National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

A study of the prevalence of generalized obesity, abdominal obesity, regional adiposity, and metabolic syndrome among young adults

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Received: February 17, 2018; **Accepted:** March 01, 2018

ABSTRACT

Background: Overweight, obesity, and metabolic syndrome (MetS) are rapidly increasing in India. **Aims and Objectives:** This study demonstrated the prevalence of generalized, abdominal obesity including intra-abdominal and subcutaneous adiposity along with other associated factors in young adults. **Materials and Methods:** A cross-sectional study was conducted with 200 subjects. The anthropometric parameters (body mass index [BMI], waist circumference [WC], and skinfold thickness), fasting blood glucose (FBG), and blood pressure were recorded. Percentage of body fat (BF), total abdominal fat (TAF), intra-abdominal adipose tissue (IAAT), subcutaneous adipose tissue (SCAT), and basal metabolic rate (BMR) were measured by predictive equations. Data were analyzed using *t*-test, analysis of variance, and Pearson's correlation tests. $P < 0.05$ was considered statistically significant. **Results:** The prevalence of generalized obesity (GO) (by BMI [>25 kg/m^2]) was 11%. The prevalence of abdominal obesity according to WC was 17 %, whereas that measured by TAF was 8%. Increased IAAT was more in females (26.02%) as compared to males (8%) with overall prevalence 16.5%. The overall prevalence of SCAT was 27%, more in males (41.56%) as compared to females (17.89%). The prevalence of impaired FBG was 19% (prediabetic), MetS 5.5%, hypertension according to systolic blood pressure 6%, and according to diastolic blood pressure 13%. The predictive BMR was significantly higher with obese subjects as compared to healthy members in both sexes ($P < 0.05$). **Conclusion:** The prevalence of GO, abdominal obesity, regional adiposity, and MetS among young adults necessitates public health intervention.

KEY WORDS: Body Mass Index; Abdominal Obesity; Regional Adiposity; Metabolic Syndrome; Basal Metabolic Rate

INTRODUCTION

Globally, obesity is pandemic of the 21st century and the occurrence of obesity in India continues to increase.[1] The prevalence among adolescents varies between 10% and 30%.[1]

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/njppp.2018.8.020771032018	

The World Health Organization has recognized the problem of obesity. The organization called for urgent action to prevent the growing epidemic of obesity, which now affects developing and developed countries the same.[2,3] Today, it is estimated that there are more than 300 million obese individuals in the world.[4] Obese individuals have higher rates of mortality and morbidity compared to non-obese individuals.[1-3] India, the second most populous country in the world currently experiencing rapid epidemiological transition. It is now evident that previously dominant undernutrition due to poverty is being rapidly replaced by obesity.[5] In general, obesity is associated with a greater risk of disability such as Type 2 diabetes mellitus, dyslipidemia, and cardiovascular diseases such as hypertension, stroke and coronary heart disease, gallbladder disease, certain cancers, and nonfatal conditions such as gout, osteoarthritis, and infertility. Obesity also carries serious implications for mental health, mainly due to societal discrimination against fatness.[3,6,7] Regional adiposity, mainly abdominal obesity is considered important for the development of insulin resistance, metabolic syndrome (MetS), and coronary heart disease.[8] The prevalence of MetS is getting higher at a frightening rate among young adults of metropolitan India.[9] It was found that 80% of total body fat (BF) is distributed in the subcutaneous adipose tissue (SCAT) and 10–20% within visceral or intra-abdominal adipose tissue (IAAT) in adult human being.[10] The major abdominal adipose tissue depots such as IAAT and SCAT have investigated in relation to metabolic disorders.[11] The Asian Indians show distinctive features of obesity; excess BF, abdominal adiposity, increased SCAT, IAAT, and ectopic fat deposition in liver, muscle, etc.,[12] which may possibly responsible for high inclination to develop insulin resistance and metabolic disorders. The importance of cutoffs of SCAT and IAAT to detect cardiometabolic risk factors, assess its prognosis and helps to identify suitable therapy.[8] Basal metabolic rate (BMR) is the minimum rate of energy expenditure required to carry out all body functions under resting, steady-state conditions.[13] It has been reported that obesity results from a positive energy balance and BMR is also increased in overweight and obese subjects.[13]

Essentially, determination of the prevalence of generalized obesity (GO), SCAT, and IAAT helps to estimate abdominal adiposity and burden of cardiometabolic risk factors. It is momentous to state that there are rare data to show regional adiposity using India specific cutoffs for young Indian adults. In this study, we intended to assess the prevalence of GO, abdominal obesity including total abdominal fat (TAF), SCAT and IAAT, predictive BMR, and the MetS among young adults in middle part of India.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Physiology, Government Medical College, Rajnandgaon, Chhattisgarh. The study period was from January to June 2017. The study was approved by the institutional ethics committee. The subjects of our study were 200 medical students. A written informed consent was taken from all the participants involved in this study. Data were collected by assessing physiological and biochemical parameters in laboratory.

Inclusion and Exclusion Criteria

Both male and female students aged between 17 and 22 years were included. Students were physically/mentally fit and cooperative and capable of understanding the procedure. Subjects suffering from hypothyroidism and any other type of metabolic/endocrine disorder were excluded.

Anthropometric parameters were measured using standardized techniques.[14,15] Height (in centimeters) was measured using a stadiometer (SECA Model 217, Seca Gmbh Co., Hamburg, Germany). The individual was asked to stand upright without shoes with his/her back against the vertical backboard, heels together, and eyes directed forward. Weight (in kilograms) was measured with an manual weighing scale (Dr. Morpen, MS-02, Delhi, India) that was kept on a firm horizontal flat surface.[14,15] Subjects were asked to wear light clothing, and weight was recorded to the nearest 0.5 kg. Body mass index (BMI) was calculated using the formula weight (kg)/height $(m)^2$.[14,15] Waist circumference (WC) (in centimeters) was measured using a non-stretchable measuring tape. WC was measured at the smallest horizontal girth between the costal margins and the iliac crest at the end of expiration. The triceps skinfold was measured using Lange skinfold calipers.[14,15]

We estimated percentage BF, TAF, and areas of abdominal adipose tissue subcompartments; IAAT and SCAT using the predictive equations developed for Asian Indians which included simple variables such as age, gender, height, weight, BMI, WC, hip circumference, and skinfold.[8,16] Cutoffs for TAF, IAAT, and SCAT developed for Asians were used to determine the abnormal values.[10] Overweight and obesity were defined as BMI $\geq$23–24.9 kg/m^2 and BMI $\geq$25 kg/m^2, respectively.[8,12] WC >90 cm for males and >80 cm for females was considered an indicator of abdominal obesity.[8,17] Cutoff for % BF was taken as 25.5 for males and 38 for females, respectively.[8,18] Cutoffs for TAF ($\geq$245.6 cm^2 [males] and $\geq$203.46 cm^2 [females]), IAAT ($\geq$135.3 cm^2 [males] and $\geq$75.73 cm^2 [females]), and SCAT ($\geq$110.74 cm^2 [males] and $\geq$134.02 cm^2 [females]) developed for Asians were used to determine the adiposity.[8,19]

Systolic blood pressures (SBP) and diastolic blood pressures (DBP) were measured using an arm-type fully automatic blood pressure monitoring system (Easy Care, Ravechi GmbH, Germany). Blood pressure was recorded in the sitting position in the right arm. Two readings were taken 5 min apart and their mean was taken as the blood pressure.[15] Fasting capillary blood glucose was determined using a One Touch Ultra glucose meter (Dr Morpen Gluco One, Model BG - 03, South Korea). The modified criteria (three out of five) of National Cholesterol Education Program, Adult Treatment Panel III (NCEP ATP III) were used to define the MetS.[8,20] We estimated BMR, using the predictive equations developed by Lazzer *et a*l., 2010.[13]

Statistical Analysis

The values are given as mean ± standard error of the mean. Statistical analysis was performed using Origin (Version 8.0). Student's *t*-test was used to compare proportions between two groups. Pearson's correlation analysis was used to examine the association between various exposures and outcomes. The differences of predicted BMR between groups were tested for significance by one-way analysis of variance with

Tukey's *post hoc* test. $P < 0.05$ was considered as the level of statistical significance.

RESULTS

Demographic, Physical, and Metabolic Characteristics of Study Participants

Out of 230 subjects, 200 medical students (77 males and 123 females) had completed records and presented in Table 1. Overall, there was a prevalence of Hindus (91%), followed by Sikhs (3%), Muslims (1%) and Christians (3%), and others (2%).

Anthropometric and BF Profile, Obesity and Regional Adiposity, Cardiometabolic Risk Factors [Tables 2-4]

The prevalence of GO was 11%, abdominal obesity by WC and TAF was 17% and 8%, respectively. Excess IAAT and SCAT were seen in 16.5% and 27% subjects, respectively. The prevalence of impaired fasting glucose was 19% (prediabetic), MetS 5.5%, hypertension according to SBP 6%, and according to DBP 13%, respectively.

Table 5 summarized the correlation analysis of fasting blood glucose levels with GO (BMI), abdominal obesity (WC), SBP, and DBP for the whole group of 200 participants. A positively statistically significant correlation was observed between serum glucose and other parameters ($P < 0.05$).

Predicted BMR of Healthy, Overweight, and Obese Subjects [Table 6]

The predicted BMR of healthy, overweight, and obese subjects in both sexes demonstrated in Tables 6 and 7. Table 7 summarizedthe BMR of obese subjects and was significantly different with healthy and overweight subjects ($P < 0.05$).

Table 8 summarized the correlations between BMR and body composition mainly with BMI and WC. All had a significantly positive correlation with BMR.

DISCUSSION

This study showing high prevalence of abdominal adiposity and adiposity in various abdominal subcompartments among young adults using predictive equations developed for Asian Indians. The prevalence of obesity according to BMI was 11%. High prevalence of obesity based on percentage BF (15%) was notable. Female group is showing the underrepresentation of obesity when defined by BMI alone (8.94%). This observation

Table 1: Physical, physiological, and metabolic characteristics

Variables	(Mean±SEM)			*P* value	Significance
	Total 200	Male 77	Female 123		
Age	20.77±0.13	21.57±0.22	20.26±0.14	0.319	NS
Weight	55.21±0.87	63.25±1.38	50.18±0.85	0.319	NS
Height	159.97±1.31	165.54±3.16	156.48±0.62	0.322	NS
SBP	118.39±0.83	123.26±1.41	115.33±0.92	0.319	NS
DBP	76.37±0.63	78.90±1.11	74.78±0.71	0.999	NS
FBG	90.8±0.66	91.22±1.18	90.54±0.77	0.945	NS

NS: Not significant. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBG: Fasting blood glucose, SEM: Standard error of the mean

Table 2: Anthropometric and BF profile

Variables	(Mean±SEM)			*P* value	Significance
	Overall	Male	Female		
BMI (kg/m^2)	21.48±0.34	22.67±0.66	20.73±0.36	0.994	NS
Triceps skinfold thickness (cm)	15.54±0.51	12.95±0.78	17.16±0.63	0.019	$P<0.05$
WC (cm)	75.34±0.83	78.54±1.4	73.34±0.98	0.319	NS
HC (cm)	93.70±0.58	93.49±0.97	93.82±0.73	0.694	NS
Waist-to-hip ratio	0.80±0.004	0.82±0.01	0.77±0.004	0.319	NS
% BF	26.93±0.72	21.85±1.42	30.10±0.62	0.002	$P<0.05$
TAF (cm^2)	123.20±2.44	132.15±5.02	125.93±2.80	0.323	NS
IAAT (cm^2)	65.03±1.73	75.55±2.71	58.44±2.04	0.319	NS
Subcutaneous adipose tissue (cm^2)	105.69±2.13	104.39±3.69	106.49±2.60	0.748	NS

NS: Not significant. BF: Body fat, SEM: Standard error of the mean, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, TAF: Total abdominal fat, IAAT: Intra-abdominal adipose tissue

Table 3: Prevalence of overweight, obesity, and regional adiposity

Variables	Total *n*=200 (%)	Male *n*=77 (%)	Female *n*=123 (%)	*P* value	Significance
Overweight (according to BMI)	37 (18.5)	15 (19.48)	22 (17.89)	0.962	NS
GO (according to BMI)	22 (11)	11 (14.29)	11 (8.94)	0.418	NS
(AO) (according to WC)	34 (17)	7 (9.09)	27 (21.95)	0.349	NS
Obesity (according to % BF)	30 (15)	15 (19.48)	15 (12.20)	0.968	NS
TAF (cm^2)	16 (8)	7 (9.09)	9 (7.32)	0.346	NS
IAAT (cm^2)	33 (16.5)	6 (7.80)	32 (26.02)	0.3188	NS
Subcutaneous adipose tissue (cm^2)	54 (27)	32 (41.56)	22 (17.89)	0.334	NS

NS: Not significant, BMI: Body mass index, GO: Generalized obesity, AO: Abdominal obesity, WC: Waist circumference, BF: Body fat, TAF: Total abdominal fat, IAAT: Intra-abdominal adipose tissue

Table 4: Prevalence of cardiometabolic risk factors

Variables	Total *n*=200 (%)	Male *n*=77 (%)	Female *n*=123 (%)
Impaired fasting glucose (prediabetic)	38 (19)	19 (24.68)	19 (15.45)
MetS	11 (5.5)	7 (9.09)	4 (3.25)
Hypertension according to SBP	12 (6)	9 (11.69)	3 (2.44)
Hypertension according to DBP	26 (13)	18 (23.38)	8 (6.50)
Prehypertension according to SBP	90 (45)	43 (55.84)	47 (38.21)
Prehypertension according to DBP	61 (30.5)	25 (32.47)	36 (29.27)

MetS: Metabolic syndrome, SBP: Systolic blood pressure, DBP: Diastolic blood pressures

Table 5: Pearson's correlation of FBG with obesity and blood pressure

Pair	Male		Female	
	Pearson's correlation	*P* value	Pearson's correlation	*P* value
FBG versus GO (BMI)$	0.51	<0.00001	0.56	<0.00001
FBG versus AO (WC)$	0.47	1.6E-05	0.46	<0.00001
FBG versus SBP*	0.22	0.0545	0.10	0.271
FBG versus DBP$	0.35	0.0018	0.20	0.0265

$Significant positive correlation, *Nonsignificant positive correlation. FBG: Fasting blood glucose, GO: Generalized obesity, BMI: Body mass index, AO: Abdominal obesity, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 6: Predicted BMR of healthy, overweight, and obese subjects

Individual	Male BMR (kcal/day) (mean±SEM)	Female BMR (kcal/day) (mean±SEM)	*P* value	Significance
Healthy according to BMI	1638.68±11.36	1252.14±7.52	0.000027	*P*<0.05
Overweight according to BMI	1732.33±12.20	1357.32±14.15	0.000027	*P*<0.05
Obese according to BMI	1907.36±35.60	1454.81±28.05	0.000027	*P*<0.05
Obese according to WC	1942.86±49.22	1375.07±19.75	0.322	NS

NS: Nonsignificant. BMR: Basal metabolic rate, BMI: Body mass index, WC: Waist circumference, SEM: Standard error of the mean

has significant practical relevance, inquiring BMI as a suitable tool in Indian population, mostly in females. The study demonstrated high prevalence of intra-abdominal (16.5%) and subcutaneous adiposity (27%). Therefore, about 17% of the population having abdominal obesity as measured by several parameters in the present study is of important concern since it is associated with metabolic and cardiovascular disorders.[1,8,9] The high percentage of subjects who had MetS in the whole group was 5.5% also notable. The present study has shown that marked increase BMR in obese group of both sexes as compared to healthy and overweight subjects.

Obesity is a worrisome in developed as well as developing countries attributed mainly to a disparity between energy intake and energy expenditure.[20] The appearance of obesity in adolescents and young adults might be due to significant

Table 7: Predictive BMR according to various groups

BMR (kcal/day)	Healthy according to BMI (a)	Overweight according to BMI (b)	Obese according to BMI (c)	Obese according to WC (d)	Significance (P<0.05)
Male subjects	1638.68±11.36	1732.33±12.20	1907.36±35.60	1942.86±49.22	a/b, a/c, a/d, b/d
Female subjects	1252.14±7.52	1357.32±14.15	1454.81±28.05	1375.07±19.75	a/b, a/c, a/d

BMR: Basal metabolic rate, BMI: Body mass index, WC: Waist circumference

Table 8: Pearson's correlation of BMR with obesity

Pair	Male		Female	
	Pearson's correlation (r)	P value	Pearson's correlation (r)	P value
BMR versus BMI[$]	0.91	<0.00001	0.88	<0.00001
BMR versus WC[$]	0.84	<0.00001	0.69	<0.00001

[$]Significant positive correlation. BMR: Basal metabolic rate, BMI: Body mass index, WC: Waist circumference

nutritional swing such as consumption of nontraditional fast food, lifestyle evolution, and a sharp increase in sedentary activities such as television viewing and computer usage. These alterations cause significant effects on body composition and metabolism, frequently resulting in increased BMI and visceral adiposity.[21,22] The prevalence of obesity according to BMI was 11% in the present paper which is comparable to the prevalence other studies.[23-25] Numerous studies have revealed that both IAAT and SCAT are coupled with adverse cardiometabolic risk factors.[26,27] SCAT as compared to IAAT is more considerably connected with the MetS in Asian Indians.[28] In this circumstance, it is matter of concern that considerable percentage of females in the present study had both high SCAT and IAAT. Augmented visceral fat and abdominal adiposity are leads to a cluster of conditions such as dysglycemia, dyslipidemia, and hypertension known as MetS, which is the most frightening complication of obesity.[29,30] In this study, the most common MetS indicators observed were increased WC while the least common components being, hyperglycemia and elevated blood pressure. Study by Usha *et al*.[9] and on larger population by Li *et al*.[31] and Singh *et al*.[32] have shown an overall MetS prevalence of 3.7%, 4.2%, and 3%, respectively, among young adults and adolescents. Recently, Nolan *et al*. published an article pertaining to analysis of pooled data from 34 studies and presented that MetS was present in 4.8–7% among young adults.[33] In accord with earlier studies performed in obese subjects, the higher BMR of our male subjects can be explained mostly by their higher fat-free mass as compared to females[34,35] and marked increase BMR in obese subjects of both sexes as compared to healthy individuals might be due to the presence of a larger fat-free mass component of the increased weight of the obese and overweight subjects.[36]

Strength and Limitations

In this study, we measured % BF, TAF, SCAT, and IAAT using standard, reliable, simple, and accurate equations for the 1st time in Asian Indians young adults. These equations can also be used for epidemiological purpose and in the clinics. This method is less expensive as compared to methods to measure total adiposity such as dual-energy X-ray absorptiometry scan, computerized tomography or magnetic resonance imaging, and special software. Some limitations are there in our study. No cause and effect inferences can be drawn since it was a cross-sectional study. Second, for estimation of BMR, we used the predictive equations not with the help of indirect calorimetry.

CONCLUSION

It is concluded that high prevalence of obesity, abdominal obesity, regional adiposity, and MetS in the young adults of Rajnandgaon of Chhattisgarh is of concern and requires action of primary prevention approach.

ACKNOWLEDGMENT

We are grateful to the subjects, staffs, and Faculties of the Department of Physiology for their cooperation and to Dr. Monika Dengani, Department of Community Medicine, GMC, Rajnandgaon, for her kind assistance and valuable advice in improving the manuscript. The authors are thankful to Dr. R.K. Singh, Dean, Government Medical College, Rajnandgaon, for providing the necessary provisions, are also praiseworthy and acknowledged here, with sincerity.

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How to cite this article: Kesh SB, Das S, Pathak S, Waghmare VS, Mendhe HG. A study of the prevalence of generalized obesity, abdominal obesity, regional adiposity, and metabolic syndrome among young adults. Natl J Physiol Pharm Pharmacol 2018;8:988-994.

Source of Support: Nil, **Conflict of Interest:** None declared.