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RELATIONSHIP BETWEEN VARIOUS ANTHROPOMETRIC INDICATORS USED FOR OBESITY MEASUREMENT AMONG COLLEGE GOING GIRLS OF AGRA

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ABSTRACT

Context: Obesity has escalated to an alarming proportion in the last twenty years. It is currently the most preventable nutritional disease of the 21st century.
Aims: 1. To find out the prevalence of obesity according to different anthropometric indicators among college going girls of Agra. 2. To study their correlation matrix.
Study design: Cross sectional study.
Setting: Degree colleges of Agra
Study period: January to June 2009
Sample size: 400 college going girls of 18-24 years.
Study variable: Height, Weight, Waist circumference (WC), Hip circumference (HC)
Statistical Analysis: Percentage, chi square, correlation coefficient
Results: The prevalence of overweight and obesity was found to be 18.5% & 4.5% respectively according to Body mass index (BMI), while using other criteria like WC, Waist to Height Ratio (WHtR) & Waist to Hip Ratio (WHR) it was 23.3, 19.3 & 11.5 percent respectively. All the obese by BMI classification were having above normal WC & WHtR. Among those 11.5 percent detected centrally obese by WHR, two third were also overweight/obese by BMI criteria. Among obese (4.5 %) detected by BMI classification, more than half (55.5%) were having their height less than reference Indian women height. Of the 14.5% subjects with below normal height, 25.9%, 27.6% and 31% were having their WHtR, WHR and WC greater as compared to normal ones. WHtR was found to be strongly correlated with WC (0.90) & BMI (0.87).
Conclusion: In addition to generalized obesity, central obesity in early ages may contribute to some chronic diseases in adulthood. An intervention programme, therefore, is urgently needed to reduce overweight and obesity in adolescent stages. Further studies need to be carried out to identify which anthropometric parameter has the highest predictive value in the identification of subjects at risk of obesity-related disorders.

INTRODUCTION

It is now evident that many diseases of adulthood have their roots in earlier life. Children with high body mass index (BMI) often become obese adults, who are at increased risk of developing obesity-related diseases (Mohamed, 2015). Obesity is a risk factor for several chronic diseases, particularly non-insulin dependent diabetes, hypertension, cardiovascular disease, gall bladder disease and some forms of cancer (World Health Organization, 2002).

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In 2014, more than 1.9 billion adults of 18 years and older were overweight. Among these, over 600 million were obese. Also, around 3.4 million adults die each year as a result of being overweight or obese (World Health Organization, 2015). Around 44% of the diabetes, 23% of the ischemic heart disease and 7%-41% of certain cancer burdens are attributable to overweight and obesity (World Health Organization, 2015). Excess intra-abdominal fat is associated with greater risk of obesity related morbidity than in overall adiposity (Ho *et al*., 2001). In routine clinical practice and epidemiological studies the most commonly used measure to define overweight and obesity is the Body Mass Index (BMI). In addition, central obesity is measured by increase in waist circumference (WC)

or waist-to-hip ratio (WHR) (Montague and O'Rahilly, 2000). Increased weight and waist circumference have been shown to be strongly associated with cardiovascular disease risk factors such as diabetes and hypertension in many populations (Foucan *et al*., 2002; Koh-Banerjee *et al*., 2004; Olinto *et al*., 2004). Other authors have demonstrated that the waist/height ratio(WHtR) is strongly associated with many cardiovascular risk factors suggesting that it can be used for population studies (Ashwell and Hsieh, 2005). The prevalence of obesity among adolescent girls in many developing countries is alarming. Many studies have shown that the prevalence of overweight among adolescents varies between 10 and 30% (Subramanya *et al*., 2003; Aggarwal *et al*., 2008; National Nutrition Monitoring Bureau, 2002; Laxmaiah *et al*., 2007; Ramachandran *et al*., 2002; Chatterjee, 2002; Kaur *et al*., 2005; Khadilkar and Khadilkar, 2004; Kapil *et al*., 2002; Mehta *et al*., 2007; Kaneria *et al*., 2006). Studies on anthropometry among college going girls in Agra are limited. It is the aim of this study, therefore, to find the prevalence of obesity in college going girls aged 18-24 years according to different anthropometric indicators as well as to correlate them with one another.

MATERIALS AND METHODS

A cross-sectional study has been conducted in 2009 on college going girls aged 18-24 years in Agra (urban and rural). The sample obtained through data from the study of Augustine & Poojara (2003) (Augustine and Poojara, 2003). The sample size was estimated by using the formula $4pq/d^2$ where prevalence was taken as 24% (Augustine and Poojara, 2003). The required precision of the estimate (d) was set at 20%. Using the above-mentioned formula, the sample size was estimated to be 316 and for the sample to be more representative of population, a total of 400 college going girls of 18-24 years were included in the study. The girls were selected using a multistage stratified random sampling technique. Colleges were divided into two educational levels, undergraduate and postgraduate. The colleges were then numbered, and two colleges (one undergraduate and one postgraduate) were chosen randomly from each geographical region. The girls were selected from each college by a systematic random sampling procedure from college records.

Anthropometric measurements

Anthropometric measurements were carried out by a professional investigator. Weight, height and circumference measurements were done by a single investigator. Height and weight of the subjects were measured using the standard procedure suggested by Jellife (Jelliffe, 1966). BMI (weight in kilograms divided by the square of height in metres) $^{(2)}$, WC (Waist circumference), HC (Hip circumference), WHtR (Waist/height ratio), waist/hip ratio (WHR) were used to assess nutritional status in the studied subjects. The girls were grouped into four categories in accordance with WHO standards of BMI to define individuals with underweight (BMI <18.5), normal (BMI ≥18.5-24.9), overweight (BMI ≥25–29.9) and obese (BMI≥30).[2] Waist circumference (WC) was taken midway between the lowest rib and the iliac crest and hip circumference at the level of the greater trochanters was measured to the nearest millimeter using a flexible tape. Waist-to-height ratio (WHtR) was obtained by dividing waist circumference by height. Waist-to-hip ratio (WHR) was obtained by dividing waist circumference by hip circumference. Subjects were classified in the obese categories on the basis of WC of ≥80 cm, WHtR of ≥ 0.5and WHR of ≥ 0.85 (Mehta *et al*., 2007; Seeja Thomachan Panjikkaran and Kumari, 2009). The height of Indian reference women was taken 151cm according to ICMR (Indian Council of Medical Research) reporting (Nutrient Requirements & Recommended Dietary Allowances for Indians, 1992). Data were analysed using the SPSS statistical package (SPSS 17.0). Partial correlation coefficients were calculated to investigate the association between anthropometric variables.The designated level of statistical significant was $p<0.05$ (two-tailed) where relevant. All measurements were performed in accordance with relevant guidelines and regulations and informed verbal consent and cooperation was sought from all subjects prior to their participation in the study. The research described was compliant with standards of institutional ethical committee.

RESULTS

Table 1 shows prevalence of obesity by various criteria and its relationship with BMI. It was found that the prevalence of obesity by BMI was 4.5 percent. While using other criteria like WC, WHtR & WHR it was 23.3, 19.3 & 11.5 percent respectively (Chart 1). Out of 23.3 percent centrally obese detected by WC criteria, 68.9 percent of the subjects were also either overweight or obese by BMI. All the obese by BMI classification were having above normal WC. Similarly, out of those 19.3 percent having their WHtR above the cut-off point, 90.9 percent were either overweight/obese by BMI. Also all the obese by BMI were having greater WHtR. Among those 11.5 percent detected centrally obese by WHR, two third were also overweight/obese by BMI criteria. Almost two third (66.7%) of the obese subjects by BMI were having higher WHR. The difference found to be statistically significant among obese and non obese classified by various criteria.

As the Table 2 illustrates, 58(14.5%) of the subjects were having below normal height. While analyzing the relationship between height and obesity by different height dependent and independent indicators, it became obvious that out of 18(4.5%) obese detected by BMI classification, more than half 10(55.5%) were having their height less than reference Indian women height. Out of 14.5 percent subjects with below normal height, marginally more girls 20.7% belonged to overweight category by BMI as compared to those having normal height (18.2%), while obesity among those with below normal height (17.2 %) was found to be almost 8 times more than those having normal height (2.3%) (Chart 2).

As evident from the findings that of the 14.5% subjects with below normal height, 25.9 percent subjects were also having greater WHtR as compared to their counterpart 18.1 percent subjects with normal height, although it was statistically not significant. Also out of 14.5% subjects with below normal height, 31% were having their WC above cut-off point as compared to only 21.9% with their height normal. The association was statistically significant. Also there were 27.6 percent of the subjects with below normal height having greater WHR as compared to only 8.8 percent with normal height.

Table 1. Prevalence of obesity according to different anthropometric indicators and their relationship with BMI

BMI categories (%)	WC(cm)				WHtR				WHR			
	Non obese		Obese		Non obese		Obese		Non obese		Obese	
	N	%	N	%	N	%	N	%	N	%	N	%
Underweight (31.5)	124	40.4	2	2.1	126	39.0	0	0	126	35.6	0	0
Normal (45.5)	155	50.5	27	29.0	175	54.2	7	9.1	166	46.9	16	34.8
Overweight (18.5)	28	9.1	46	49.5	22	6.8	52	67.5	56	15.8	18	39.1
Obese (4.5)	0	0	18	19.4	0	0	18	23.4	6	1.7	12	26.1
Total (%)	307 (76.7)	100	93 (23.3)	100	323 (80.7)	100	77 (19.3)	100	354 (88.5)	100	46 (11.5)	100
Level of significance*	p<0.001				p<0.001				p<0.001			

*statistically significant
(BMI=Body Mass Index, WC=Waist Circumference, WHtR=Waist to Height Ratio, WHR= Waist to Hip Ratio)

Table 2. Correlation of height with height dependent and height independent indicators of obesity

Height dependent Indicators		TOTAL		Height (cm)				Level of significance
				Ideal (≥151)		Below ideal(<151)		
		N	%	N	%	N	%	
BMI	Underweight	126	31.5	113	33.0	13	22.4	p<0.001*
	Normal	182	45.5	159	46.5	23	39.7	
	Overweight	74	18.5	62	18.2	12	20.7	
	Obese	18	4.5	8	2.3	10	17.2	
Total (%)		400	100	342 (85.5)	100	58 (14.5)	100	
WHtR	Non obese	323	80.7	280	81.9	43	74.1	p>0.05
	Obese	77	19.3	62	18.1	15	25.9	
Total(%)		400	100	342 (85.5)	100	58 (14.5)	100	
Height independent Indicators								
WC(cm)	Non obese	307	76.7	267	78.1	30	69.0	p<0.05*
	Obese	93	23.3	75	21.9	18	31.0	
Total(%)		400	100	342(85.5)	100	58(14.5)	100	
WHR	Non obese	354	88.5	312	91.2	42	72.4	p<0.001*
	Obese	46	11.5	30	8.8	16	27.6	
Total(%)		400	100	342(85.5)	100	58(14.5)	100	

*statistically significant
(BMI=Body Mass Index, WC=Waist Circumference, WHtR=Waist to Height Ratio, WHR= Waist to Hip Ratio)

The difference between obese and non obese subjects with normal and below normal height for obesity had been found to be statistically significant by using BMI, WC and WHR criteria. ($p<0.05$)

Table 3. Correlation matrix of various indicators used for determining obesity status

Indicators	WC	BMI	WHR	WHtR
WC	1	0.75	0.42	0.90
BMI	0.75	1	0.25	0.87
WHR	0.42	0.25	1	0.39
WHtR	0.90	0.87	0.39	1

(BMI=Body Mass Index, WC=Waist Circumference, WHtR=Waist to Height Ratio, WHR= Waist to Hip Ratio)

Pair-wise partial correlation between BMI, WC, WHR and WHtR was investigated (Yusuf and Khader, 2010). The results are presented in Table 3. WHtR was strongly correlated with WC (0.90) & BMI (0.87) however, only fairly correlated with WHR (0.39). WC was also strongly correlated with BMI (0.75). WHR was found to be only fairly correlated with WC (0.42) and BMI (0.25).

DISCUSSION

This study highlights the rise in overweight and obesity in Agra, whether measured by BMI, WC, WHR or WHtR, and highlights the emergence of non-communicable diseases and their risk factors as major contributors to the burden of ill-health in college students.

The socioeconomic development of recent decades in Agra has generated a neo middle class, both at the rural and urban level which may be responsible for rise in prevalence of overweight. The study done by Sharda Sidhu and Prabhjot (2002) Sharda Sidhu and Prabhjot, 2004 have reported a higher prevalence of overweight and obesity of 28.2% & 15% respectively among college girls of more than 18 years of age in Punjab as compared to our study.

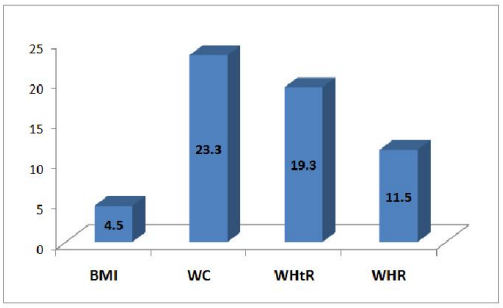
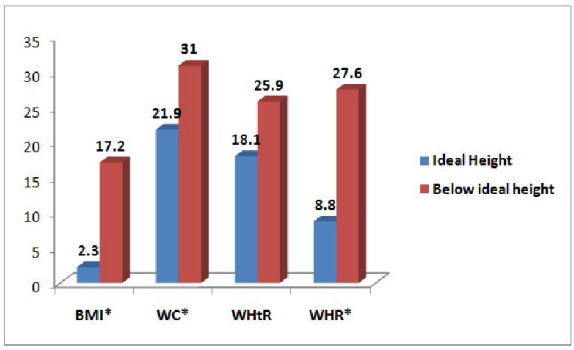


Chart 1. Prevalence of obesity according to different anthropometric indicators

The higher prevalence of obesity/overweight may be because the study was done in a economically more developed state. Also the difference in culture and food habits in Punjab might be responsible for it. Kapil *et al*. (2002) had also reported a 7.4% prevalence of obesity in affluent adolescent school children in Delhi which is higher than our results.



*Statistically significant

Chart 2. Prevalence of obesity in relation with height

The rationale for the difference might be that the latter was conducted in Delhi among affluent class of subjects. The findings of study conducted by Augustine and Poojara (2003) on urban college going girls of Ernakulam also showed the higher prevalence of overweight and obesity of 24% & 10.5% respectively, the difference from our results is due to different criteria (WHO Regional Report, 2000) used to determine the weight category status in their study. Similar study conducted by Priyanka Tiwari and Aarti Sankhala (2007) had given the nearly same prevalence of obesity of 4.4% among college going girls of Udaipur as ours. In Asian subjects, the risk associated with diabetes and cardiovascular diseases occurs at lower levels of BMI as compared to their western counterpart. This is attributed to body fat distribution; Asian Indians tend to have more visceral adipose tissue, causing higher insulin resistance, despite having lean BMI (Wang *et al*., 1994). Dalton *et al*. (2003) also reported that BMI and WHR identified different proportions of the population, as measured by both the prevalence of obesity and cardiovascular disease risk factors. It has been established that Asian Indians have a higher body fat % for the same BMI when compared to Caucasians (Deurenberg *et al*., 2002; Jessica Smith *et al*., 2006). In that context, Lower BMI cut-points have been suggested to evaluate overweight and obesity specifically for Asian populations by WHO Expert Consultation (Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies.

In the present study, in addition to Body Mass Index (BMI), different anthropometric indicators of obesity were also studied like WC, WHR & WHtR as BMI does not reflect body fat distribution, whereas the intra-abdominal deposition of adipose tissue is a major contributor to the development of hypertension, insulin resistance, type 2 diabetes mellitus and dyslipidemia (Webb, 2002). Kopelman, (2000) also suggested these parameters to be used as an alternative to BMI to study the prevalence of obesity. In our study, BMI by WHO classification detected 23 percent of either overweight/ obesity which is also more corresponding to the percentages catched by WC & WHtR than to WHR. Our findings show that BMI correlated well with WHtR as both are height dependent indicators. Among those 11.5 percent detected centrally obese by WHR, almost two third (65.2%) were also overweight/obese by BMI criteria. Interestingly, all the obese subjects by BMI were also having higher WC & WHtR and two third of them had higher WHR. M. Mehta *et al*. (2002) (Mehta *et al*., 2007) also reported the prevalence of central obesity amongst obese girls 95.4% using the similar criteria of WC which is almost similar to ours and 54.4% by WHR which is lower than ours. They have attributed their relatively smaller WHR to their larger hip circumferences.

In current study, WHtR detected 19.3% as centrally obese and all the obese subjects by BMI were having higher WHtR. Seeja Thomachan Panjikkaran, KS Kumari (2008) (Seeja Thomachan Panjikkaran, 2009) have reported only 16.8% of the samples at risk by using WHtR. The difference from our study is that their study was done among school-children. Weight is an indicator of present nutritional status and is influenced by environmental factors; hence, while considering obesity, it is necessary to consider height also for the past nutritional status to attain a standard definition for obesity. Kosin *et al*. (1987) and Sawaya *et al*. (1989, 1995) have also reported that a high prevalence of obesity associated with stunting (indicative of chronic growth faltering during childhood and the main consequence of poor nutrition in developing countries) has been found in a number of protocols over the years, indicating that obesity could occur in an individual subsequent to growth faltering.

Kurpad SS *et al*. (2003) also reported that WC correlates well with BMI in comparison to waist hip ratios in adults. VM Herrera *et al*. (2004) conducted a study on interethnic differences in the accuracy of anthropometric indicators of obesity in the Latin-American and the US populations also shown that WC was strongly correlated with BMI (0.83) and the correlation between WHR and BMI was only fair (0.28). However, they reported moderate degree of correlation between WHR and WC (0.67). This can be due to the interethnic variation.

Neovius *et al*. (2005) also reported BMI and WC to perform well as diagnostic tests for fatness, while WHR was less useful. Adediran *et al*. (2007) also found a strong correlation between BMI and WC in both diabetic patients with and without metabolic syndrome. Kayode A. Jimoh *et al*. (2009) found that WC as a measure of intraabdominal obesity had a poor correlation with BMI while WC and WHR had a good correlation as compared to our study. The difference is that their study was conducted among diabetic patients whereas ours has been done in healthy subjects.

Conclusion

The study provides current data on anthropometric measurements and obesity in college girls of Agra. Prevalence varied according to the measure used. Although BMI provides the most useful, albeit crude, population level measure of obesity, the study also exposed the fact that under nutrition is still prevailing in the state along with rise in over nutrition. The findings suggest that measures of central obesity are also useful indicator for epidemiological studies and clinical practice. The study also highlights the need to carry out further related studies for the identification of people at risk of obesity-related disorders, and indicate the need to implement interventions to reverse increasing levels of obesity. In view of the fact that college going girls are not representative of the general population, studies should be extended to the young adult population and investigate the presence of obesity and their trends over time.

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