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Original Article

Body Mass Index, Waist Circumference and Hip Circumference are Independent Predictors of Obesity

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Abstract

Obesity is the biggest challenge in the health management as it is an important risk factor for cardiovascular disease. Therefore, it is important to ascertain which anthropometric measurements are better predictors of obesity. This is a cross-sectional study and total 384 subjects (male 66.7% and female 33.3%) with the age group of 18 to 60 years were recruited from the outdoor patients department of cardiology, King George's Medical University, Lucknow. All the anthropometric data was collected on a predesigned history proforma. Weight, body mass index, waist circumference, hip circumference and waist hip ratio were significantly different among the groups (p=0.0001). Among the obese subjects the body mass index was positively correlated with the weight, WC, and HC. There was no additional, clinically relevant information obtained after measuring different anthropometric profile together with BMI. In conclusion the anthropometric marker; BMI, WC, HC and WHR were independently associated with obesity in north India.

Introduction

In the 21st century, there were great changes not only in the science and technology but also in the life style. The changes have made life easier but also invited certain chronic ailments such as cardiovascular disorders, osteoarthritis, hypertension and obesity (1). According to the World Health Organization (WHO) the prevalence of obesity is increasing rapidly in the world as well as in India. The WHO survey (2012) estimated that more than 200 million men and approximately 300 million women were obese (2). Recently in India it is estimated that in the whole country, 135, 153 and 107 million individuals will have generalized obesity, abdominal obesity and combined obesity, respectively (3). Now-a-day's it has been increasing up to 300 million in men and 400 million in women. Large prospective studies such as the Framingham Heart Study, the Nurses' Health Study and the Buffalo Health Study have all shown that overweight and obesity are associated with increased cardiovascular disease (CVD) risk. Excess adipose tissue contributes to the cardiovascular and other risks associated with

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being overweight or obese (4-8).

Obesity is defined as a disease in which excess body fat has accumulated in such a way that health may be negatively affected. Obesity results from an energy imbalance where energy intake has exceeded over a considerable period. Now-a-days, obesity has become the biggest health problem, which affects a person physically, psychologically and also has become an epidemic in many parts of the world (9).

Currently used anthropometric measures for assessing adiposity-related risk and central obesity are body mass index (BMI; weight in kilograms divided by square of height in meters), hip circumference (HC), waist circumference (WC), waist hip ratio (WHR; ratio of WC to HC), waist stature ratio (WSR; ratio of WC to height) and body adiposity index (BAI; (100 X HC (m) / Height (m) X √ Height) – (18)). (10) Out of them BMI or WC is most commonly used to measure the central obesity (11).

However, it is unclear that which anthropometric measurements are better for obesity and CVD risk, because the adiposity is highly heterogeneous with gender, age and ethnic differences in body fat distribution (8). Several reports suggested that Indians tend to have increased waist circumference, also have excess body fat, truncal and abdominal adiposity for any given Body Mass Index. Similarly, for any given waist circumference, they have excess body fat accumulation, as well as for any given body fat, they have increased insulin resistance (12). Some previous studies reported that BMI identified individuals at increased risk of CVD as effectively as WC (13, 14). However, some studies suggested that BMI is a better predictor of CVD than WC (15). Contrarily, some studies reported that WC is a better indicator of CVD risk than BMI and WHR, in ethnically different groups (16, 17). As per the Framingham risk score model; WC and WHR have also been identified as independent predictors of CVD risk but not BMI (18).

Considering these controversies, more research is needed to establish an independent anthropometric parameter as better predictor for obesity. The aim of this study was to find out the anthropometric parameter that correlated more significantly with BMI in non obese, over weight and obese subjects in north India.

Material and Methods

This is a cross-sectional study, conducted in department of physiology, King George's Medical University, Lucknow. After the ethical clearance and obtaining informed consent, total 384 subjects (male 66.7% and female 33.3%) with the age group of 18 to 60 years were included in the study. All the subjects recruited from the outdoor patients department of cardiology, King George's Medical University, Lucknow. All the anthropometric data was collected on the pre designed history proforma. For measuring weight, the subject was requested to stand still on the platform of a pre-calibrated digital weighing machine. Height was measured using stadiometer with the help of a fixed scale. Body mass index was calculated by the formula; weight (kg)/height (m^2). Waist circumference (WC) was measured mid-way between iliac crest and lowermost margin of the ribs. Hip circumference (HC) was measured at the maximum protruding part of buttocks at the level of the greater trochanter while keeping the feet together with the subjects wearing minimal clothing. Waist hip ratio was calculated with the help of the formula WC (cm.)/HC (cm.). Blood Pressure was measured by a manual mercury sphygmomanometer (Diamond) at the time of subject recruitment by the clinician. All the recruited subjects were grouped in to three categories (1) non-obese, (2) over weight and (3) obese as per the WHO guidelines. The WHO guidelines; BMI <25 kg/m^2 non obese, BMI 25-29.9 kg/m^2 over weight and BMI >30 kg/m^2 obese. (19) The subjects who were not able to stand still and with major trauma were excluded from the study.

Statistical analysis:

The collected data were entered in Microsoft Excel computer program and checked for any inconsistency. The results were presented as Mean±SD and percentages. The chi-square test was used to compare dichotomous/categorical variables among the groups. The one way analysis of variance (ANOVA) was used to compare the means among the groups with Tukey's pair wise comparison test for normally distributed variables. The Pearson correlation coefficient was calculated between BMI and study parameters. All the statistical test were two tailed and p-value<0.05 was considered as significant. All the analysis was carried out by using SPSS 16.0 version

Results

A Total of 384 subjects were included in the study, out of which 88 (22.92%) subjects were non obese, 188 (48.95%) subjects were overweight and 108 (28.13%) subjects were obese. The anthropometric measurements were described in Table I. Age, gender, height and blood pressure were not significantly different among the group (p>0.05). However, weight, body mass index, waist circumference, hip circumference and waist hip ratio were significantly different among the groups (p=0.0001). The post hoc test reveals that all the significant variables were also significantly different between the groups. The mean of weight, body mass index, waist circumference, hip circumference and waist hip ratio was observed to be the highest among the obese subjects.

The correlation of body mass index with other anthropometric parameters was described in Table II. Among the non obese subjects the body mass index was positively correlated with the weight, waist

TABLE I: Comparison of anthropometric parameters among the non-obese, over weight and obese subjects.

S.No.	*Parameters*	*Non obese (n=88) Mean±SD*	*Over weight (n=188) Mean±SD*	*Obese (n=108) Mean±SD*	*p value*
1.	Age (yr)	41.64±10.32	39.99±8.99	39.56±10.02	0.285
2.	Male gender, no (%)	66 (75%)	125 (66.5%)	65 (60%)	0.09
3.	Weight (kg)	60.25±8.52[1]	70.86±8.66[1]	85.51±12.49[1]	0.0001*
4.	Height (cm)	162.07±8.56[1]	160.21±8.79[1]	159.17±10.32[1]	0.088
5.	Body mass index (kg/m^2)	22.85±1.89[1]	27.52±1.41[1]	33.70±3.49[1]	0.0001*
6.	Waist Circumference (cm)	89.02±8.94[1]	96.90±8.73[1]	105.29±12.31[1]	0.0001*
7.	Hip Circumference (cm)	94.64±8.91[1]	100.09±7.51[1]	108.09±12.06[1]	0.0001*
8.	Waist hip ratio	0.94±0.07[2,3]	0.97±0.08[2]	0.98±0.08[2,3]	0.009*
9.	Systolic Blood Pressure (mm/Hg)	136.20±19.34	133.96±14.95	135.36±11.50	0.484
10.	Diastolic Blood Pressure (mm/Hg)	90.77±10.77	89.40±8.43	90.50±8.72	0.412

Data are presented as Mean±SD and compared by one way ANOVA test with Post hoc comparison test. Level of significance indicated as *p<0.05, (Post hoc comparison test: [1]p=0.0001, [2]p=0.001, [3]p=0.05test)

TABLE II: Correlation of body mass index with anthropometric parameters among the non-obese, over weight and obese subjects.

S.No.	*Parameters*		*Non obese (n=88)*	*Over weight (n=188)*	*Obese (n=108)*
1.	Age (yr)	r value	–0.088	–0.076	–0.134
		p value	0.412	0.301	0.166
2.	Weight (kg)	r value	0.678	0.435	0.486
		p value	0.0001*	0.0001*	0.0001*
3.	Height (cm)	r value	0.120	0.021	-0.199
		p value	0.266	0.778	0.039*
4.	Waist Circumference (cm)	r value	0.474	0.240	0.499
		p value	0.0001*	0.001*	0.0001*
5.	Hip Circumference (cm)	r value	0.269	0.298	0.521
		p value	0.011*	0.0001*	0.0001*
6.	Waist hip ratio	r value	0.304	0.001	0.050
		p value	0.004*	0.994	0.606
7.	Systolic Blood Pressure (mm/Hg)	r value	0.189	–0.167	0.0001
		p value	0.078	0.022*	0.999
8.	Diastolic Blood Pressure (mm/Hg)	r value	0.225	–0.024	-0.040
		p value	0.035*	0.746	0.678

Pearson correlation test; Level of significance indicated as *p<0.05

circumference, hip circumference, waist hip ratio and diastolic blood pressure. However, there was no significant correlation with age, height and systolic blood pressure. Similarly, among the overweight subjects the body mass index was positively correlated with the weight, waist circumference, hip circumference, but negatively correlated with systolic blood pressure. Among the obese subjects the body mass index was positively correlated with the weight, waist circumference, hip circumference and a mild negative correlation with the height observed.

Discussion

To save time and resources in a clinical and research setting, it is very necessary to minimize the number of anthropometric measurements. In this study, we investigated the correlation of BMI with other anthropometric parameters of obesity among non-obese, overweight and obese subjects in North India. Our result suggested that no more additional and clinically relevant information obtained after performing the anthropometric assessment other than BMI among the non-obese, overweight and obese subjects in North India, as the BMI was positively correlated with WC and HC among overweight and obese subjects. This may be because of the extremeness of obesity is at higher BMI cutoff range. The observation was in agreement with previous report but limited to the North Indian population (20, 21). On the other hand several findings suggested that BMI is a flawed measure as it does not correctly identify individuals with excess body fat due to its inability to differentiate fat and fat-free mass and it does not account for the effect of age and ethnicity on body fat distribution (22-26). Furthermore, our findings indicate that BMI, WC, HC and WHR were independent markers for obesity, suggesting that only one of these measures need to be obtained for clinical and research purpose. However, WHR was positively correlated with BMI only in the non-obese group. Therefore it seems that the use of only single marker to assess the obesity is still not sufficient to achieve optimal accuracy. Thus, we recommended a detailed study with larger sample size is required to validate the accuracy of findings.

In our study we have observed that the prevalence of overweight and obesity was 48.9% and 28.1% respectively in north India. Our finding was in agreement with a previous study conducted in western Maharashtra (27). Additionally a poor positive correlation of BMI with diastolic blood pressure among non obese and a poor negative correlation with systolic blood pressure among overweight was observed. There was no correlation between BMI and blood pressure among obese subjects. The topic of obesity related hypertension is still debatable and various conflicting reports were published. However, according to a clinical report of Australia, blood pressure is related to weight or bulk of the body, but not to obesity except insofar as it contributes to bulk (28).

However, the study has several limitations like; the study was not originally designed to answer the specific question as it is a secondary analysis of data. Study also included a small sample size with limited gender and ethnic distribution. Some other anthropometric measurements like; neck circumference, arm circumference, waist height ratio, deltoid skin fold thickness and triceps skin fold thickness were also not included in the study. In spite of these limitations the findings of this study explores some clinically relevant points for the management of obesity. It provides the primary data regarding the correlation of BMI with other anthropometric parameters and their utility among north Indian obese subjects.

Conclusion

Based on these finding we concluded that there was no additional and clinically relevant information obtained after performing the other anthropometric assessment along with BMI. The anthropometric marker BMI, WC, HC and WHR were independently associated with Obesity. However the conclusion is limited to a small sample size and north Indian population. For the validation and implementation of results, it is recommended that further study with larger sample size, detailed ethnic and gender distribution as well as with more anthropometric parameters must be conducted.

Conflict of interest

The authors declare none conflict of interest.

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References

1. Ramachandran A, Ma RC, Snehalatha C. Diabetis in Asia. *Lancet* 2010; 375: 408–418.
2. World Health Organization. Obesity and overweight. Secondary obesity and overweight, 2012. http://www.who.int/mediacentre/factsheets/fs311/en/.
3. Pradeepa R, Anjana RM, Joshi SR, et al. Prevalence of generalized & abdominal obesity in urban & rural India—the ICMR-INDIAB Study (Phase-I) (ICMR- NDIAB-3). *Indian J Med Res* 2015; 142: 139–150.
4. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation* 1983; 67: 968–977.
5. Manson JE, Colditz GA, Stampfer MJ, et al. A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med* 1990; 322: 882–829.
6. Manson JE, Willett WC, Stampfer MJ, et al. Body weight and mortality among women. *N Engl J Med* 1995; 333: 677–685.
7. Dorn JM1, Schisterman EF, Winkelstein W Jr, Trevisan M. Body mass index and mortality in a general population sample women of men and women: the Buffalo Health Study. *Am J Epidemiol* 1997; 146: 919–931.
8. Cornier MA, Després JP, Davis N, et al. Assessing adiposity: a scientific statement from the American Heart Association. *Circulation* 2011; 124: 1996–2019.
9. Kopalman PG.. Obesity as a medical problem. *Nature* 2000; 404: 635–643.
10. Bergman RN, Stefanovski D, Buchanan TA, et al. A better index of body adiposity. Obesity (Silver Spring) 2011; 19: 1083–1089.
11. Park YS, Kim J-S. Obesity phenotype and coronary heart disease risk as estimated by the Framingham risk score. *J Korean Med Sci* 2012; 27: 243–249.
12. Ramachandran A, Snehalatha C, Vijay V, Viswanathan M, Haffner SM. Risk of NIDDM conferred by obesity and central adiposity in different ethnic groups—A comparative analysis between Asian Indians, Mexicans Americans and Whites. Diabetes Res Clin Pract, 1997; 36:121-125.
13. Satoh H, Kishi R, Tsutsui H. Body mass index can similarly predict the presence of multiple cardiovascular risk factors in middle-aged Japanese subjects as waist circumference. *Intern Med* 2010; 49: 977–982.
14. Ryan MC, Fenster Farin HM, Abbasi F, Reaven GM. Comparison of waist circumference versus body mass index in diagnosing metabolic syndrome and identifying apparently healthy subjects at increased risk of cardiovascular disease. *Am J Cardiol* 2008; 102: 40–46.
15. Ying X, Song ZY, Zhao CJ, Jiang Y. Body mass index, waist circumference, and cardiometabolic risk factors in young and middle-aged Chinese women. *J Zhejiang Univ Sci B* 2010; 11: 639–646.
16. Zhu S, Heymsfield SB, Toyoshima H, Wang Z, Pietrobelli A, Heshka S. Race-ethnicity–specific waist circumference cutoffs for identifying cardiovascular disease risk factors. *Am J Clin Nutr* 2005; 81: 409–415.
17. Huang KC, Lee MS, Lee SD, et al. Obesity in the elderly and its relationship with cardiovascular risk factors in Taiwan. *Obes Res* 2005; 13: 170–178.
18. Dhaliwal SS, Welborn TA. Central obesity and multivariable cardiovascular risk as assessed by the Framingham prediction scores. *Am J Cardiol* 2009; 103: 1403–1407.
19. (WHO) WHO: Obesity: Preventing and Managing the Global Epidemic. Report of WHO Consultation on Obesity, 3-5 June 1997. Geneva: WHO, 1998. Edited by: WHO. Geneva; 2006.
20. Mei Z, Grummer-Strawn LM, Wang J, et al. Do skinfold measurements provide additional information to body mass index in the assessment of body fatness among children and adolescents? *Pediatrics* 2007; 119: e1306–e1313.
21. Hastings ES, Anding RH and Middleman AB. Correlation of Anthropometric Measures Among Obese and Severely Obese Adolescents and Young Adults; Infant, Child, & Adolescent Nutrition; 2011, 3; 171–174.
22. Fogelholm M. Physical activity, fitness and fatness: relations to mortality, morbidity and disease risk factors. A systematic review. *Obes Rev* 2010; 11: 202–221.
23. Romero-Corral A, Somers VK, Sierra-Johnson J, et al. Accuracy of body mass index in diagnosing obesity in the adult general population. *Int J Obes* 2008; 32: 959–966.
24. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser: WHO, 2000.
25. Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta-analysis among different ethnic groups. *Int J Obes* 1998; 22: 1164–1171.
26. Welborn TA, Dhaliwal SS. Being correct about obesity. *Med J Aust* 2011; 194: 429–430.
27. Sabale BB, Barhate AA. Study of prevalence of overweight and obesity in shopkeepers in wetern Maharashtra; *IJBAMR* 2014; 3: 419–422.
28. Whyte HM. Blood Pressure and Obesity. *Circulation* 1959; 19: 511–516.