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Association of Anthropometric Indices of Obesity and Body Fat Composition with Diabetes Mellitus, Hypertension, and Dyslipidemia: A Case-control Study

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ABSTRACT

Introduction: Presently, obesity has evolved as a global epidemic, impacting both developed and developing nations with same intensity. It require serious attention from both public and clinicians.

Aim: To evaluate anthropometric indices as potential indicators of increased risk of Diabetes Mellitus (DM), hypertension, and dyslipidemia.

Materials and Methods: This case-control study, conducted between November 2012 to April 2014 at the General Medicine Department of a tertiary care teaching hospital in Sulia, Karnataka, India. A total of 200 patients of either gender, aged 30 to 90 years with either hypertension, or type 2 DM, or dyslipidemia, or obesity or any combinations of the above were recruited and grouped as cases. Another 200 apparently healthy volunteer were considered controls. Anthropometric indices, like height, weight, Body Mass Index (BMI), Waist Circumference (WC), Waist-to-Hip Ratio (WHR), Hip Circumference (HC), body and visceral fat percentage, and skin fold thickness were measured. Statistical tests like Shapiro-Wilk test, Chi-square test and Mann-Whitney test were applied using software R version 3.6.0.

Results: Out of total 200 patients, majority were males (52%) followed by females (48%). No significant difference was observed between study groups with respect to age (p-value=0.115). Among cases, 54 (27%) had only DM, 44 (22%) had only hypertension, whereas 102 (51%) had both DM and hypertension. Statistically, a significant difference was found between study groups with respect to distribution of BMI (p-value <0.0004), WC (p-value <0.001), WHR (p-value <0.001), body fat (p-value <0.001), visceral fat (p-value <0.0002), skin fold (p-value <0.001), glycaemic (p-value <0.001) and lipid profile (p-value <0.00001). Cases were 3.2 times more likely to have dyslipidemia than controls (OR: 3.2; CI: 2.1-4.9). With a unit increase in the body fat, visceral fat, Fasting Blood Sugar (FBS), triglycerides and BMI, odds of having hypertension or diabetes increases by a factor of 1.39, 1.16, 1.46, 1.03 and 0.67, respectively.

Conclusion: There was a strong significant association of anthropometric indices of obesity and body fat percentage with hypertension, diabetes, and dyslipidemia.

Keywords: Body mass index, Glycaemic profile, Karada scan, Risk factors, Visceral fat, Waist-hip ratio

INTRODUCTION

In recent times, obesity has evolved as a global epidemic, impacting both developed and developing nations with same intensity, India being no exception. According to report of National family health survey, 12.1% men and 14.8% women are obese in India [1]. Obesity is a chronic, complex condition associated with significant morbidity and mortality rate being most prevalent globally [2,3]. In this modern era, presence of physical inactivity and unbalanced dietary intake increases the adipose tissue energy stores which paves the way to multiple diseases [4,5].

Using simple, non invasive, anthropometric methods, diagnosing obesity as a possible predictor of dyslipidemia is expected to be helpful in efforts to prevent, diagnose early, and control both mortality and morbidity. Further, identifying the best anthropometric index in any population is essential to predict chronic disease risk factor and to facilitate enhanced screening for disease risk factors. Recent research also suggested that the higher incidence of hypertension and diabetes is associated with the dramatic increase in the prevalence of obesity [6,7]. Obesity can be defined by different anthropometric measurements and indices. However, previous studies on this remain controversial. Body Mass Index (BMI) is commonly used in many epidemiologic studies on obesity [8,9]. Some studies found statistical evidence that supports the superiority of measures of centralised obesity, such as Waist Circumference (WC), Waist-to-Hip Ratio (WHR), over BMI, for detecting cardiovascular risk factors in both men and women [7-9]. In a very recent study, from Japan proved that BMI and abdominal obesity were similarly associated with cardiovascular disease in middle-aged men [10].

It is proved that many metabolic risk factors, the validity and utility of the anthropometric indices in identifying risk factors tended to be similar to or better than those of the body composition indices, except for hypertension and hypercholesterolemia in men and hyperlipidemia and hypercholesterolemia in women [11]. To date, none of the studies in south India evaluated the association of anthropometric profile of obesity with diabetes, hypertension, and dyslipidemia. Thus, this study was intended to evaluate anthropometric indices as potential indicators of increased risk of Diabetes Mellitus (DM), hypertension, and dyslipidemia.

MATERIALS AND METHODS

This case-control study was conducted form November 2012 to April 2014 at the General Medicine Department of a tertiary care teaching hospital (KVG Medical College and Hospital) in Karnataka, India, after taking approval from the Institutional Ethics Committee (KVG Medical College and Hospital Sullia 2012).

Inclusion and Exclusion criteria: A total of 200 patients of either gender, aged 30 to 90 years who had either hypertension, or type

2 DM, or dyslipidemia, or obesity or any combinations of the above were recruited in the study and grouped as cases. Patients with surgical illnesses, ascites, critical illness with medical emergencies, and pregnancy were exempted from the study.

In addition, unmatched non diabetic and normotensive individuals of either gender were considered as control group (n=200) [12]. A written informed consent was obtained from all the study participants.

The data regarding socio-demographic variables and detailed medical history including obesity risk factor profile (tobacco addiction, and alcohol), hypertension, and DM were recorded in a predesigned proforma using routine clinical diagnostics questionnaire by well-trained doctoral/internship candidates. To obtain a more accurate findings, the traditional anthropometric indices, such as height, weight, BMI (normal range 18.5-24.9 kg/m^2), Waist Circumference (WC), Waist-to-Hip Ratio (WHR) (<0.9 for men; <0.8 female are normal), Hip Circumference (HC), body fat percentage, visceral fat percentage (0.5-9.5 normal), and skin fold thickness were measured. Laboratory parameters, such as Fasting Blood Sugar (FBS) (<100 mg/dL), Postprandial Blood Sugar (PPBS) (2 hrs 140 mg/dL), Total Cholesterol (TC) (<200 mg/dL), High Density Lipoprotein (HDL) (40-60 mg/dL), Low Density Lipoprotein (LDL) (<100 mg/dL), Triglycerides (TG) (<150 mg/dL), and Very Low Density Lipoprotein (VLDL) (3-30 mg/dL) were also recorded and evaluated between the study groups.

Height was measured to the nearest 0.5 cm by asking the study group to stand with heels, buttocks, and shoulders resting lightly against the wall so that the frankfurt plane is horizontal. Weight and BMI, body fat percentage, and visceral fat percentage were measured using karada scan. Waist circumference was measured as halfway between the lower border of the ribs and the iliac crest in a horizontal plane. HC is measured at the widest point over the buttocks. WHR was calculated by dividing the mean WC by mean HC. Skin fold thickness was taken in suprailiac region using skin fold calipers. Glycaemic profile (FBS and PPBS using glucose oxidase method) and lipid profile {TC (enzymatic end point method), HDL (Direct precipitation method), LDL and VLDL (Fridwald formula), and TG (glycerol 3 phosphate oxidase phenol aminophenazone method)} were determined and compared between the study groups [13-15].

STATISTICAL ANALYSIS

Statistical analysis was done using software R version 3.6.0. Normality of the data was determined using the Shapiro-Wilk test. Continuous variables with normal distribution were presented as mean±standard deviation and compared using paired t-test, whereas Chi-square test was employed for dichotomous data (Monte-Carlo's simulation). Mann-Whitney U test was performed for variables without a normal distribution. Categorical variables were presented as frequencies and percentages. Association of anthropometric indices with hypertension and diabetes were determined by odds ratios. In addition, logistic regression model using step-wise regression were also employed to check the association. A p-value of <0.05 was considered statistically significant at 95% confidence interval.

RESULTS

In the study, majority were males (208,52%) followed by females (192,48%) with overall mean age of 54.9±9.9 years. Statistically, no significant difference was observed between study groups with respect to age (p-value=0.115). Socio-demographic data of the study participants shown in [Table/Fig-1]. Among cases, 54 (27%) had only DM, 44 (22%) had only hypertension, whereas 102 (51%) had both DM and hypertension. Distribution of anthropometric indices of obesity between study groups are presented in [Table/Fig-2]. Statistically, a significant difference was found between study groups with respect to distribution of BMI (p-value <0.0004), WC (p-value <0.001), WHR (p-value<0.001), body fat (p-value <0.001), visceral fat (p-value <0.0002), skin fold (p-value <0.001), glycaemic (p<0.001) and lipid profile (p-value <0.00001) [Table/Fig-2,3]. Cases were 3.2 times more likely to have dyslipidemia than controls (OR: 3.2; CI: 2.1-4.9). [Table/Fig-3] shows the association between lipid and glycaemic profile and study groups. [Table/Fig-4] depicts an association of age, BMI, body fat, visceral fat, FBS, triglycerides with hypertension and diabetes by using logistic regression model using step-wise regression. With a unit increase in the body fat, visceral fat, FBS, TG and BMI, odds of having hypertension and diabetes increases by a factor of 1.39, 1.16, 1.46, 1.03 and 0.67, respectively. Area under curve was 0.979 [Table/Fig-5].

Variables	Sub-group	Case (%)	Control (%)	p-value
Age (in years)	30-40	11 (5.5)	18 (9)	0.009*
	41-50	55 (27.5)	55 (27.5)	
	51-60	75 (37.5)	67 (33.5)	
	61-70	48 (24)	60 (30)	
	71-80	8 (4)	0	
	81-90	3 (1.5)	0	
Gender	Female	100 (50)	92 (46)	0.423#
	Male	100 (50)	108 (54)	

[Table/Fig-1]: Socio-demographic details of the study groups.
*Monte-carlo's simulation used in chi-square test; #Chi-square analysis; p-value <0.05 was considered statistically significant

Variables	Sub-group	Case (n,%)	Control (n,%)	p-value
BMI	UW	2 (1)	0	0.0004*
	Normal	86 (43)	127 (63.5)	
	OW	74 (37)	62 (31)	
	Obese	38 (19)	11 (5.5)	
		Mean, interquarantile range	Mean, interquarantile range	
Waist circumference (cm)		96 (74, 181)	88 (66, 102)	<0.001**
WHR		0.97 (0.81, 104)	0.88 (0.82, 0.97)	<0.001**
Body fat%		36 (20, 49.2)	25 (17, 35)	<0.001**
Visceral fat%		16 (8.5, 40)	14 (9, 24)	0.0002**
Skin fold (cm)		28 (9, 110)	19 (9, 34)	<0.001**

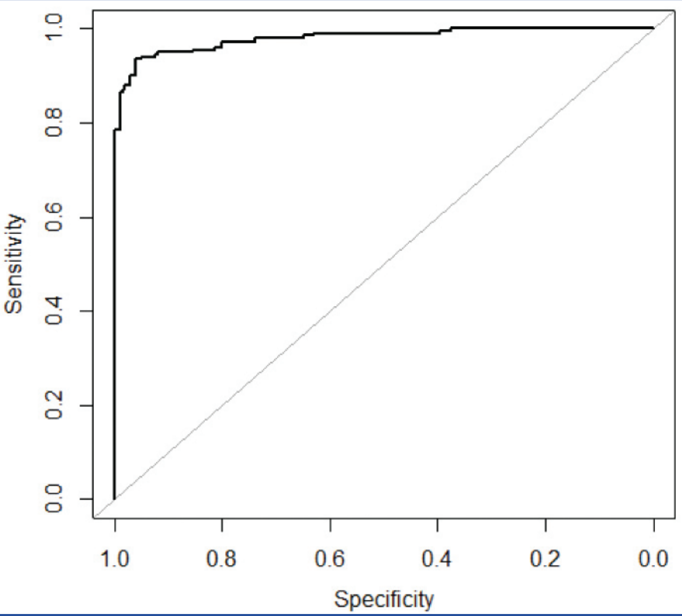
[Table/Fig-2]: Distribution of anthropometric indices of obesity between study groups.
*Monte-Carlo's simulation used in chi-square test; **Mann-whitney U test; BMI; Body mass index; WHR: Waist-to-hip ratio; UW: Underweight; OW: Overweight (Numbers in the parenthesis signifies either percentage or range); p-value <0.05 was considered statistically significant

Variables		Case (median, range)	Control (median, range)	p-value
FBS (mg/dL)		100 (80, 130)	80 (70, 94)	<0.001**
PPBS (mg/dL)		138.5 (124, 180)	124 (104, 140)	<0.001**
TC (mg/dL)		190 (134, 240)	150 (120, 250)	<0.001**
HDL (mg/dL)		36 (20, 66)	50 (26, 68)	0.001**
LDL (mg/dL)		190 (110, 290)	134 (100, 240)	<0.001**
TG (mg/dL)		200 (130, 260)	150 (120, 240)	<0.001**
VLDL		36 (14, 50)	28 (18, 44)	0.0002**
Dyslipidemia (n,%)	No	60 (30%)	116 (58%)	<0.00001*
	Yes	140 (70%)	84 (42%)	

[Table/Fig-3]: Distribution of glycaemic and lipid profiles between study groups.
*Monte-Carlo's simulation used in chi-square test; **MW: Mann-Whitney U test FBS: Fasting blood sugar; PPBS: Postprandial blood sugar; TC: Total cholesterol; HDL: High density lipoprotein, LDL: Low density lipoprotein; TG: Triglycerides; VLDL: Very low density lipoprotein; Numbers are presented in median. Numbers in the parenthesis signifies range; p-value <0.05 was considered statistically significant

Variables	Estimate	p-value	OR (CI)
Age	-0.003368	0.896	0.99 (0.9-1.05)
BMI	-0.400489	0.0007	0.67 (0.5-0.82)
Body fat	0.332999	<0.0001	1.39 (1.2-1.59)
Visceral fat	0.153357	0.045	1.16 (1.02-1.36)
FBS	0.383135	<0.0001	1.46 (1.3-1.64)
TG	0.030787	0.001	1.03 (1.01-1.05)

[Table/Fig-4]: Association of age, Body Mass Index (BMI), body fat, visceral fat, Fasting Blood Sugar (FBS), triglycerides with hypertension and diabetes using logistic regression model.
OR: Odds ratio; CI: Confidence interval; BMI: Body mass index; FBS: Fasting blood sugar; TG: Triglycerides; Chi-square test used to calculate p-value; p-value <0.05 was considered statistically significant



[Table/Fig-5]: Receiver Operator Characteristic (ROC) curve (Body mass index vs hypertension/diabetes).

DISCUSSION

In this case-control study, majority of the study participants were belonged to age group between 51 to 70 years. These findings are in concordance with many previous studies indicating that hypertension and diabetes are highly prevalent in the age group of 60-70 years. Statistically, a significant difference was found between study groups with respect to distribution of BMI (p-value <0.001). Phulpoto JA in their study observed that the mean BMI of male patients with diabetes was greater than control group, which is in accordance with the results found in the current study [16]. Brown CD et al., concluded that association of BMI with abnormal lipids was statistically significant after controlling the age, race, or ethnicity, education, and smoking [17]. Obese patients (BMI >97percentile) exhibits increased systolic (+6.3 mmHg) and diastolic B.P (+3.9 mmHg). Accordingly, Grober-gratgz D et al., proved that BMI is associated with hypertension [18].

In the present study, analysis of WC shows that, in males 78.8% who had WC >90 cm have diabetes, while 37.3% who have WC >90 cm were non Diabetic. In case of females 72.9% who had WC >80 cm had diabetes, while 44.9% who had WC >80 cm were non diabetic. Okosun IS et al., reported that substantial reduction in hypertension in men and women is achievable if the waist size get decreased [19]. Gröber-Grätz D et al., also concluded that WC was associated with dyslipidemia [18]. These findings were in accordance with the present study findings.

In the present study, a significant association was found between WHR and gender (males/females). Schmidt MI et al., found that centralised obesity measures, such as WHR was strongly and independently associated with non insulin dependent DM [20]. All these findings indicating that obesity assessed by WHR could be a better predictor of DM. Mohan V et al., concluded that increased WHR in females is significantly associated with dyslipidemia. Dyslipidemica had a mean visceral fat of 16.5% while non dyslipidemics had 9.2%. Research also indicated that visceral, but not subcutaneous component of abdominal fat is associated with insulin resistance, cardiovascular risk factors, and metabolic syndrome in non diabetic Asian Indians [21]. By considering all these findings including strengths of association and discrimination statistics suggested that WHR could be the best predictor of diabetes.

Limitation(s)

Though the present study provided association of anthropometric parameters with metabolic disorders, it was limited to a single center. The study with follow-up and study with different generation in the same family might help to assess the cause factors for increase metabolic disorder cases over the period of time. Further, it provides scope for policymakers to go different for multicenter study with larger samples size. As study deals with the previously diagnosed cases of diabetes and also many patients extra test was not affordable because of low economic status, so HbA1c was not done.

CONCLUSION(S)

There was a strong significant association of anthropometric indices of obesity and body fat composition with hypertension, diabetes, and dyslipidemia. In summary, there are age and gender differences in the association between anthropometric indices of obesity and hypertension and diabetes in south Indians. This study finding indicate a need to develop gender-specific strategies for the male and females in the primary and secondary prevention of hypertension and diabetes.

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