Cardiovascular risk factors in middle age obese Indians: a cross-sectional study on association of per cent body fat and intra-abdominal fat mass

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ABSTRACT

Objectives To determine the association of per cent total body fat (TBF), intra-abdominal fat (IAF) mass and subcutaneous abdominal fat with cardiovascular risk factors in middle age obese Indians.

Design Cross-sectional study.

Setting Hydrostatic Laboratory, Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University, India. Participants: 51 subjects aged 30—55 years with a body mass index value 23 and above.

Methodology In all the participants, TBF was estimated by underwater weighing machine and IAF and subcutaneous fat were measured by ultrasonography. Lipid profile was determined by a semiautomated analyser. Main outcome measures were: IAF, per cent body fat to TBF ratio, lipid profile and risk of developing cardiovascular diseases.

Results IAF was found to be significantly associated with lipid variables (95% CI, $p<0.01$) and risk of developing cardiovascular diseases (95% CI, $p\leq0.05$) in both male and female subjects. TBF and subcutaneous fat thickness showed no significant results (95% CI, $p>0.05$) with either lipid variables or risk of developing cardiovascular diseases (tables 1 and 2). IAF mass showed significant association with age (95% CI, $p<0.01$) and significant negative association with physical activity (95% CI, $p<0.05$) in male subjects (tables 3 and 4).

Conclusion An ultrasonic measurement of IAF is a better predictor of the risk of developing cardiovascular diseases in middle aged Indian population. In male subjects, physical activity of 5 or more days a week showed lesser amount of IAF as compared with those with physical activity <5 days a week.

INTRODUCTION

The Asian Indian population has a very high incidence of ischaemic heart disease with an abnormal lipid profile as one of the risk factors, which is different from those seen in Western populations.[1] Obesity in India has reached epidemic proportions in the 21st century with 5% of the total population affected with morbid obesity.[2] Obesity is an important risk factor for diabetes mellitus, hypertension, hyperlipidaemia, development and progression of coronary heart disease, and various other cardiovascular diseases (CVDs).[3] As early as 1956, it had been indicated that the total body fat (TBF) and the distribution of this fat are important indicators of various CVDs and other chronic diseases such as hypertension diabetes, and certain types of cancer, etc.[4] An android fat distribution predominating in male sex is related to an increased risk of CVDs. In contrast, gynoid fat distribution commonly observed in female subjects is thought to protect against CVD.[5 6]

In spite of these facts, there have been few focused attempts to determine whether any particular association exists between body fat distribution and lipid profile in the Asian Indian population, which may be implicated in an increased risk for CVD. Association of lipid profiles is reported with lifestyle,[7 8] age,[9] intra-abdominal adiposity[10 11] and obesity.[12 13] This further dilutes the available information once specific age, gender and other demographic data are considered. Researchers earlier have used simpler and cheaper anthropometric and skin folds measurements to quantify TBF and regional body fat distribution which have a low reliability.[14] Hence, the earlier studies done in Indian setup are unable to predict whether the TBF or regional fat distribution is responsible for causing CVDs.[15]

The gold standard of body composition in a two compartmental model is underwater weighing.[14] Underwater weighing measures body density using Archimedes' principle, from which total fat and lean body mass are estimated, by assuming standard figures for density of these compartments.[16] Ultrasonography has been proved to be a useful alternative to CT in identifying intra-abdominal fat (IAF) and predicting visceral obesity [17] and is a more reliable method to quantify visceral fat as compared with other simple anthropometric methods like weight, height, waist circumference and hip circumference.[18 19]

This study was devised to determine the association among TBF, intra-abdominal and subcutaneous abdominal fat mass with lipid profile and other metabolic risk factors for CVDs in the middle aged Asian Indian population. Specifically, we aimed to use reliable methods to quantify TBF and IAF in this population to explore this relation.

METHODOLOGY

Subjects

Fifty-one overweight or obese individuals with a body mass index value of 23 and above as indicated by WHO[20] were randomly selected from the community (male subjects N=22; female subjects N=29) aged 30—55 years. Subjects with a history of respiratory illness, medical or surgical conditions, pregnancy and hydrophobia were excluded. Written informed consent was obtained from every subject. The institutional ethics committee of the Faculty of Sports Medicine and Physiotherapy, Guru Nanak

Dev University, India approved the study protocol. The study was conducted in a pleasant environment in the months of August–October 2010 when the average ambient temperature reported was 28°C and humidity was around 25%.

Anthropometric measurements

Subjects were weighed with minimal clothing, using a digital load cell balance (Soehnle, West Germany), which had a precision of 0.1 kg. The height of the subjects was recorded, without footwear, using a vertically mobile scale (Holtain, Crymych, UK) and expressed to nearest 0.1 cm. A pretested semistructured questionnaire was developed to obtain information on the demographic, nutritional and lifestyle profiles of the participants. Framingham risk scoring was used to evaluate 10-year (short-term) risk for developing CVDs (CVR).[21]

Venous blood samples were taken from all the subjects in the morning after overnight fasting. Plasma levels of total cholesterol, triglycerides, high density lipoprotein-cholesterol (HDL-C), low density lipoprotein-cholesterol (LDL-C) and very low density lipoprotein (VLDL) were determined with a semi-automated enzymatic analyser (RA 50, Semiauto Chemistry Analyser, Thyrocare India Ltd, India). The ratio of total cholesterol to HDL-C is considered to be the best predictor of heart disease and has been used in our study.[22]

The amount of abdominal adipose tissue was determined according to the procedure described by Armellini *et al* (1991) ultrasonographically by a single experienced operator using a real-time ultrasound scanner (Sonoline 20, Siemens, Germany). The subcutaneous fat thickness (SC) was measured as the distance between the skin fat and fat muscle interfaces and the IAF thickness was measured as the distance between the internal face of the rectus abdominis muscle and the rear wall of aorta.[23] An ultrasound determined intra-abdominal to subcutaneous fat ratio of 2.50 was established as the cut-off value to define subjects with abdominal visceral obesity.[24–26]

Per cent TBF was measured using the hydrostatic underwater weighing machine 'Vacumed Turbofit 5.10' (http://www.vacumed.com). The subjects were directed to slowly expel the inhaled air prior to submerging and continue until complete exhalation. They were urged to move slowly into the tank to reduce the dynamic effect of any moving water. The total body was submerged and no part of the body was allowed to touch the bottom or the sides of the tank. The underwater weight was entered automatically in the computer when the indicator was stable. An average of three readings was taken as the final reading. The vital capacity was calculated using a Rolex Spirometer. The software estimated the residual lung volume using the following equations: Male residual lung volume=Vital Capacity×0.24 and Female residual lung volume=Vital Capacity×0.28.[27] Final per cent body fat was automatically calculated by the software using Brozek's formula.[28]

Statistical analysis

SPSS software (V.16.0; SPSS, Inc) was used for statistical analysis. The NPar test in the SPSS software was used to calculate power of the study and minimal sample size. This was found to be 50 subjects with the power of the study at 0.80. The relation among lipid profile, TBF, IAF and SC was assessed using the Pearson correlation coefficient test. To find out the relation of cardiovascular risk (CVR) with TBF, IAF and SC, analysis of variance (ANOVA) was used. Further, for comparison of age with TBF, IAF and SC, the subjects were divided into two age groups, 30–40 and 40–50 years, and ANOVA was used. To find out the relationship among TBF, IAF and SC and physical activity of each subject, ANOVA and independent t tests were used. This analysis was performed independently for both the genders. Data are presented as mean±SD in the following tables 2–4. CI was set at 95% for all statistical analysis.

RESULTS

The mean age of our male subjects was 44.50±7.03 years and that of female subjects was 39.48±4.50 years with a mean body mass index of 27.74±2.77 kg/m^2 for male subjects with mean height and weight being 1.71±0.07 m and 81.60±10.38 kg, respectively, and a mean body mass index of 27.79±2.81 kg/m^2 for female subjects with mean height and weight being 1.57±0.05 m and 68.25±7.24 kg.

In table 1, significant positive association ($p \leq 0.05$) was found between lipid concentrations like serum cholesterol, serum triglycerides, serum LDL and serum VLDL, TC to HDL ratio, trigylceride to HDL ratio, LDL to HDL ratio and IAF in male subjects and trigylceride to HDL ratio and IAF in female subjects. Serum HDL showed significant negative correlation with IAF in both male and female subjects. There was no significant association ($p>0.05$) found among lipid profile, TBF and SC in male and female subjects.

In table 2, there was a significant difference of CVR with IAF in male ($p<0.05$) and female subjects ($p<0.04$). There was no significant difference of CVD risk with TBF and SC between the groups ($p>0.05$).

In table 3, mean values of TBF and IAF in male subjects were lower in age group 30–40 years (33.4±5.14, 58.8±11.1, respectively) as compared with 40–50 years (35.1±8.41, 68.0±19.02, respectively). The mean values of SC remained unchanged. In

Table 1 Correlation of lipid profile with total body fat, intra-abdominal fat and subcutaneous fat

	Total body fat (%)		Intra-abdominal fat (mm)		Subcutaneous abdominal fat (mm)	
Lipid profile	Male	Female	Male	Female	Male	Female
s. Cholesterol (mg/dl)	0.258	0.003	0.460*	−0.214	0.044	0.022
s. Triglycerides (mg/dl)	0.159	0.083	0.562**	0.178	0.013	0.267
s. HDL (mg/dl)	0.051	−0.191	−0.833**	−0.529**	−0.312	−0.085
s. LDL (mg/dl)	0.136	−0.017	0.596**	−0.247	0.060	0.039
s. VLDL (mg/dl)	0.159	0.071	0.562**	0.158	0.013	0.268
TC:HDL ratio	0.168	0.086	0.777**	0.079	0.191	0.048
Trigylceride:HDL ratio	0.106	0.183	0.802**	0.488**	0.164	0.194
LDL:HDL ratio	0.122	0.60	0.776**	−0.009	0.157	0.058

*$p<0.05$, **$p<0.01$.
HDL, high density lipoprotein; LDL, low density lipoprotein; s., serum; TC, total cholesterol; VLDL, very low density lipoprotein.

Table 2 Relationship of cardiovascular disease risk with total body fat, intra-abdominal fat and subcutaneous abdominal fat

Cardiovascular disease risk	N (male)	N (female)	Total body fat (%)		Intra-abdominal fat (mm)		Subcutaneous abdominal fat (mm)	
			Male	Female	Male	Female	Male	Female
Very low	5	3	32.73±6.12	38.04±4.77	54.08±8.88*	50.30±6.27*	16.64±3.48	16.23±4.88
Low	6	14	33.55±9.51	36.67±5.39	62.20±18.0	53.98±7.84*	18.30±5.21	19.21±5.19
Moderate	4	5	35.61±3.70	41.43±4.73	71.63±12.54	63.00±6.64*	20.70±3.14	19.32±3.12
Borderline high	3	2	35.06±8.85	37.20±3.96	75.37±20.49	68.85±0.49	21.70±4.78	20.35±3.04
High	4	5	30.89±9.10	33.96±6.94	84.40±12.36*	81.84±17.8*	23.23±6.39	19.38±3.14
Total	22	29	33.46±7.25	37.20±5.57	67.90±17.14*	60.98±14.2*	19.72±4.91	19.03±4.28

*$p<0.05$, $p<0.01$.

female subjects, mean values of TBF and SC were slightly more in 40–50 years age group (37.4±5.45, 19.3±3.86) and the mean value of IAF were lower in 40–50 years age group (58.1±10.28) as compared with 30–40 years (62.7±16.14). Carl–Pearson correlation coefficient showed significant correlation ($r=0.550$, $p<0.01$) between IAF and age in male subjects.

In table 4, the mean values of TBF and IAF were lower in subjects with physical activity of 5 or more days a week (31.94±8.59 and 64.87±15.29, respectively, in male subjects and 36.93±6.21 and 55.98±9.70, respectively, in female subjects) as compared with subjects with physical activity less than once a week (34.74±4.29 and 91.80±7.03, respectively, in male subjects and 37.54±5.72 and 66.25±6.72, respectively, in female subjects). The mean value of SC was higher in male subjects with 5 or more days a week of physical activity (19.9±4.14). In female subjects, the values of SC were unchanged. The independent t test for male subjects showed significant difference ($p<0.05$) of IAF with respect to their physical activity once a week and physical activity 5 days or more in a week.

DISCUSSION

The main purpose of our study was to explore the relationship of lipid profile and risk of developing CVDs with TBF and ultrasonic measurements of IAF and subcutaneous abdominal fat. The second objective was to determine the association among TBF, IAF and SC with age, gender and physical activity of the subjects.

Relation of lipid profile with TBF, IAF and SC

In the current study, the relationship of lipid profile with TBF, IAF and SC showed three principal findings (table 1). First, the total serum cholesterol, serum triglycerides, serum LDL and serum VLDL had significant association ($p<0.01$) with the amount of IAF and no such relation was found with either TBF or SC in both male and female subjects. Second, the results were significantly negative ($p>0.01$) in case of association between serum HDL and IAF in both male and female subjects. Third as the ratio of TC to HDL is considered to be the best predictor of CVD risk, the relationship between the TC to HDL ratio and IAF showed a significant positive association in male subjects indicating that measurements of IAF may be the best tool to define the risk of developing CVDs. These results were more pronounced in male than in female subjects. Various other studies had also found similar results.[10–12] Manabe *et al* (1999) observed that unfavourable lipid profile was related with IAF in both genders among the non-obese Japanese population.[10]

Relation of CVR with TBF, IAF and SC

We demonstrated that CVR was significantly associated with IAF in both male and female subjects (table 2). The subjects with very low risk of developing CVD as interpreted by Framingham risk scoring showed lower amount of IAF both in male (mean=54.08±8.88 mm) and in female subjects (mean=50.30±6.27 mm) compared with the significantly higher values observed both in male (mean 84.20±12.36 mm) and in female subjects (mean=81.84±17.78 mm) with a high risk of developing CVDs. We also observed that subjects with lower values of TBF (30.89±9.10 in male and 33.96±6.94 in female subjects) in fact had a higher risk of developing CVDs while subjects with higher values of TBF (32.73±6.12 in male and 38.04±4.77 in female subjects) showed a very low risk of developing CVDs (table 2). On examining the individual variation for this population, we noted that one male and two female subjects had low TBF (17.43, 24.45 and 30.45, respectively) within normal ranges but very high amount of IAF (76.8, 77.7 and 71.9, respectively) and were also listed in the high risk of CVD by the Framingham scoring. Recent studies have demonstrated that regional distribution of adipose tissue is critical in the clinical assessment of patients, particularly if they are obese. In prospective studies[29] it has been demonstrated that independent of overall obesity, excess fat in the central (visceral abdominal) region is associated with higher plasma levels of both glucose and insulin, hyperlipidemia and decreased HDL-C; components of the insulin resistance syndrome as well as a cluster of risk factors for atherosclerotic CVD. It has been hypothesised that visceral fat could cause metabolic abnormalities by secreting inflammatory adipokines such as interleukin-6, tumour necrosis factor α, macrophage chemoattractant protein-1 and resistin, which induce insulin resistance and diabetes.[30 31] There is now evidence that visceral adipose tissue is the primary determinant of systemic inflammation in type 2 diabetes.[32]

Table 3 Comparison of total body fat, intra-abdominal fat and subcutaneous abdominal fat in different age groups

Age range (years)	N (male)	N (female)	Total body fat (%)		Intra-abdominal fat (mm)		Subcutaneous abdominal fat (mm)	
			Male	Female	Male	Female	Male	Female
30–40	7	18	33.4±5.14	37.0±5.79	58.8±11.1	62.7±16.14	18.6±4.47	18.8±4.61
40–50	9	11	35.1±8.41	37.4±5.45	68.0±19.02	58.1±10.28	18.7±4.38	19.3±3.86

Table 4 Comparison of total body fat, intra-abdominal fat and subcutaneous abdominal fat in subjects with different levels of physical activity

Physical activity (days/week)	N (male)	N (female)	Total body fat (%)		Intra-abdominal fat (mm)		Subcutaneous abdominal fat (mm)	
			Male	Female	Male	Female	Male	Female
Less than once a week	3	6	34.74±4.29	37.54±5.72	91.80±7.03*	66.25±6.72	16.56±3.08	19.35±2.28
1–2 days a week	2	–	38.08±0.82	–	61.15±13.93	–	23.20±11.45	–
3–4 days a week	3	7	36.14±1.37	37.53±4.53	62.63±20.23	67.91±22.81	19.7±6.24	18.57±3.48
5 or more days a week	14	16	31.94±8.59	36.93±6.21	64.87±15.3*	55.98±9.70	19.9±4.14	19.10±5.24

*$p<0.05$.

Thus, it was concluded that excess TBF is not a direct cause of developing CVDs while the amount of fat stored in abdomen region might be considered as directly increasing the risk of CVDs. Furthermore, the subcutaneous fat had lower mean values in subjects with a very low risk of developing CVDs while higher mean values were seen in subjects with a high risk of developing CVDs. However, a less linear relation was observed in female subjects indicating that it is actually the presence of fat in the intra-abdominal region which is the main culprit behind the increased risk of CVDs in both male and female subjects. Previous studies have used CT measurement for measuring subcutaneous and IAF,[32] which have been considered to be the most accurate and reproducible technique of body fat measurement,[33] particularly the abdominal adipose tissue[34] However, CT scans are costly and time consuming and involve exposure to ionising radiation.[35] We believe that our observations support the use of ultrasound as a non-invasive technique to assess IAF, to quantify risk of developing CVDs for specific prevention purposes.

Relation of age with TBF, IAF and SC

Further, we tried to explore the relationship of TBF, IAF and SC with age. In our sample of obese men and women, TBF tended to increase from age group 30–40 (mean=33.4) to age group 40–50 (mean=35.1) in male subjects. No change was observed in TBF with respect to age in female subjects (table 3). IAF value was higher in male than in female subjects of same age group. High IAF amounts found in male subjects are possibly thought to occur because of sex hormone differences.[36] A partial Pearson correlations showed a significant positive association of IAF with age in male subjects while no such relation was observed in female subjects. With normal ageing, negative changes in body fat distribution including increased fat storage in the heart, liver, bone marrow and skeletal muscle resulting in increase amount of IAF occurs.[37] However, in female subjects, age was not clearly associated with IAF as before menopause the amount of IAF distribution is primarily guided by hormones such as oestrogen that check excess increase of IAF with age; once menopause sets in, the amount of IAF increases considerably in women independent of their age and TBF.[38] In our study, some women under the age of 40 years were in their menopausal stage, which may explain the increase in mean value of IAF in age group of 30–40 years. No significant relation was observed between age and SC in both genders indicating only a marginal and creeping increase in obesity. Studies in comparable age groups have indicated that the Swedish population had a lower TBF (21.2±4.9 in male and 30.7±4.9 in female subjects)[39] as also observed in Melanesians (male subjects had 17.8±5.7 while female subjects had 28.8±7.6 TBF)[40] and Americans (21.9±7.1 in male and 32.3±7.1 in female subjects).[41] These results point to the fact that this Asian Indian population had a much higher per cent TBF compared with other populations. Kaiser family foundation study and CADI study indicated that Asian Indians are at a much higher risk of developing CVDs in their studies based on Indians living in the USA, Canada, Singapore, the UK, South Africa, Middle East and many other countries.[42]

Non-linear relation of TBF with IAF and SC

We observed that in both genders, it was not necessary that with greater amount of TBF the amount of IAF and SC was also greater, but a non-linear relation was observed in individuals with high TBF demonstrating low abdominal deposition of fat.

Relation of physical activity with TBF, IAF and SC

The association of physical activity with TBF, IAF and SC has been reported in several studies.[43–45] Westerterp and Goran (1997) concluded that in male subjects, there is a significant inverse cross-sectional relationship between activity energy expenditure and per cent body fat, whereas no such relationship was apparent in female subjects.[44] In our study, it was observed that male subjects with higher levels of physical activity had lower mean values of TBF (31.94±8.59) as compared with male subjects with negligible physical activity (34.74±4.29) (table 4). In female subjects, there was lesser difference of mean values of subjects with high physical activity (37.54±5.72) and subjects with negligible physical activity (36.93±6.21). The interpretations of our observations are limited by the low number of subjects in each group. A larger number of subjects in each group would give us more conclusive evidence with respect to physical activity association with TBF, IAF and SC. However, in this small group preliminary observations do indicate that there were higher mean values of IAF (91.80±7.03 in male and 66.25±6.72 in female subjects) with negligible physical activity. In contrast, there were low mean values of IAF (64.87±15.29 in male and 55.98±9.70 in female subjects) with high levels of physical activity. Independent t test showed a significant negative association ($p<0.01$) between two groups of physical activity, that is, less than once a week and physical activity of 5 or more days a week with IAF in male subjects thus indicating that physical activity and IAF were negatively associated with each other. The mean SC showed more or less no change at all levels of physical activity in female subjects and was higher in male subjects with high levels of physical activity as compared with male subjects with lesser amount of physical activity.

We had initiated the study to analyse the parameters associated with CVDs in middle aged subjects. Most of our volunteers reported that they had indulged in 30 min or more of moderate intensity activities for most of the days of a week at least for 2–3 months already. Our study is limited by the fact that we did not include a dietary history. It is possible that the shift towards calorigenic high glycaemic index processed food with high fats could have led to the increase in TBF as well as IAF in individuals. Our study is also limited by the fact that we did not include the variable of waist circumference >90 cm for male and >80 cm for female subjects (for Asians) as an effective clinical predictor of metabolic risk comparable with clinical, biochemical and other imaging modalities.

In spite of these limitations, the power of the study at 0.80 indicated that the results and conclusions drawn from our study may be applied for clinical purposes. Thus, our study provides evidence for the fact that it is the deposition of fat in intra-abdominal region which is associated with increased risk of CVDs. It also provides evidence to the fact that physical activity may be an important modulating factor in the distribution of fat and that people should be encouraged to participate in a physically active lifestyle.

CONCLUSION

In the present study, IAF mass showed an association with unfavourable lipid profile. Our results show that ultrasonic measurements of IAF is a better indicator in predicting the risk of developing CVDs in obese middle aged Asian Indians than TBF and SC. Physical activity showed a negative association with IAF in male subjects.

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