Comparison of Anthropometric Body Adiposity Indices to Assess the Prevalence of Obesity among Middle Class Punjabi Females

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ABSTRACT: The present cross-sectional study was conducted among 1520 Punjabi females (age ranges 25-55 years) during the period from June 2013 to September 2014 residing in various urban and rural areas of Amritsar (Punjab). The aim of the present study was to compare screening ability of different anthropometric obesity indices named as BMI, WC and WHtR to predict the occurrence of obesity. Body weight, height, WC were measured and then BMI and WHtR were calculated. The prevalence of obesity was found to be the highest (73.5%) using WHtR cut-offs and the lowest (27.8%) according to BMI classification of WHO ('98) in the study group. The most interesting finding of this study was combined screening of femalesbased on the application of four criteria i.e. BMI ('98, 2000), WC and WHtRwhich demonstrated that 20.7% (314) females exhibited obesity due to the overlapping of criteria.

INTRODUCTION

Obesity is widely acknowledged as one of the most prevalent nutritional disorder throughout the world including Asia (Yoon *et al.*, 2006; Ramachandran *et al.*, 2010; Kshatriya and Acharya, 2016). In the span of time, it has increased tremendously in both developed and developing countries and is recognised as a global epidemic (Popkin and Doak,'98; WHO, 2000; Chopra *et al.*, 2002; Kalra and Unnikrishnan, 2012; Ellulu *et al.*, 2014; Poobalan and Aucott, 2017). The National Family Health Survey (NFHS-4, 2015-16) report indicated that the number of obese females has almost doubled in India over the period of ten years. The prevalence of obesity on the basis of Body Mass Index (BMI$\geq$25 kg/m^2) has increased from 12.6% in 2005-06 (NFHS-3) to 20.7% in 2015-16 (NFHS-4) among females. In Punjab, 31.3% females were encountered as obese. Furthermore, NFHS-4 findings illustrated that the figures for obese women varies from district to district postulating the highest (43.6%) prevalence of obesity among females hailing from Doaba region of Punjab (Roop Nagar district) followed by Malwa region with 41.0% (Fategarh Sahib district) and then Majha region with 31.6% (Gurdaspur district), respectively. In Amritsar, 30.3% (urban: 30.6%; rural: 30.1%) females were reported as obese which is quite alarming.

Obesity is the forerunner of metabolic dysfunction and predisposes individuals to various non-communicable chronic medical health conditions which includes hypertension, Type 2 Diabetes Mellitus (T2DM), dyslipidemia, Night Eating Syndrome (NES), atherosclerosis, osteoarthritis, stroke, gall bladder disease, Polycystic Ovarian Syndrome (PCOS), Cardiovascular Diseases (CVDs) and certain forms of cancer (Howard *et al.*, 2003; Sharma and Chetty, 2005; WHO, 2010; Wolin *et al.*, 2010; Yataru, 2011; Randhawa *et al.*, 2014; Sidhu and Randhawa, 2014; Oommen *et al.*, 2016; Rath *et al.*, 2016). These numerous medical complications impair quality of life and leads to morbidity and mortality (Folsom *et al.*, '93; Visscher *et al.*, 2001; Kopelman *et al.,* 2006;Whitlock *et al.,* 2009; Rehman *et al.,* 2010). Innumerable factors influence the obesity epidemic including genetic susceptibility, socioeconomic, cultural, behavioural, environmental factors, dietary pattern, lack of physical activity and sedentary lifestyle encouraged by television viewing as well computer usage (Hill and Peters, '98 ; Seikh *et al.*, 2011; Poterico *et al.*, 2012; Bhurosy and Jeewon, 2014; Tripathy *et al.,* 2016; Ghose, 2017).

The role of anthropometry is well recognized as a pioneer in the screening and diagnosis of health risk and nutritional status, regardless of age, gender, region and ethnicity (Scafoglieri *et al.,* 2014). Currently, various methods and techniques are available for assessment of obesity but still in clinical practice and public-health studies, the measurements of anthropometric indices are found as the simplest, easiest, non-invasive and cost-effective potential predictors of medical complications of obesity (Pua and Ong, 2005; Ouyang *et al.,* 2015). BMI (an overall obesity measure) is a simple universal index used for assessment of overweight and obesity in the terms of weight and height. However, despite of its common usage among clinical settings and large scale epidemiological studies still its facing criticism in the terms of its diagnostic accuracy (Romero-Corral *et al.,* 2008; Daniels, 2009; Gurunathan and Myles, 2016). BMI has inability to discriminate between lean mass and fat mass. Therefore, it introduces misclassification problem by not providing information about fat free components (bone mass, muscle mass, mineral content and body fluids) for a given BMI across age, gender and ethnicity (Jackson *et al.,* 2002; Whitlock *et al.,* 2009). Thus, resulting in variability in different individuals and populations (Rothman, 2008; Wells, 2011; Gomez-Ambrosi *et al.*, 2012; Pasco *et al.,* 2014; Grier *et al.,* 2015). Various researchers (Raji *et al.,* 2001; Deurenberg *et al.,* 2002; Rush *et al.,* 2004; Kagawa *et al.,* 2006) reported that Indians and other Asians have a smaller body frame and BMI classification of obesity based on large framed Euroid populations may be inappropriate for them. In fact BMI of 30 kg/m^2 among Europeans correlates with about 25% of percent body fat content in males and 30% of percent body fat in females, while for same age, gender and BMI; South Asians have an increased percent body fat and lesser lean mass predicting higher risk for CVDs (Forbes and Reina,'70; Larsson *et al.,*'84 ; Bagry *et al.*, 2008; Abdullah *et al.,* 2010). Accumulating evidences have elucidated that at a similar value of BMI, Asian Indians have significantly greater total abdominal and visceral fat area (McGee, 2005) compared with white Caucasians resulting in metabolic disorders at much lower levels of BMI (Lorenzo *et al.,* 2003; Gupta *et al.,* 2004; Ortega *et al.,* 2013).

Abdominal obesity also known as belly fat or central obesity, is excessive accumulation of fat around the abdomen which is subjected to the presence of Visceral Adipose Tissue (VAT). Increased amount of VAT (accumulation of fat around the internal organs) leads to visceral obesity which act as driving force for the progression of insulin resistance (Wagenknecht *et al.,* 2003), dyslipidemia (Pascot *et al.,*'99), hypertension (Sironi *et al*., 2004) and Metabolic Syndrome (MS) (Carr *et al.*, 2004). However, precise measurement of intraabdominal fat requires the use of radiological imaging techniques which are quite expensive. Various studies (Pouliot *et al.,*'94; Kamel *et al.,*'99; Onat *et al.,* 2004) revealed direct relationship of WaistCircumference (WC) with VAT. Evidently, WC has been proposed to be the best amongst anthropometric measurements manifesting strong correlation with abdominal imaging and high association with CVD risk factors particularly in countries of Asia-Pacific region where individuals may exhibit a relatively normal BMI (<25 kg/m^2) but have a disproportionately large WC (Reddy *et al.,* 2002; Nyamdorj *et al.,* 2008; Cornier *et al.,* 2011; InterAct *et al.,* 2012). Moreover, the measurement of WC to determine abdominal obesity has been recommended as mandatory component for the diagnosis of MS according to International Diabetes Federation (IDF, 2005) guidelines.

WC is the easiest of the obesity-related anthropometric parameters to measure because, i) it involves measurement of single parameter i.e. waist circumference, ii) it requires homely, economical, painless portable string called as non-stretch tape, iii) effortless basic technical skill involved in the measurement of waistline, iv) respondents are more likely to cooperate because it does not require the exposure of private body parts or any electric current passage as necessary for other body composition techniques. These make WC more easily applicable to population screening studies while it can also be incorporated into daily routine general clinical physical examination at no additional cost to the patient. The limitation of WC as an anthropometric parameter lies in the non-uniformity of its measurement method as well over and under evaluation of risk for tall and short individuals because it does not account differences in height (Browning *et al.,* 2010; Ghazali and Sanusi, 2010; Monzani *et al.,* 2016).

Waist-to-Height Ratio (WHtR) is highly sensitive, simple, cheap and global screening tool for the prediction of abdominal obesity independent of age, sex and ethnicity. Ashwell and Hseih (2005) very well documented the importance of using WHtR over other anthropometric obesity indices by a tag line 'Keep your WC to less than half your height' along with six key points for the application of WHtR at every stage of life throughout the world. The most important key points mentioned by Ashwell and Hseih (2005) overwhelmingly solved the under or over evaluation obesity issues accordingly i) WHtR is more sensitive than BMI in predicting abdominal obesity among subjects who have moderate BMI (Hseih *et al.,* 2000; Obeidat *et al.,* 2015). In addition to this, WHtR can be even more sensitive than WC to define abdominal obesity by taking height into consideration among several different populations possibly because it encompasses the adjustment to different statures (Lin *et al.,* 2002; Sayeed *et al.,* 2003) as height may influence the fat distribution (Hseih*et al.,* 2006). ii) A cheap and reliable homely string is required to measure height and then by joining the ends of same string it can be wrapped around your waist to ensure your WC is less than half your height. iii) WHtR allows the same boundary value i.e. 0.5 to indicate increased risk for adult men and women (Ashwell, 1998; Hsieh *et al.*, 2003).iv) WHtR allows the same boundary value for different ethnic groups. v) WHtR boundary values can be converted into a consumer-friendly chart to diagnose the severity of metabolic risks in the terms of measuring obesity.vi) WHtR may allow the same boundary value for children and adults. Since the height and WC of children increases continually as they age, the same boundary value could be used across all age groups (McCarthy & Ashwell, 2006).Several investigators (Dobbelsteyn *et al.,* 2001; Ho *et al.,* 2003; Kahn *et al.,* 2005; Duvjnak and Duvjnak, 2009; Guh *et al.,* 2009) marked that WHtR to be superior to BMI and WC for the identification of cardiovascular risk factors and related health conditions. The predictive power of an anthropometric index is population dependent and varies from race to race (Esmailzadeh *et al.,* 2004).Therefore, the primary objective of the present study was to compare the efficacy of BMI, WC and WHtR in the diagnosis of obesity among middle class Punjabi females.

MATERIALS AND METHODS

The present cross-sectional study has been conducted among 1520 females ranging in age between 25 to 55 years. The data for the study group was collected from various urban and rural areas of Amritsar (Punjab) during the period from June 2013 to September 2014. Ethical clearance from the Institutional Ethical Review Committee of Guru Nanak Dev University was obtained prior to carrying out the study. First of all, females were taken into confidence. After fully explaining the nature, procedure, aims and objectives of the study to all the females in a language they understood, verbal as well as written informed consent was obtained. The participation of females was voluntary. All the females were interviewed in person at their homes to collect information regarding socio-demographic variables (name, age, residence, education, marital status, type of family, job status), reproductive history (menstrual status), dietary pattern (vegetarian/non-vegetarian, fruits and salad intake, junk food consumption, soft drinks intake) physical activity pattern (low/moderate), sedentary behaviour (sleep pattern, TV watching) using a well-designed and structured pro forma.

Anthropometric measurements (body weight, height) were taken on each subject using standard methodology given by Weiner and Lourie (1981) while subjects were lightly clothed and wore no shoes. Body weight was measured to the nearest 0.1 kg using automated calibrated electronic scale. Standing height was measured without shoes to the nearest 0.5 centimetre using anthropometric rod. From height and weight measurements, BMI was calculated by dividing weight in kilograms with height in metre squared as follows:

$$BMI = weight\ (kg)/\ (height)^2\ (m)$$

The suggested critical limits of BMI by WHO ('98) were used for assessment of obesity

BMI (kg/m^2)	Category
<18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
≥ 30	Obese

The suggested critical limits of BMI by WHO (2000) were used for assessment of obesity:

BMI (kg/m^2)	Category
<18.5	Underweight
18.5-22.9	Normal
23.0-24.9	Overweight
≥ 25	Obese

WC is the best tool for the assessment of abdominal obesity. It was measured with the help of a non-stretch fibre glass measuring tape at a point midway between the inferior margin of the ribs and the superior border of the iliac crest on each subject single handedly by the investigator herself according to the guidelines of WHO (2008). From WC and height, Waist-to-Height ratio (WHtR) was calculated by dividing WC in centimeterwith height in centimeteras follows:

$$WHtR= WC\ (cm)\ /\ Ht\ (cm)$$

Following criteria were used for the assessment of abdominal obesity

Variable	Normal	Obese	Criteria
WC	<80	≥ 80	Snehalatha *et al.*, 2003
WHtR	<0.5	≥ 0.5	Hseih and Muto, 2005

Socioeconomic Status (SES) is one of the most important social determinants of health and disease, thus, widely studied in epidemiological studies. Though it was pre-decided to enroll middle class women in this study but still to confirm their status; the assessment of SES was done. Several ways of measuring SES have been suggested for categorizing different rural and urban populations in last few decades. The most widely used scale is Kuppuswamy's socioeconomic scale which was devised by Kuppuswamy in 1976. This scale is a composite score of three domains i.e. education, occupation and income of the head of the family along with monthly income of family which yields a score of 3-29. This scale classifies the study population into high, middle and low SES. The latest upgraded version of the scale was used in the present study (Kumar *et al.*, 2013). Physical activity is defined as any force exerted by skeletal muscles that results in energy expenditure above resting level (Casperson *et al*., '85). It is a major independent modifiable risk factor for obesity related co-morbidities. Surveillance of physical activity in community based studies using a standardized protocol is an important and necessary part of a public health response to current concerns regarding lack of physical activity in many populations. Physical activities can vary widely in intensity that further varies according to the type of activity and the capacity of the individual. METs (Metabolic Equivalents) are commonly used to express the intensity of physical activities .MET is the ratio of a person's working metabolic rate relative to the resting metabolic rate. One MET is defined as the energy cost of sitting quietly, and is equivalent to a caloric consumption of 1 kcal/kg/hour. In the present study, physical activity was assessed by using Global Physical Activity Questionnaire (GPAQ) which was developed by WHO for physical activity surveillance in various countries (WHO, 2004). Data was analysed using the Statistical Package for Social Sciences (SPSS inc, Chicago, IL, USA; version 17). The percentage was calculated for categorical variables. Venn diagram was drawn to check overlap of different criteria used in the study for assessment of obesity. All analyses considered p-value <0.05 statistically significant.

RESULTS

Socio-Demographic and Lifestyle Habits

Table 1 shows the percentage prevalence of socio-demographic variables and lifestyle habits of middle class Punjabi females. The present study included 1520 females, out of which 52.6% females were residing in urban areas, whereas 47.4% were hailing from rural areas. The prevalence of participants who were educated (50.5%) was marginally higher as compared to their uneducated (49.5%) counterparts. Alarmingly, the present study sample comprised of 91.4% married females which was almost ten times more than unmarried (8.6%) ones. Considering type of family, 41.2% females belonged to nuclear families, whereas 58.8% females hailed from joint family system. Apparently, 84.8% females were reported as non-working and 15.2% as working. When we looked at SES, majority (65.4%) of the females represented upper middle class, whereas 34.6% belonged to lower middle class. As per menstrual status, 52.0% were premenopausal and 48.0% were postmenopausal, respectively. In context to the lifestyle habits, it was evident from this table that 68.1% females were vegetarians. On the other hand, 31.9% females had non-vegetarian eating pattern. The prevalence of females who had less than 3 times per week ingestion of fruits and salad was on higher side (68.8%) than their counterparts (≥ 3 times per week: 31.2%) who had optimum intake. The subjects who prefer junk food consumption ≥ 3 times per week were 51.6%, whereas 48.4% females were not indulged in junk food consumption regularly. 53.6% females had habit of drinking soft drinks frequently as compared to 46.4% who did not gulp down such drinks on a regular basis. The prevalence of females who invest ≥ 2 hours per day in watching T.V. was found to be 40.3%. In contrast to this, 59.7% females did not show such sedentary lifestyle habit. Moreover, the data suggests that the prevalence of females with respect to their sleep duration was 65.9% (<8 hours per day) and 34.1% (≥ 8 hours per day), respectively. On analysing the levels of physical activity i.e. moderate (600-3000 MET-min/week) or low (<600 MET-min/week), it was found that 61.1% females exhibited low levels of physical activity which was almost two times more than those who demonstrated moderate levels (38.9%) of physical activity.

Prevalence of Obesity & Anthropometric Body Adiposity Indices

Table 2 depicts the percentage prevalence of obesity according to anthropometric body adiposity indices namely BMI, WC and WHtR . BMI is the most frequently used, inexpensive and reliable diagnostic tool for the assessment of overall obesity in epidemiological studies as well as clinical settings. The prevalence of overweight and obesity in the studied females was computed using WHO (‘98) criterion of BMI. Females having BMI less than 18.5 kg/m^2 were considered as underweight, less than 25.0 kg/m^2 were considered as normal, less than 30.0 kg/m^2 were considered as overweight. On the other hand, those females who had BMI more than 30.0 kg/m^2 were categorized as obese females. In the present study, the prevalence of obesity was 27.8%, whereas 34.0% females were overweight, 32.1% were normal and 6.1% were underweight. Using WHO (2000) criterion of BMI, the prevalence of overweight and obesity was also assessed in the present study. Females having BMI less than 18.5 kg/m^2 were considered as underweight, less than 23.0 kg/m^2 were considered as normal, less than 25.0 kg/m^2 were considered as overweight. On the other hand, those females who had BMI more than 25.0 kg/m^2 were categorized as obese females. In the present sample, the prevalence of overweight and obese females was 12.8% and 61.4%, respectively. Further, it was observed that 19.6% females were normal, while 6.2% females were underweight. WC is the most widely used, easiest and internationally recommended tool for assessing abdominal fat and determining health risks. The percentage prevalence of abdominal obesity was assessed among studied females using WC cut-offs (Normal: WC < 80 and Obese : WC e” 80) devised by Snehalatha *et al*. (2003). In the pooled sample, 70.5% females were found to be abdominally obese, whereas 29.5% were normal. WHtR is an eminently sensitive, precise and useful anthropometric parameter for the assessment of body fat which has been associated with many chronic diseases (hypertension, T2DM, cardiovascular diseases and stroke etc.) and mortality. In the present study, the prevalence of obesity was also determined using WHtR criterion given by Hseih and Muto (2005). According to which the females who had WHtR<0.5 were considered as normal whereas those females who had WHtR e” 0.5 were categorized as obese. Using WHtR criterion, the prevalence of obesity was 73.5%, whereas 26.5% females were found as normal.

Differences in the Percentage Prevalence of Obesity Using Different Anthropometric Obesity Indicators

Table 3 illustrates the differences in the percentage prevalence of obesity using

TABLE 1

Percentage prevalence of socio-demographic variables and lifestyle habits among middle class Punjabi females

Socio-demographic Variables	*Overall (N=1520)*
Place of Residence	
Urban	52.6 (800)
Rural	47.4 (720)
Education Status	
Illiterate	49.5 (752)
Educated	50.5 (768)
Marital Status	
Unmarried	8.6 (131)
Married	91.4 (1389)
Type of Family	
Nuclear	41.2 (626)
Joint	58.8 (894)
Job Status	
Working	15.2 (231)
Non-Working	84.8 (1289)
Socioeconomic Status (SES)	
Upper Middle	65.4 (994)
Lower Middle	34.6 (526)
Menstrual Status	
Premenopausal	52.0 (791)
Postmenopausal	48.0 (729)
Lifestyle Habits	
Eating Pattern	
Vegetarian	68.1 (1035)
Non-Vegetarian	31.9 (485)
Fruits and Salad Intake	
<3 times per week	68.8 (1045)
≥ 3 times per week	31.2 (475)
Junk Food Consumption	
<3 times per week	48.4 (736)
≥ 3 times per week	51.6 (784)
Soft Drinks Intake	
Frequent	53.6 (815)
Infrequent	46.4 (705)
T.V Watching	
<2 hours per day	59.7 (907)
≥ 2 hours per day	40.3 (613)
Sleep Duration	
<8 hours per day	65.9 (1002)
≥ 8 hours per day	34.1 (518)
Physical Activity	
Low (<600 MET-min per week)	61.1 (929)
Moderate (600-3000 MET-min per week)	38.9 (591)

Figures in parenthesis indicate the number of subjects.

TABLE 2

Percentage prevalence of underweight, normal, overweight and obesity according to Body Mass Index (BMI), Waist Circumference (WC) and Waist-to-Height Ratio (WHtR) Adiposity Indices among middle class Punjabi females

Obesity Indices	Percentage Prevalence
BMI (1998) (kg/m^2)	
Underweight (<18.5)	6.1 (93)
Normal (18.5-24.9)	32.1 (489)
Overweight (25.0-29.9)	34.0 (515)
Obese (≥ 30.0)	27.8 (423)
BMI (2000) (kg/m^2)	
Underweight (<18.5)	6.2 (93)
Normal (18.5-22.9)	19.6 (298)
Overweight (23.0-24.9)	12.8 (195)
Obese (≥ 25)	61.4 (934)
WC (cm)	
Normal (<80)	29.5 (448)
Obese (≥ 80)	70.5 (1072)
WHtR	
Normal (<0.5)	26.5 (403)
Obese (≥ 0.5)	73.5 (1117)

Figures in parenthesis indicate the number of subjects. (kg/m^2): kilograms per square meter; (cm): centimetre

TABLE 3

Differences in percentage prevalence of obesity using Body Mass Index (WHO '98; 2000), Waist Circumference (Snehalathaet al., 2003) and Waist-to-Height Ratio (Hseih and Muto, 2005) Cut-Offs among middle class Punjabi females

Nutritional Status	Reference Cut-Offs	Percentage Prevalence
Obese	BMI (1998) (kg/m^2)	27.8
	BMI (2000) (kg/m^2)	61.4
	WC (cm)	70.5
	WHtR	73.5
	WHtR minus WC	3.0
	WHtR minus BMI (2000)	12.1
	WHtR minus BMI (1998)	45.7
	WC minus BMI (2000)	9.1
	WC minus BMI (1998)	42.7
	BMI (2000) minus BMI (1998)	33.6

BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist-to-Height Ratio; ($kg.m^2$): kilograms per square meter; (cm): centimetre.

anthropometric body obesity indicators i.e. BMI, WC and WHtR on the basis of four reference criteria named as BMI (WHO,'98; 2000), WC (Snehalatha *et al.*, 2003) and WHtR (Hseih and Muto, 2005), respectively. In the pooled sample, the prevalence of obesity according to WHtR parameter was 3.0, 12.1 and 45.7 percentage points higher than WC and BMI classification of 2000 and 1998, respectively. Further, considering WC measure, the prevalence of obesity was observed to be 9.1 percentage points more than BMI criterion of 2000. On the other hand, compared to BMI criterion of '98, WC variable manifested far higher estimates (42.7) of obesity. On comparison of BMI criterion of '98 and 2000, the results indicated that the obesity assessed by the most recent criterion of BMI i.e. (WHO, 2000) was 33.6 percentage points greater as compared to BMI criterion of '98.It is noteworthy from the investigated results that the maximum difference in the prevalence of obesity was found between WHtR and BMI indicator (WHO,'98), whereas the minimum difference was observed between WHtR and WC obesity indicators, respectively. This proves that the estimates of prevalence of obesity was the highest on utilizing WHtR obesity variable and the lowest according to BMI obesity parameter using WHO ('98) criterion.

Overlapping of Subjects with Obesity Based on Four Different Criteria of Assessment

Among studied females, the overlapping of subjects with obesity based on the application of four criteria [BMI (WHO, '98, 2000), WC and WHtR] has been presented through Venn diagram (see Figure 1). 1 out of 1520 females, 91.1% (1385) females had obesity according to any of the above-stated four criteria, whereas none of these guidelines predicted obesity among 8.9% (135) females. This figure clearly indicates that the prevalence of females who were encountered as obese independently by BMI (WHO, 2000) criterion was 2.8% (43). Surprisingly, not even a single female satisfied BMI (WHO,'98) criterion solely i.e. without getting overlapped by any other criterion. On the other hand, 2.8% (43) and 13.6% (206) females were identified obese only on the basis of WC and WHtR cut-off points, respectively. The overspreading of two standards namely BMI (WHO,'98, 2000) calculated the prevalence of obesity among 1.2% (19) females

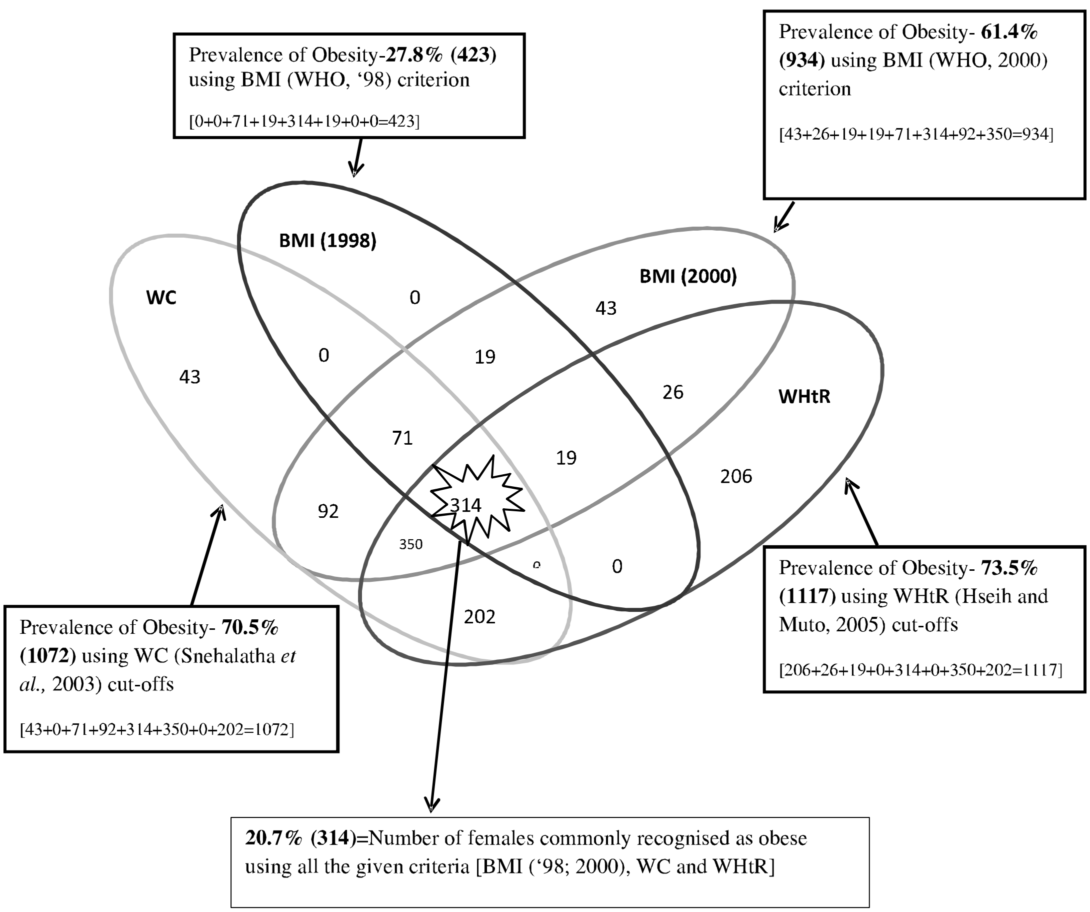

Figure 1: Venn diagram represents overlapping of subjects with obesity based on four different criteria

which is preceded by the overlying of BMI (WHO, 2000) and WC cut-offs [6.1% (92)] then WC and WHtR [13.3% (202)] standards, respectively in the study group. Based on the overlapping of three definitions, 4.7% (71), 1.2% (19) and 23.0% (350) females were found as obese using combination of BMI (WHO,'98) + BMI (WHO, 2000) +WC cut-offs, BMI (WHO,'98) + BMI (WHO, 2000) +WHtR cut-offs and BMI (WHO, 1998) + WC +WHtR cut-offs, respectively. It is interesting to note that 20.7% (314) females were commonly diagnosed obese by using four criteria of interest all together.

DISCUSSION

The multiplicity and variability of anthropometric indices for the prediction of obesity using different cut- off points among population based studies have made the diagnosis controversial and complex. Our results suggested that BMI, WC and WHtR were all associated with obesity but the predictive power of these anthropometric indices was genuinely comparable among middle class Punjabi females. Therefore, in general, our main finding was that WHtR yielded the highest (73.5%) prevalence of obesity which was followed by WC (70.5%) and BMI [61.4% (WHO, 2000); 27.8% (WHO,'98)], respectively. Several researchers (Pua and Ong, 2005; Ashwell and Gibson, 2009; Mombelli *et al.*, 2009; Rodrigues *et al.*, 2009; Rajput *et al.*, 2014; Rodea-Montero, 2014; Obeidat *et al.*, 2015; Bullapa and Mahendra, 2017) show agreement with the results of the present study in context to the validation of WHtR as the most sensitive and best anthropometric index for the prediction of abdominal obesity. In contrast to this, few studies (Han *et al.*, '97; Kato *et al.*, 2008; Ghazali and Sanusi, 2010; Nakamura *et al.*, 2011; Bener *et al.*, 2013; Ouyang *et al.*, 2015) reported WC as the leading anthropometric measure to assess body fat distribution. Kotian and Kedilaya (2013) and Lam *et al.* (2015) documented BMI as the universal and foremost obesity indicator compared to other anthropometric body adiposity indices; at times utilizing solely or in combination with other obesity variables. However, one of the study conducted among 772 Chinese subjects during the period between 2008-2009 concluded that BMI, WC and WHtR values may equally predict multiple metabolic risk factors (Liu *et al.*, 2011).Nevertheless, WHtR conveys the highest risk of obesity related metabolic complications regardless of age, gender, geographical background and ethnicities (Ashwell,'98; Hseih and Muto, 2006; Parikh *et al.*, 2007). This is because the height of an individual influences the distribution of body fat, and this factor should be taken into consideration before adopting any anthropometric variable as a measure of adiposity. Asians populations tend to be shorter than their Caucasian counterparts. Further, the health risks for Asians begin to increase for smaller amounts of abdominal fat and smaller WCs than their Caucasian counterparts (WHO, 2004). In conclusion, Although WHtR has been turned out as globally unrivalled economical anthropometric index for the assessment of obesity but the unsurpassed key point of the present study was combined screening of subjects which is encouraged by the overstretched debates regarding the use of different anthropometric indices in the epidemiological studies.

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