IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 9 Ser.11 (September. 2019), PP 01-06
www.iosrjournals.org

A Comparative Study of Anthropometric Measurements in Relation to Lipid Profile in Overweight and Obese Individuals.

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Abstract: *The surge in obesity prevalence is a threat to health and economy. South Asians have been recommended lower cut-off values of Body Mass Index (BMI). The study aimed to evaluate the effect of overweight and obesity on lipid profile parameters and the association between anthropometric measurements and lipid profile parameters. This cross-sectional study comprised of 164 healthy asymptomatic individuals whose socio-demographic data, measurements of heart rate (HR) and blood pressure (BP), anthropometric measurements and estimation of lipid profile were obtained. Categorical variables were analysed by Chi-square test. The mean values of various anthropometric measurements and lipid profile parameters among different BMI groups were analysed with one-way ANOVA with post-hoc test (95% Confidence interval). Estimation of Pearson's correlation coefficient measured the strength of linear relationship between anthropometric measurements and lipid profile parameters. P-value <0.05 was accepted for statistical significance. Overweight and obesity were seen in 25.61% and 20.73%participants respectively. Obese had statistically significant higher HR, systolicand diastolic BP than normal and overweight participants. Amongst the overweight, total cholesterol (TC), triglycerides (TG) and low-density lipoproteins (LDL) was increased in 9.52%, 14.28% and 11.90% respectively. Raised TC, TG and LDL were present in 66.67%, 73.53% and 69.05% obese individuals respectively. Lower high-density lipoprotein (HDL) was present in 16.67% and 71.43% of overweight and obese individuals respectively. BMI, waist circumference (WC) and waist-to-height ratio (WHtR) showed positive linear relationship with all lipid profile parameters except HDL which showed negative correlation. In either gender, WHtR showed more better correlation with lipid profile parameters as compared to BMI and WC. Thus, the study showed significant association of obesity with sympathetic overactivity and atherogenic lipid profile. WHtR proved to be superior than BMI and WC for predicting dyslipidemia.*

Keywords: *Body Mass Index, Waist-to-height ratio, obesity, overweight, lipid profile*

Date of Submission:07-09-2019 Date of Acceptance: 23-09-2019

I. Introduction

At present, India is witnessening unabated surge in obesity pandemic attributed to health-compromising lifestyle Obesity is defined as abnormal or excessive fat accumulation that mounts a risk to health. It can have a major influence on economy, productivity, population fitness and quality of life. In 2015, the prevalence rate of overweight and obesity in India varied from 16.9–36.3% and 11.8–31.3% respectively[1]. For any given Body Mass Index (BMI) value, large inter-individual variations in percentage body fat are seen, attributed to age, sex and ethinicity. At the same BMI, Asian populations had 3–5% higher percentages of body fat than the European population[2]. Hence, World Health Organization (WHO)has recommended lower cut-off values of BMI for South Asians[3]. Measurement of waist circumference (WC) is a surrogate for abdominal fatness[4]. WC and Waist-to-height ratio (WHtR) are better indicators for obesity-related health risk as compared to traditional measurements like weight and BMI[5].

The adipose tissue is no longer just a repository of fat, but highly dynamic paracrine and endocrine organ that can affect body weight homeostasis, insulin sensitivity, lipid profile, inflammation and even symapthetic nervous system (SNS) activity[6,7,8]. The heterogeneity of adipogenic capacity is influenced not only by its size, distribution and metabolism, but also by the genetic, environmental and neuroendocrinal factors. Intraabdominal adipoctyes exhibits a greater lipolytic response than other anatomic depots, resulting in increased release of free fatty acids (FFAs), adipokines, cytokines and proinflammatory molecules into the portal circulation[9]. These may mitigatedevelopment of an atherogenic lipid profile and insulin resistance that predisposes to a myraid of medical conditions[10]. The purpose of the study was to evaluate the effect of overweight and obesity on the lipid profile parameters in young healthy individuals and to determine the association of various anthropometric measurements like BMI, WC and WHtR with lipid profile parameters.

II. Materials and methods

This study was carried on healthy asymptomatic individuals who underwent initial screening for the inclusion into the study. The study was initiated after obtaining the approval from the Institutional Ethical Committee.
Study design: Cross-sectional, Observational study.
Study Location: Rangaraya Medical College, Kaninada, Andhra Pradesh.
Study Duration: Feb 2019 to May 2019
Sample size: 164
Sample size calculation: Based on National Family Health Survey (NFHS) 2015-16, the prevalance of obesity in India varied from 11.8% to 31.3% [1]. With the 95% confidence interval and 5% margin of error, the minimum sample size for the study was 160 which was calculated using the following formula,

$$\text{Sample size} = \frac{Z_{1-\alpha/2}{}^2 p(1-p)}{d^2}$$

Where *'Z'* is standard normal variate, *'d'* is the absolute error or precision and *'p'* is the estimated proportion in population depending on previous studies. For our present study, $Z = 1.96$ [at 5% type I error (P-value < 0.05)], c = 0.05, $p = 0.118$ [1].

Inclusion criteria:
1. Healthy asymptomatic individuals
2. Age ≥25 years and ≤45 years.
3. BMI ≥18.5 kg/m^2

Exclusion Criteria:
1. Age <25 years and >45 years
2. BMI<18.5 kg/m^2
3. Presence of cardiovascular diseases, diabetes mellitus, thyroid diseases, psychiatric diseases, inflammatory diseases (eg: rhuematoid arthritis, hepatitis, etc), familial dyslipidemia, autoimmune diseases, genetic disorders, polycystic ovarian disease
4. Individual on hormonal replacement therapy, treatment with corticosteroids or any medication that can affect weight and /or body composition.
5. Individuals with habits of smoking or alcohol consumption or drug abuse.
6. Pregnancy or lactation

Procedure methodology

The participation in the study was voluntary. The informed written consent was obtained from the participants and confidentiality was assured. No incentive or rewards were offered for the participation in the study. The participants were subjected for face-to-face interview, clinical examination and anthropometric measurements. The socio-demographic data included age, gender, marital status, educational qualification, medical history, drug history, family history and history of substance abuse.

After 10 min of physical and mental rest, Heart Rate (HR) and Blood pressure (BP) were measured in sitting position. Using mercury sphygmomanometer, BP was recorded as per standard protocols. BP recordings were obtained thrice with 2 min rest intervals and the average was taken as the final reading[11].

Standing barefoot, height of the subject was measured by standiometer to the nearest 0.5cm. The weight was measured using digital weighing machine to the nearest 0.1kg with minimal clothes. BMI was calculated using Quetelet's index and was expressed in kg/m^2. WC was measured in standing position with a measuring tape (unstretchable) with accuracy of ± 0.5 cm midway between lowest costal margin and superior iliac crest with breathing normally. WHtR was calculated as WC (in cm) divided by height (in cm). Irrespective of age and sex, the WHtR values below 0.5 are accepted as normal[12]. All anthropometric measurements were taken in triplicates by the same investigator. The mean of the values was calculated and considered as the final reading. The classification of obesity, as recommended by Asia-Pacific Task Force, was adapted for the study[3]. So, the participants were dichotomized into 3 groups: normal(BMI between 18.5 – 22.9 kg/m^2); overweight (BMI between 23 – 24.99 kg/m^2) and obese (BMI >25 kg/m^2).

For biochemical studies, 12 hours of fasting was requested prior to blood sampling. A venous blood sample was drawn with the subject in the sitting position under all aspetic precautions, with the limited use of tourniquet. The sample was processed on the same day of the blood collection. Enzymatic colorimetric methods were used to quantify parameters of lipid profile namely, total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), very low-density lipoprotein cholesterol (VLDL). All the cutoff value for each parameter was adapted as per guidelines of American College of Cardiology and AmericanHeart Association Task Force [13,14].

Statictical analysis

The data was organized into Microsoft Excel worksheet and SPSS-version-22 was utilized for statistical calculations. Categorical variables were computed as frequency and proportions and were analysed by Chi-square test. Continous variables were expressed as Mean ± Standard Deviation (SD). One-way ANOVA with *post-hoc* test (95% Confidence interval) was utilised to test for significance in mean values of various anthropometric measurements and lipid profile parameters among different BMI groups. Pearson's correlation coefficient was estimated to measure the strength of linear relationship between anthropometric measurements and lipid profile parameters. P-value <0.05 was accepted for statistical significance.

III. Results

For the study, 219 individuals volunteered and underwent initial screening.55 were excludeddue to various reasons as shown in Figure no1.So, the final study comprised of data from remaining 164 participants.

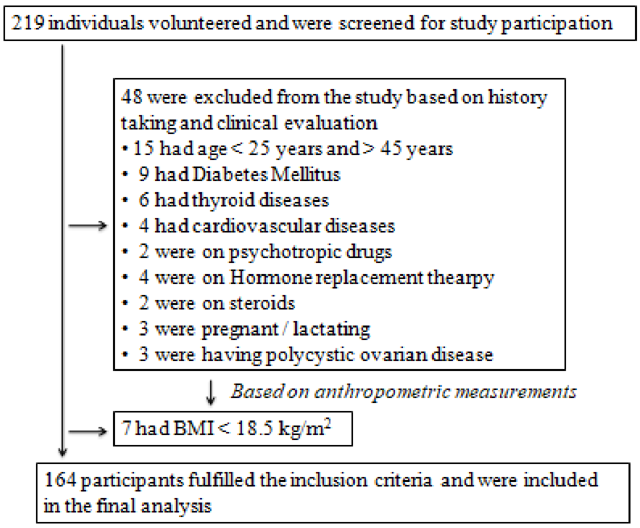

Figure no 1: Flowchart of the present study showing recriutment of participants

Females constituted 56.09% (N=92) of the participants. Within range of 25-45 years, the mean age of the participants was 34.72±4.89 years. Overweight was seen in 25.61% (N=42) participants [males (10.98%) vs. females (14.63%)]. 34(20.73%) participants were obese [males (8.53%) vs. females (12.20%)]. Only 53.66% participants had normal BMI. Obese had statistically significant higher HR, SBP and DBP than normal and overweight participants (Table no 1).

Table no 1: Anthropometric measurements and lipid profile parameters of the study population

Variable	Normal	Overweight	Obese	P-value [#]
Female N (%)	48 (54.54%)	24 (57.14%)	20 (58.82%)	-
Age (in years)	33.96 ± 6.12	34.6 ± 3.8	33.48 ±4.6	0.6506
Height (cm)	160.54 ± 5.21	161.91 ±6.16	159.63 ± 6.69	0.2192
Weight (kg)	57 ± 4.53	61.88 ± 4.72 [a]	80.56 ± 8.6 [a, b]	<0.0001 [*]
BMI (kg/m^2)	22.01 ± 0.85	23.57 ± 0.35 [a]	33.51 ± 4.09 [a, b]	<0.0001 [*]
SBP (mm Hg)	116.32 ± 5.33	119.92 ± 4.27 [a]	132 ± 10.88 [a, b]	<0.0001 [*]
DBP (mm Hg)	70.46 ± 5.54	73.52 ± 5.90 [a]	86.04 ± 9.44 [a, b]	<0.0001 [*]
HR (beats/min)	68.35 ± 7.64	71.41 ± 9.53	84.26 ± 11.76 [a, b]	<0.0001 [*]
WC (cm)	74.68 ± 4.89	75.44 ± 4.83	82.92 ± 5.83 [a, b]	<0.0001 [*]
WHtR	0.46 ± 0.03	0.47 ± 0.03	0.52 ± 0.04 [a, b]	<0.0001 [*]
TC (mg/dL)	117.42 ± 18.52	122.86 ± 21.62	187.4 ± 35.54 [a, b]	<0.0001 [*]
TG (mg/dL)	91.86 ± 19.37	103.68 ± 31.63	164.84 ± 68.72 [a, b]	<0.0001 [*]
HDL (mg/dL)	43.36 ± 4.64	39.7 ± 3.28 [a]	36.24 ± 2.58 [a, b]	<0.0001 [*]
LDL (mg/dL)	62.68 ± 8.79	64.74 ± 5.96	89 ± 27.3 [a, b]	<0.0001 [*]
VLDL (mg/dL)	25.28 ± 2.8	25.72 ± 2.64	40.4 ± 9.76 [a, b]	<0.0001 [*]
TC/ HDL ratio	2.73 ± 0.53	3.1 ± 0.35 [a]	4.76 ± 1.14 [a, b]	<0.0001 [*]

'a' – Statistically significant when compared to group A in *post-hoc* test p < 0.05.
'b' – Statistically significant when compared to group B in *post-hoc* test p < 0.05.
– p-value is calculated using one-way ANOVA with *post-hoc* test
*- p-value <0.05, statistically significant
BMI – Body Mass Index
SBP – Systolic Blood Pressure
DBP – Diastolic Blood Pressure
HR – Heart Rate
WC – Waist Circumference
WHtR – Waist-to-Height Ratio
TC – Total cholesterol
TG – Triglycerides
HDL – High Density Lipoprotein
LDL – Low Density Lipoprotein
VLDL – Very Low-Density Lipoprotein

WC and WHtR was significantly higher among obese. The alterations of lipid profile parameters depending on BMI categories are shown in Table no 2. TC (≥200mg/dL), TG (≥150mg/dL) and LDL (≥100mg/dL) were presentin 66.67%, 73.53% and 69.05% respectively of obese individuals. Amongst the overweight, TC, TG and LDL was increased in 9.52%, 14.28% and 11.90% respectively. HDL (≤ 40mg/dL) was present in 16.67% and 71.43% of overweight and obese individuals respectively. All the parameters of lipid profile except HDL were statistically significantly raised in obese as compared to normal and overweight participants. HDL was significantly reduced in both overweight and obese as compared to normal. TC/HDL ratio (>3.5) was present in 14.28% and 71.43% of overweight and obese respectively and was significantly higher than normal ones.

Table no 2: Proportion of altered lipid profile as per BMI categories

Variable	Normal	Overweight	Obese	P-value $^{\#}$
TC ≥ 200mg/dL	1.33%	9.52%	66.67%	<0.0001*
TG ≥150mg/dL	2.27%	14.28%	73.53%	<0.0001*
HDL ≤ 40mg/dL	3.41%	16.67%	71.43%	<0.0001*
LDL ≥100mg/dL	2.27%	11.90%	69.05%	<0.0001*
TC/ HDL ratio >3.5	1.33%	14.28%	71.43%	<0.0001*

– p-value is calculated using Chi-square test
*- p-value <0.05, statistically significant
TC – Total cholesterol
TG – Triglycerides
HDL – High Density Lipoprotein
LDL – Low Density Lipoprotein

The relationship between different lipid profile parameters to various anthropometric measurements in terms of direction and strength of association is summarized in Table no3. Statistically significant positive linear relationship was observed between anthropometric measurements and all lipid profile parameters among males and females except HDL which showed strong negative corelation with BMI, WC and WHtR. As compared to males, females had higher correlation coefficient values of lipid profile parameters with BMI, WC andWHtR. In either gender, WHtR showed more better association with lipid profile parameters as compared to BMI and WC.

Table no 3: Estimation of Pearson Coefficient Correlation 'r' between anthropometric measurements and lipid profile parameters of the study population

	Men			Women		
	BMI	WC	WHtR	BMI	WC	WHtR
TC	0.4217*	0.5047**	0.5831**	0.4324*	0.5672**	0.6675**
TG	0.4517*	0.5586**	0.6118**	0.4760**	0.6234**	0.6859**
LDL	0.4375**	0.5202**	0.5391**	0.4711**	0.5770**	0.5932**
HDL	– 0.4132*	– 0.5294**	– 0.5563**	– 0.4876**	– 0.5411**	– 0.5929**
TC / HDL	0.4895**	0.6006**	0.6056**	0.4823**	0.5784**	0.6175**

BMI – Body Mass Index
WC – Waist Circumference
WHtR – Waist-to-Height Ratio
TC – Total cholesterol
TG – Triglycerides
LDL – Low Density Lipoprotein
HDL – High Density Lipoprotein
* – p <0.05, statistically significant

** – p <0.001, statistically very significant

IV. Discussion

Obesity is emerging as a huge epidemiological challenge due to its associated burden of non-communicable diseases[9,10]. As per the guidelines of Asia-Pacific Obesity Task Force, the present study showed 25.61% and 20.73 % of the participants were overweight and obese respectively. These findings wereconsistent with the data of NFHS2015-16 [1]. Also, Luhar S*et al.* had observed increasing trend of overweight/obesity among Indians using national representative data of duration between 1998 to 2016 [15].

Higher prevalence of overweight and obesity was observed among women in our present study, similiar to the findings by Ahirwar R and his collegues in their systematic review based on studies of past 20 years[16]. Reasons could be increasing participation in employment, declining physical activity due to household machineries, stress and vulnerability to unhealthy obesogenic lifestyle like consumption of energy-dense foods, more screen time, etc. Also, parity contributes to significant weight gain due to care and diet given during and after pregnancy.

In the present study, obese participants had statistically significant higher HR, SBP and DBP as compared to normal weight and overweight ones, suggestive of sympathetic overdrive. Higher cerebral nuclei cause direct post-prandial physiological activation of sympathetic nervous system (SNS) to maintain adequate splanchnic circulation and facultative thermogenesis. Obesity potentiates sympathetic stimulation and disruption of hypothalamic insulin-signalling through various neurohumoral pathways. Hyperinsulinemia and visceral fat act as a major driver for muscle SNS activity by increasing circulating norepinephrine levels and release of adipokines respectively, which translate as sympathetic dysregulation and reduced baroreflex sensitivity causing hyperkinetic circulation and increased peripheral resistance[7]. These account for development of obesity-induced hypertension. Also, chronic SNS overactivity may blunt sympathetic-mediated thermogenesis contributing to further weight gain[6].

In the present study, abnormal lipid profile was seen in almost 9-16% of overweight and 66-73% of the obese participants. TC, TG, LDL and TC/HDL ratio were statistically significantly higher among the obese group as compared to other groups and showed strong positive association with BMI, WC and WHtR similiar to findings by Gayathri B. *et al* among South Indian adults[17]. Pathological adipocyte hyperplasia and hypertrophy with limited angiogenesis initiates a series of events which includes hypoxia, cell death, increased chemokine secretion. These create a permissive environment for macrophage-orchestrated inflammatory response leading to development of adipocyte insulin resistance and release of FFAs[8]. Thus, visceral fat acts a potentiator in lipotoxicity-induced metabolic syndrome either because of its restricted capacity to handle increasing triglyceride load or its preferential release of deleterious cytokines.

The present study showed significantly lower HDL values in overweight and obese individuals, as compared to normal individuals. Also, HDL showed strong negative correlation with anthropometric measurements. These were suggestive that mild changes in body composition &/ weight can influence the plasma HDL levels. Reduced HDL in obese has been attributed to enhanced fractional clearance of HDL, reduced production of apolipoprotein A-1 and elevated concentrations of inflammatory cytokines[18]. The consellation of hypertriglyceridemia, high LDL and VLDL levels, low HDL levels and inflammatory cytokines can effectuate endothelial dysfunction and development of an atherosclerotic lesion[14,19].

The present study revealed significantly better association of WHtR with the lipid profile parameters in both genders as compared to BMI and WC. This was suggestive that WHtR was a better anthropometric tool for determining abdominal obesity and evaluating obesity-related cardiometabolic risks similiar to findings in a study in South Asian adults by Jayawardhana R *et al.*[5]. Also, Ashwell M *et al*. had proposed to maintain the waist circumference below half the height as a mass preventive measure for obesity-related morbidy and mortality[20].

Stabilization of the obesity prevalence is the need of the hour that demands deliberate initiation, formulation and implementation of policies aimed towards patient, clinician and healthcare system. The strategies should address awarenessabout compounding health threats due to obesity and promotion of healthy dietary practices and physical activity to achieve and maintain healthy weight among individuals. Screening, early diagnosis and treatment of dyslipidemia is of paramount importance[14], especially in visceral obesity. Even, overweight individuals with presence of risk factors should be targetedfor medically significant and therapeutic interventions to reduce premature cardiovascular event [12].

There arelimitations of the study. It was cross-sectional in nature. The body composition analysis was not done to describe the exact body fat distribution and establish a causative relationship between heterogeneity of adipose tissue and lipid profile.

V. Conclusions

The study showed that obesity was significantly associated withsympathetic overactivity andatherogenic lipid profile (higher values of TC, TG, LDL, TC/HDL ratio and lower HDL). Dyslipidemia was present in almost 9-16% of overweight and 66-73% of the obese participants. Among the anthropomeric measurements, WHtR proved to be superior than BMI and WC for predicting dyslipidemia.

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