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Original Article

Association of Lipid Profile, Body Mass Index, and Waist Circumference as Cardiovascular Risk Factors for Obese Male Adults of North India

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Abstract

Background: Obesity is one of the most important modifiable risk factors in the pathogenesis of cardiovascular disorders such as atherosclerosis hypertension and type-2 diabetes mellitus. The aim of the study was to evaluate the association of obesity, plasma lipid profile, and atherogenic indices as markers for cardiovascular diseases (CVD) among North Indian population.

Method: A cross-sectional study in a randomly selected sample was conducted in 70 subjects 18-58 years of age. Anthropometric measurements, including body weight, height, waist circumference (WC), and body mass index (BMI) were calculated. The subjects were divided into 4 groups in two categories. Group A (BMI< 25 kg/m^2) and Group B (BMI >25 kg/m^2), Group C (WC< 90 cm) and Group D (WC >90 cm). Total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), Low-density lipoprotein-cholesterol (LDL-C), and triglycerides (TG) were measured, and atherogenic index (AI) was calculated.

Results: Group B had significantly higher BMI when compared with Group A (P <0.0001). Group B had a nonsignificantly increased risk of high TC (P = 0.27), TG (P = 0.08) and significant increased risk of high (LDL) (P <0.01), AI (P <0.001), and low HDL-C (P < 0.001) compared with Group A. Group D had significantly higher WC when compared with Group C (P < 0.0001). Group D had a nonsignificantly increased risk of high TC (P = 0.86), LDL-C (P = 0.41) and significantly increased TG (P < 0.05), AI (P < 0.05), and low HDL-C (P < 0.01). The partial correlation coefficient for the cardiovascular risk marker of BMI indicated a positive significant association with TC (R = 0.345, P =0.003), TG (R = 0.223, P = 0.06) and LDL-C (R = 0.342, P = 0.003), AI (R = 0.46, P <0.001), and negative with HDL-C (R = -0.381, P = 0.001). For WC indicated a positive significant association with TC (R = 0.205, P = 0.096), TG (R = 0.283, P = 0.018), and LDL-C (R = 0.16, P = 0.185), AI (R = 0.29, P = 0.014), and negative with HDL-C (R = −0.301, P = 0.011). Obesity significantly increased the risk of atherosclerosis (assessed by AI).

Conclusion: Obese people screened by the World Health Organization reference values are at increased risk of CVD in adults.

Key words: Body mass index, Cardiovascular risks, Lipid profile, Obesity, Waist circumference

INTRODUCTION

Cardiovascular diseases (CVD); the leading cause of morbidity and mortality in the western world, are now emerging public health challenges in developing countries,[1] accounting for 80% of deaths and 87% of related disability currently recorded in the low-and middle-income countries.

In India, CVD accounts for 31.7% of total deaths. In developing countries, mortality due to CVD is expected to rise to 19 million by 2020.[2]

In the Indian subcontinent, CVD manifests itself almost 10 years earlier on an average compared with the rest of the world, in western countries, CVD accounts for only 23% of the CVD deaths occurring below the age of 70

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compared to 52% of CVD deaths below the age of 70 in India.[3] The association between dyslipidemia, obesity, and hypertension is well established and all have been found to be major risk factors for the development of CVD, a leading cause of visits to physicians and cause of death.[4-6]

Blood cholesterol has long been recognized as a major independent risk factor for CVD in adults. More recently, the level of triglycerides (TG) has been incriminated as a CVD risk factor independent of cholesterol.[7]

However, obese individuals differ not only in the amount of excess fat that they store but also in the regional distribution of the fat within the body. In adults, intra-abdominal adipose tissue is the most clinically relevant type of body fat, apart from total body fat.

Some studies have shown that waist circumference (WC) may be a better predictor of CVD than body mass index (BMI) and waist-hip ratio.[8] A population is viewed as much vulnerable to dyslipidemia and other cardiovascular risk factors due to the western lifestyle, such as alcohol consumption, cigarette smoking, sedentary life, and consumption of diet with high fat contents, all of which are associated with abnormal lipid metabolism. Therefore, this study was designed to investigate the association of obesity, plasma lipid profile, and atherogenic indices as markers for CVD among North Indian population.

MATERIALS AND METHODS

This study was conducted on a total of 70 men (aged 18-58 years), including both the students of M B B S and Faculty Members in the Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun for lipid profile. The subjects were briefed about the study, and their consent was taken.

Subjects with the history of diabetes mellitus, hypertension, coronary heart disease, and endocrinopathy or subjects taking any lipid-altering medicine were excluded from the study.

Anthropometric measurements such as height, weight and WC of each subject were recorded, and BMI was calculated. A fasting venous blood sample was drawn from each subject for lipid profile.

The subjects were divided into 4 groups in two categories based on BMI and WC cut-off points.

Groups Based on BMI Cut off Points

- Group A, it consists of 37 with their BMI <25 kg/m^2
- Group B, it consists of 33 subjects with their BMI >25 kg/m^2

Groups Based on WC Cut off Points

- Group C, it consists of 51 subjects with their WC <90 cm
- Group D, it consists of 19 subjects with their WC >90 cm

This study was conducted with the aim of comparing lipid profile and atherogenic index (AI) in normal weight, and obese subjects according to their BMIs and WC as markers for CVD.

Anthropometric Measurements

Weight

It was measured in kilograms (kg) to the nearest 0.5 kg on a portable weighing scale with the subject in light clothing and without shoes.

Height

It was measured in centimeters (cm) to the nearest 0.1 cm with the subject standing against the vertical wall with no shoes, heels together and heels buttocks, shoulders, and head touching the vertical wall surface.

BMI

It was calculated using the formula:

Weight (kg)/Height (m^2).

WC

It was measured in centimeters (cm) to the nearest 0.1 cm, at the level of umbilicus, at the end of expiration with person breathing silently, and using a flexible plastic tape.

Biochemical Parameters

A morning venous blood sample after an overnight fast (10-12 h) was drawn at each clinic unit. The blood samples were placed on ice until separation within 2 h. The samples were centrifuged at 2000 g for 5 min, after which plasma was isolated into dry plain plastic screw-capped containers and stored frozen −20°C before analyses. Plasma total cholesterol (TC) and TG concentrations were determined by enzymatic colorimetric assay as described above and modified by Richmond, and high-density lipoprotein-cholesterol (HDL-C), and low-density lipoprotein-cholesterol (LDL-C) were determined enzymatically after precipitation of other lipoproteins as described by Burstein *et al.* and Assmann *et al.*, respectively, using kits from Biosystem laboratories.[9-12] All samples were analyzed in duplicates, after which the mean was determined. AI was calculated for individual subjects by the equation:

AI = [(TC - HDL-C)/HDL-C].[13]

Cut-off Values

The World Health Organization reference values were adopted for classification of obesity.[14] Abdominal obesity was defined as having a WC 90th percentile for age and gender.[15] The cutoff values from the national cholesterol education program lipid assessments were adopted.[16] Abnormalities in lipid levels have traditionally been defined as concentrations 95th percentile for TC, TG, and LDL-C, whereas low HDL-C concentrations have traditionally been defined as, 5th percentile. All samples were analyzed in duplicates, after which the mean was determined.

The normal values of lipid profile used in our study are:

- TC: <200 mg/dl
- TG: <150 mg/dl
- LDL: <130 mg/dl
- HDL: >40 mg/dl

Statistical Analysis

The significance between the standard errors of means of different sets of observation was assessed by applying student's - *t*-test and 95% level of confidence ($P < 0.05$). Pearson's correlation coefficient was calculated between the anthropometric measurements (BMI and WC) and lipid profile (TC, TG, LDL-C, AI, and HDL-C).

OBSERVATIONS AND RESULTS

The subjects included in this study were divided into 4 groups in two categories based on BMI and WC cut-off points.

Group A - age group 18-58 years (mean 31.05 + 10.63 years) with BMI< 25 kg/m^2 (mean 21.41 ± 1.87 kg/m^2), Group B - age group 18-58 years (mean 33.55 ± 12.96 years) with BMI> 25 kg/m^2 (mean 27.69 ± 1.97 kg/m^2), Group C - age group 18-58 years (mean 31.37 ± 11.5 years) with WC <90 cm (mean 80.23 ± 5.24 cm), and Group D - age group 19-58 years (mean 34.53 ± 13.30 years) with WC >90 cm (mean 96.44 ± 5.39 cm).

Comparison of Lipid Profile According to BMI

TC

In Group A, it ranged from 96 to 220 mg/dl with mean of 146.73 ± 33.96 mg/dl (mean±standard deviation [SD]). In Group B, it ranged from 120 to 216 mg/dl with mean of 155.30 ± 30.3 mg/dl (mean±SD). It was statistically not significantly increased in Group B when compared with Group A ($P > 0.05$, Table 1).

TG

In Group A, it ranged from 90 to 350 mg/dl with mean of 133.89 ± 50.56 mg/dl (mean±SD). In Group B, it ranged from 82 to 349 mg/dl with mean of 158.30 ± 63.26 mg/dl (mean±SD). It was statistically not significantly increased in Group B when compared with Group A ($P > 0.05$, Table 1).

Table 1: Parameters based on BMI

Variables	Nonobese (Group A) *n*=37	Obese (Group B) *n*=33	*P*
Age (years)	31.05±10.63	33.55±12.96	0.38
BMI (kg/m^2)	21.41±1.87	27.69±1.97	<0.0001*
TC (mg/dl)	146.73±33.96	155.30±30.37	0.27
TG (mg/dl)	133.89±50.56	158.30±63.26	0.08
LDL-C (mg/dl)	72.15±36.39	94.27±18.46	0.0019*
AI	2.17±1.07	3.11±0.721	0.0001
HDL-C (mg/dl)	47.76±8.35	41.33±5.63	0.00031*

BMI: Body mass index, TC: Total cholesterol, TG: Triglycerides, LDL-C: Low-density lipoprotein-cholesterol, AI: Atherogenic index, HDL-C: High-density lipoprotein-cholesterol. Data are presented as the mean±standard deviation. *P<0.05, statistically significant when compared with nonobese or obese

LDL-C

In Group A, it ranged from 13 to 158 mg/dl with mean of 72.15 ± 36.39 mg/dl (mean±SD). In Group B, it ranged from 43.4 to 121 mg/dl with mean of 94.27 ± 18.46 mg/dl (mean±SD). It was statistically highly significantly increased in Group B when compared with Group A ($P < 0.01$, Table 1).

HDL-C

In Group A, it ranged from 31 to 67 mg/dl with mean of 47.76 ± 8.35 mg/dl (mean±SD) In Group B, it ranged from 32 to 57 mg/dl with mean of 41.33 ± 5.63 mg/dl (mean±SD). It was statistically highly significantly decreased in Group B when compared with Group A ($P < 0.01$, Table 1).

AI

In Group A, it ranged from 0.81 to 5.18 mg/dl with mean of 2.17 ± 1.06 (mean±SD). In Group B, it ranged from 1.79 to 5.55 with mean of 3.11 ± 0.72 (mean±SD). It was statistically highly significant increased while compared Group A with Group B ($P < 0.01$) (Table 1).

Comparison of Lipid Profile According to WC

TC

In Group C, it ranged from 96 to 220 mg/dl with mean of 153.98 ± 31.73 mg/dl (mean±SD). In Group D, it ranged from 114 to 210 mg/dl with mean of 155.37 ± 29.54 mg/dl (mean±SD). It was increased in Group D while compared with Group C, but the difference was not statistically significant ($P > 0.05$, Table 2).

TG

In Group C, it ranged from 82 to 350 mg/dl with mean of 136.76 ± 54.94 mg/dl (mean±SD). In Group D, it ranged from 90 to 284 mg/dl with mean of 169.10 ± 60.23 mg/dl (mean±SD). It was increased in Group D while compared with Group C and the difference was statistically significant ($P < 0.05$, Table 2).

LDL-C

In Group C, it ranged from 13 to 158 mg/dl with mean of 80.14 ± 34.06 mg/dl (mean±SD). In Group D, it ranged from 43.4 to 120 mg/dl with mean of 85.93 ± 22.33 mg/dl (mean±SD). It was increased in Group D while compared with Group C but the difference was not statistically significant ($P > 0.05$, Table 2).

HDL-C

In Group C, it ranged from 31 to 67 mg/dl with mean of 46.39 ± 8.15 mg/dl (mean±SD). In Group D, it ranged from 32 to 48 mg/dl with mean of 40.26 ± 4.72 mg/dl (mean±SD). It was statistically highly significantly decreased in Group D while compared with Group C ($P < 0.01$, Table 2).

AI

In Group C, it ranged from 0.81 to 5.55 l with mean of 2.17 ± 1.06 (mean±SD). In Group D, it ranged from 0.81 to 4.52 l with mean of 3.11 ± 0.72 (mean±SD). It was statistically significantly increased in Group D while compared with Group C ($P < 0.05$, Table 2).

Correlation of BMI and WC with Lipid Profile

BMI was positively correlated with TC (R = 0.34), TG (R = 0.22) LDL-C (R = 0.34), and AI (R = 0.46). The correlation was found to be statistically highly significant with TC ($P < 0.01$). LDL-C ($P < 0.01$) AI ($P < 0.001$), and statistically nonsignificant with TG ($P > 0.05$) (Table 3).

BMI was negatively correlated with HDL-C (R = −0.39). The correlation was found to be statistically highly significant ($P < 0.01$) (Table 3).

Table 2: Parameters based on WC

Variables	Nonobese (Group C)	Obese (Group D)	*P*
Age (years)	31.37±11.15	34.53±13.30	0.32
WC (cm)	80.23±5.24	96.44±5.39	<0.0001*
TC (mg/dl)	153.98±31.73	155.37±29.54	0.86
TG (mg/dl)	136.76±54.94	169.10±60.23	0.039*
LDL-C (mg/dl)	80.14±34.06	85.93±22.33	0.41
AI	2.46±1.04	3.03±0.91	0.03*
HDL-C (mg/dl)	46.39±8.15	40.26±4.72	0.003*

TC: Total cholesterol, TG: Triglycerides, LDL-C: Low-density lipoprotein-cholesterol, AI: Atherogenic index, HDL-C: High-density lipoprotein-cholesterol, WC: Waist circumference. Data are presented as the mean±standard deviation. *P<0.05, statistically significant when compared with nonobese or obese

Table 3: Correlation coefficient analysis

Variables	TC	TG	LDL-C	HDL-C	AI
BMI	0.34**	0.22	0.34**	−0.38**	0.46***
WC	0.20	0.28*	0.16	v0.30**	0.29**

TC: Total cholesterol, TG: Triglycerides, LDL-C: Low-density lipoprotein-cholesterol, AI: Atherogenic index, HDL-C: High-density lipoprotein-cholesterol, WC: Waist circumference, BMI: Body mass index. *P < 0.05, **P < 0.01, ***P < 0 0.001

WC was positively correlated with TC (R = 0.20), TG (R = 0.28) LDL-C (R = 0.16), and AI (R = 0.29). The correlation was found to be statistically nonsignificant with TC ($P > 0.05$), LDL-C ($P > 0.05$) and statistically significant with TG ($P < 0.05$) and AI ($P < 0.05$), and WC was negatively correlated with HDL-C (R = −0.30). The correlation was found to be statistically significant ($P < 0.01$) (Table 3).

DISCUSSION

This study evaluated the relationship of lipid profile, BMI, and WC as cardiovascular risk factors with obesity in adults. The main findings of this study were that obese subjects had statistically significantly more adverse cardiovascular risk factors; increased BMI and WC, hypercholesterolemia, hypertriglyceridemia, and more AI, with lower levels of HDL-C as compared to nonobese subjects (Figures 1 and 2).

Several studies have shown that the association between obesity and cardiovascular risk begins early in life.[17] BMI and WC; each measure a distinct component of obesity or body fat distribution, and WC are consistently the best predictors of cardiovascular risk.[18] The results of this study showed significant positive correlations between BMI,

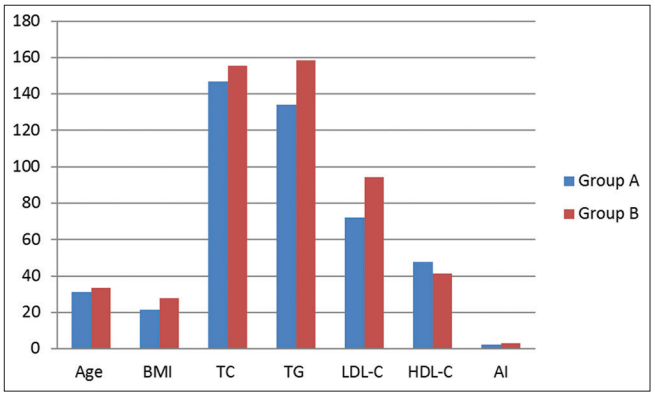

Figure 1: Variables in two groups based on body mass index

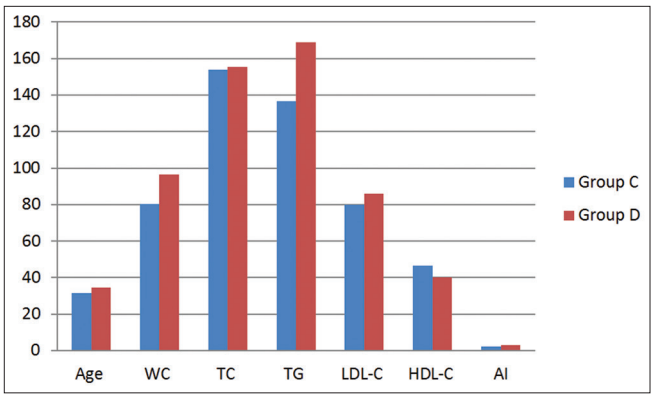

Figure 2: Variables in two groups based on waist circumference

WC and TC, TG, AI and nonsignificant with LDL-C, and an inverse correlation with HDL-C after adjustment for age. Abnormal serum lipid levels, especially decreased HDL-C and elevated TC, TG, LDL-C, and AI are generally recognized as independent risk factors for CVD.[19] Our study demonstrated an abnormal lipid profile with regard to elevated TC, TG, LDL-C, and AI, and reduced HDL-C in overweight or obese.

BMI and Lipid Profile

When compared according to BMI a nonstatistically significant increase in TC ($P > 0.05$) and TG ($P > 0.05$), and statistically significant increased LDL-C ($P< 0.01$), and statistically significant decreased HDL-C ($P < 0.001$) level in obese compared to nonobese but both the groups were having values within normal range. This finding was similar to observation reported by Regina Fisberg *et al.*,[20] While Njelekela *et al.* observed a significant increase in TC level in obese men.[21] Similar observations were made by Bertsias *et al.,* Mataix *et al.*, and Nagila *et al.* in their study.[22-24]

AI was found to be highly statistically significantly increased ($P < 0.001$) in obese compared to nonobese, which was also shown by studies of Rizk and Yousef,[25] Ugwuja *et al.* also observed an increased AI in obese subjects.[26]

WC and Lipid Profile

When compared according to WC obese subjects were found to have increased level of TC, TG, and LDL-C levels as compared to nonobese, but the difference observed was not statistically significant ($P > 0.05$) in TC and LDL-C levels but was significant in TG ($P < 0.05$) and AI (<0.05). A similar finding was reported by Mataix *et al.* who also observed no statistically significant difference in these lipid levels in obese and nonobese men.[23] Bertsias *et al.* found statistically significant increase in TC, TG and LDL-C levels, and decreased HDL-C ($P < 0.01$).[22] Ugwuja *et al.* also observed an increased AI in obese subjects.[26]

Correlation between Anthropometric Variables and Lipid Profile

Anthropometric variables viz. BMI and WC were correlated positively with TC, TG, LDL-C, and AI while correlated negatively with HDL-C. TC, TG, HDL-C, AI correlated significantly with BMI, and WC. LDL-C correlated statistically nonsignificantly with WC. Similar observations were also reported in the previous studies.[25-30] This may be attributed to the different age distribution of subjects as well as to the ethnic variations in fat distribution.

WC has been shown to be better predictors of dyslipidemia than BMI.[27] This study found BMI as a better predictor of dyslipidemia than WC (Table 3) which may be due to the younger population under study or due to ethnic variations in fat distribution. Kondo *et al.* also found the BMI as a better predictor of metabolic risk factors than WC.[31]

Thus, obesity measured by any of the anthropometric variable is an important contributor to dyslipidemia.

In summary, this study indicates that the combination of elevated TC, TG, AI and LDL-C, and decreased HDL-C, with BMI and, WC above the 90th percentile in obese, would place them at greater risk for CVD. These data are consistent with the previous studies in different ethnic groups.[32] Further studies are needed in larger sample sizes to investigate if other biomarkers could be used to define obesity and the implications for early detection of increased cardiovascular risk.

This study was limited by its small sample size. Blood pressure was not measured, which limits the associations of obesity with the metabolic syndrome as a cluster of potential risk factors for atherosclerotic CVD and type-2 diabetes.

CONCLUSION

Thus, it is concluded that the parameter indicating increased cardiovascular risk such as high TC, TG, LDL-C, AI, and low HDL-C in obese group as compared to nonobese. As TG, TC, LDL-C, and AI showed positive correlation while HDL-C showed a negative correlation with both BMI and WC. Hence, both the anthropometric indices (i.e., BMI and WC) can be used both alone and also in combination as a predictor of abnormal lipid profile and as a cardiovascular risk also.

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