 24.47±4.31mm on left side), individuals was found. (Table 11, 12, 13)

Roberta et al in their study found that no skin fold was identified as an independent predictor of hypertension. (31) Masaharu K et al indicated that skin folds may reflect obesity risk in young population. While accuracy and precision 73

of skin fold measurements largely relates to the expertise of the individual, it is cheap, non-invasive, portable and a convenient method. (27)

Body Mass Index (BMI)

In the present study there was an increase in BMI among the study group though not significant. Mean BMI in controls were 23.29 ± 4.884, diabetics had BMI of 24.43±4.399 and hypertensive were 24.77±4.735. (Table 14) Various studies have demonstrated the unreliability of BMI for predicting body fat. They suggested that body weight is the sum of fat, muscle, visceral organs, and bone. So subjects with long trunks and short legs for height have higher BMIs regardless of their fat content. BMI is a commonly used indicator of obesity and has been associated with risk factors for CVD. However, a number of limitations with using BMI have been recognized, including the inability to account for wide variation in body fat distribution and failure to distinguish between the respective contributions of fat and muscle to body weight. Darren et al found WC to be a stronger predictor of cardio metabolic health when compared with BMI. (36)

CONCLUSIONS

WC, WHR and SAD were found to significantly higher in hypertensive and diabetics than in controls. Thus these anthropometric indicators can be used for identifying individuals with elevated risk to develop diabetes and hypertension.

They can also be used as markers to slow the progress of the disease after diagnosis. Greater SAD or WHR and WC is associated with increased CVD mortality. Thus maintaining a healthy weight and a healthy waist size are important to prevent abdominal obesity which is associated with diabetes and hypertension. 78

The ethnic origin of the population studied influences the predictive power of various anthropometric indices. Hence, population specific anthropometric indices are needed to identify subjects at risk for hypertension and type 2 diabetes. WC, WHR and SAD are simple, inexpensive anthropometric measurements

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