ORIGINAL ARTICLE CODEN: AAJMBG

Body mass index a better predictor of insulin resistance than waist circumference in normoglycemics

B.L. Preethi[1*], K.M. Prasannakumar[2] and Vijay Culmalgae[3]

[1]Department of Physiology, M.S. Ramaiah Medical College & Teaching Hospitals, MSRIT Post, MSR Nagar, Bangalore-54 Karnataka, India, [2]Department of Endocrinology, M.S. Ramaiah Medical College & Teaching Hospitals, MSRIT Post, MSR Nagar, Bangalore-54 Karnataka, India and [3]Department of Epidemiology & Biostastics, Kidwai Memorial Institute, Dr. M.H. Marigowda Road, Bangalore-29 Karnataka, India

Abstract: *Background:* Body Mass Index (BMI) is the most common method of measuring obesity. Many studies have reported that waist circumference is a stronger predictor of insulin resistance in non-type 2 diabetes. *The objective of the study* was to investigate whether waist circumference (WC) or body mass index (BMI) is a better predictor insulin resistance. *Method:* 79 normal young adult volunteers in the age range of 18 to 25 years were enrolled for the Study. All subjects underwent a detailed general physical examination including Blood Pressure, body weight, height, hip & waist circumference. BMI (Body Mass Index), waist and hip circumference & waist hip ratio calculated. 2hr OGTT with serum Insulin was performed and Insulin resistance calculated. *Result:* Simple clinical measures of obesity like height, weight, waist circumference, hip circumference and their indexes like BMI (body mass index), WHR (waist hip ratio) were evaluated and correlated with the measures of Insulin resistance (IR) and insulin sensitivity. BMI was found to significantly correlate with most of the IR parameters and there was a trend towards significance with weight. Waist circumference did not correlate significantly with IR parameters. *Conclusion:* Body Mass Index (BMI) is a useful tool in evaluating obesity in normoglycemic subjects. BMI is a better predictor of Insulin Resistance and risk stratification than waist circumference.

Keywords: Obesity, Screening, BMI, Body mass index, Waist circumference, WHR, Syndrome X, Diabetes, Prevention, Insulin Sensitivity, Insulin resistance

Introduction

Bipolar disorders like obesity and cardiovascular disease are associated with insulin resistance. Insulin resistance associated with distribution of body fat, specifically abdominal visceral fat and fat accumulation in skeletal muscle. Reduced capacity to utilize fat has been linked with obesity and insulin resistance [1]. In many Asian countries overweight and obesity have reached epidemic proportions with impending raise in obesity-related disorders such as diabetes, hypertension, and cardiovascular diseases, developing at much younger age than in Western populations [2]. Westernization, changes in economics and lifestyle have dramatically improved leading to a significant increase Obesity and metabolic syndromes [3].

Epidemiological studies in Indians have shown that the increasing prevalence of diabetes is attributed to high genetic risk and lower risk thresholds for acquired risk factors such as age, obesity, abdominal adiposity and a high percentage of body fat. Diabetes occurs at a younger age in Indians compared to Whites. Asian Indians have higher central adiposity. There is also evidence of higher insulin resistance amongst Indians, and this is partly explained by higher body fat percentage. A large proportion of urban adults have metabolic syndrome which also predisposes them to both diabetes and cardiovascular diseases. With the early recognition of these conditions, preventive measures can be instituted [4].

The Body Mass Index (BMI) is the most common method of measuring obesity. BMI is generally considered the best way to determine if an individual is at a healthy weight. Using BMI is popular because it is simple, quick, effective and applies to adult men and women, as well as children. BMI is a measure of body fat based on height and weight that applies to adult men and women. BMI is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m2) [5-6].

Many studies have demonstrated that a simple waist circumference is a strongly associated with cardiovascular disease [7-10]. Many studies have reported that waist circumference is a stronger predictor of insulin resistance in non-type 2 diabetes [11-12]. Several studies have indicated that waist circumference is superior to BMI as a risk factor maker in non-type 2 diabetes populations [13-15]. Waist circumference is a predictor of insulin resistance.

BMI may not correspond to the same degree of fatness in different populations due, in part, to different body proportions. BMI is an adequate proxy measure for monitoring the underlying increase in health risk due to excess weight at a population level. although BMI is not a 'gold standard' measure of overweight or obesity, its advantages in terms of ease of measurement, established cut offs, and existing published statistics make it the only currently viable option for producing high level summary figures at population level [16-19].

BMI has limitations; it does not directly measure body fat, it is more accurate at approximating degree of body fatness than weight alone. BMI does not have exact weight or measurement, to be considered 'normal.' There is a range within each classification to allow for different body types and shapes. Very muscular individuals often fall into the overweight category when they are not overly fat. BMI is an indicator of heaviness rather than fatness, and cannot distinguish body fat from fat-free mass [20-21].

Rationale for the study: Body mass index (BMI) is a commonly used measure of obesity, it is an indicator of heaviness rather than fatness, and cannot distinguish body fat from fat-free mass. Waist circumference being a simple measure has been found to be a better measure of obesity and insulin resistance in diabetics. The current study was designed to explore the correlation between indicators of obesity like BMI, WC, and WHR, and hs-CRP and insulin resistance in normoglycemic young adults.

The aim of this study is to investigate whether waist circumference (WC) or body mass index (BMI) is a better predictor insulin resistance

Material and Methods

Healthy young adult volunteers in the age range of 18 to 25 years were enrolled for the Study. 79 Volunteers who satisfied the inclusion and exclusion criteria, were educated regarding the study, an Informed consent was obtained as per ICH GCP good clinical practice guidelines. Subjects with Infections, inflammatory diseases, tissue injury & Corticosteroids medications were excluded from the study.

There was no financial liability on the study subjects. The study was approved by the IEC. All subjects underwent a detailed general physical examination including Blood Pressure, body weight, height, hip & waist circumference. All measures were done while subjects wore light clothes without shoes and BMI (Body Mass Index), waist and hip circumference & waist hip ratio calculated.

Waist circumference was measured mid-way between the lateral lower rib margin and the iliac crest, hip circumference (HC) was measured at the levels of the major trochanters through the pubic symphysis. BMI was calculated (BMI=body weight/height (kg/ m2). Concentrations of total cholesterol, triglyceride & HDL cholesterol were determined by enzymatic kinetic method using an auto analyzer. VLDL cholesterol level was calculated using the formula Triglyceride/5 & LDL using the formula [Total Cholesterol – (HDL + VLDL)].

A standard OGTT was performed on all subjects and Blood sample was analyzed for hsCRP. Fasting (basal), 30, 120 min venous plasma glucose and Insulin was measured. The serum plasma was stored at - 20 degree C until assayed. Highly sensitive C- reactive protein (hs CRP) was assessed from fasting sample by turbidimetric method.

Insulin Resistance was calculated with mathematical models like, Homeostatic model assessment HOMA-IR. HOMA %B, Insulin Sensitivity Index ISI $_{0\text{-}120}$. The data was systematically collected in the case record form designed for the study.

Statistical Analysis: The Student t test and Mann Whitney U test have been carried out to find the significant difference between various BMI parameters & Indices between subjects in Group A & B. The Statistical software namely SPSS 10.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

Results

In this study all the subjects were from south Indian urban agglomerate. The mean age of the study population was 19 $\pm$1.69years (18 to 25) years. The Sex distribution was Male: 41.3% (n=33) and Female: 58.8% (n=47). The Clinical parameters [Table 1] and laboratory parameters [Table 2] of the study subjects are within normal limits. The overall Insulin resistance and sensitivity indexes derived from simulated mathematical models are in normal range [Table 3] as all the subjects are healthy and normoglycemic.

Table-1: Clinical Parameters (n=79)

	Mean	Std. Devn
Age (yrs)	19	1.7
Blood Pressure		
Systolic (mmHg)	119.67	6.23
Diastolic (mmHg)	74.22	5.12
Height (cms)	163.28	9.35
Weight (kgs)	59.5	12.22
Waist (cms)	75.06	10.68
Hip (cms)	92.62	8.86
BMI	22.34	4.10
WHR	0.80	0.06

Table-2: Laboratory Parameters

OGTT	Mean	Std. Devn
Fasting Glucose	81.87	9.90
2hr Post Prandial Glucose	90.75	17.19
Fasting insulin	8.18	6.33
2hr Post Prandial insulin	37.70	32.89
Total Cholesterol	156.94	26.51
Triglycerides	96.14	28.20
HDL	40.59	4.74
VLDL	18.99	5.11
LDL	97.42	26.84
hsCRP	1.41	2.10

Table-3: Insulin Resistance / Sensitivity parameter

	Mean	Std. Devn
HOMA- IR	1.67	1.30
HOMA (%B)	218.67	273.15
Insulino Genic Index (IGI)	0.73	16.51
QUICKI	0.31	0.07
ISI $_{0\text{-}120}$	63.82	22.78
I_0/G_0 Ratio (IGR)	0.10	0.08

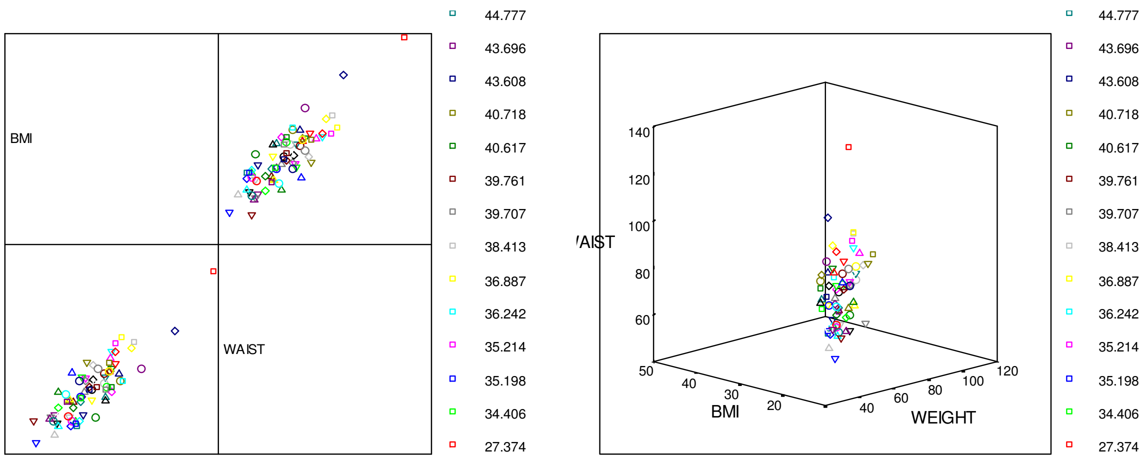
Simple clinical measures of obesity like height, weight, waist circumference, hip circumference and their indexes like BMI (body mass index), WHR (waist hip ratio) were evaluated and correlated with the measures of Insulin resistance (IR) and insulin sensitivity. Spearmans correlations revealed that unlike what was presumed BMI was found to stastically significantly correlate with majority of the IR parameters (Table 4) and there was a trend towards significance with weight. Waist circumference did not correlate significantly with IR parameters.

Table- 4: Correlations Spearman							
		HOMA_IR	**HOMA%B**	**Insulin_gen_Index**	**QUICKIE**	**ISI 0-120**	**I0 G0 ratio**
		79	**79**	**79**	**79**	**79**	**79**
BMI	Correlation Coefficient	0.261464	0.144731	0.004431	-0.26146	-0.27089	0.231558
	Sig. (2-tailed)	0.019936	0.203159	0.969088	0.019936	0.015747	0.040041
WAIST	Correlation Coefficient	0.172931	0.109171	-0.04508	-0.17293	-0.14425	0.150986
	Sig. (2-tailed)	0.127495	0.338196	0.693194	0.127495	0.20468	0.184101
HIP	Correlation Coefficient	0.181121	0.135156	0.001826	-0.18112	-0.18203	0.174692
	Sig. (2-tailed)	0.110172	0.234989	0.987255	0.110172	0.108364	0.123606
WHR	Correlation Coefficient	0.152154	0.100331	-0.05257	-0.15215	-0.09903	0.137855
	Sig. (2-tailed)	0.180691	0.378984	0.645415	0.180691	0.38522	0.225685
HEIGHT	Correlation Coefficient	-0.1083	0.033879	-0.01181	0.108304	0.141571	-0.08929
	Sig. (2-tailed)	0.342071	0.766916	0.917741	0.342071	0.213303	0.433899
WEIGHT	Correlation Coefficient	0.19015	0.168249	0.035221	-0.19015	-0.12848	0.181104
	Sig. (2-tailed)	0.09325	0.138291	0.757964	0.09325	0.259145	0.110206

Clinical measures of obesity like height, weight, waist circumference, hip circumference and their indexes like BMI (body mass index), WHR (waist hip ratio) were evaluated and correlated with the Laboratory parameters in these healthy subjects. BMI, waist and Hip circumference were stastically significantly well correlated with hsCRP a marker of IR, significance was observed even with Multiple Step Wise Regression (Table 5).

Table-5: Correlations Spearman						
	T.CHOL	**TRIGLY**	**HDL**	**VLDL**	**LDL**	**hsCRP**
	79	79	79	79	79	78
BMI	0.2477	-0.00474	0.084282	0.00769	0.212447	0.305557
	0.02774	0.966956	0.460214	0.946371	0.06015	0.00652
WAIST	0.176689	-0.11044	0.30466	-0.0838	0.134444	0.274276
	0.119305	0.332594	0.006335	0.462822	0.237488	0.015098
HIP	0.230481	-0.04921	0.063346	-0.02566	0.200209	0.243768
	0.041002	0.666721	0.57916	0.822377	0.076878	0.0315
WHR	0.001043	-0.10857	0.352416	-0.088	-0.02311	0.186465
	0.992718	0.340876	0.001446	0.440597	0.839775	0.102133
HEIGHT	-0.21955	-0.07755	0.486957	-0.05143	-0.27428	-0.06987
	0.05188	0.496913	5.35E-06	0.652638	0.01444	0.543274
WEIGHT	0.095659	-0.04661	0.367937	-0.02296	0.031118	0.224376
	0.401691	0.683331	0.00085	0.840817	0.785435	0.048279

Figure-A: Shows the correlation of BMI and Waist circumference with Insulin Sensitivity Index (ISI $_{0\text{-}120}$)



The subjects were grouped into lower quartiles and higher quartiles at various BMI cutoff values and Insulin Sensitivity index (ISI 0-120) was found to significantly decrease as BMI increases, subjects in lower quartiles also showed a decrease in IR values as BMI increased (Figure A).

Discussion

The impact of obesity has been considerable in both developed and developing countries. The population at large are bound to face a grave burden i.e., increase by many folds of obesity-related disorders such as diabetes, hypertension, cardiovascular diseases & cancers etc, which develop at much younger age than in Western populations. The major causative factors being lifestyle changes occurring due to rapid socioeconomic transition [1-4]. Early detection and prevention plays a key role in tackling this potentially huge economic and health care burden of the obesity-related disorders [22].

Most epidemiologic studies identifying strong associations between hs-CRP, IR parameters obtained from OGTT and obesity indicators predominantly use anthropometric indexes [23-30]. Consequently, a strong positive association has been found between measures of obesity, such as waist circumference (WC) and body mass index (BMI), with CRP [31-32]. Moreover, while some studies have observed a relationship between T2DM and higher IR and CRP levels [33]. In a study from India, by Ambika et al, there has been a significant increase in abdominal obesity in both sexes in the last 2 decades, the prevalence of overweight rose from 2% to 17.1% [3]. Prevalence of overweight/obesity among Adolescents (14-18 yrs) in Delhi is reported to be 29.0%. The risk of diabetes increases with a body mass index (BMI) of >23 kg/m2 and waist circumference of 85 cm for men and 80 cm for women in Asian Indians [5]. In our study subjects with BMI > 24 had significantly higher waist circumference (83.3cms+9.9).

Oliveira et al in a study of 1319 subject, 833 women and 486 men in Portugal. Reported central obesity has been shown to be significantly associated with increased levels of the inflammatory marker hs-CRP in men, while a high proportion of peripheral subcutaneous fat was inversely associated with hs-CRP in women [34].

In a study from Egypt, 150 children in the age range 6-16, BMI was 27.20 ± 12.30 kg/m2 in the obesity group and was 16.68 ± 2.00 kg/m2 in the control group. Obese group (n=100) had significantly higher hs-CRP levels than control group, hs-CRP levels were 1.40 ± 0.78 mg/dL vs. 0.56 ± 0.47. mg/dL, $p < 0.01$ [35]. A similar picture was seen in our study, subjects with BMI >24 had significantly higher hsCRP values 2.08+2.08 compared to 1.03+2.0(normal range) in subjects with BMI<23.9[36].

Den Engelsen et al, In a study of 1721 participants , mean age 48.4 years, The median hs-CRP for the total population was

1.9 mg/L (IQR 1.1-3.6) subjects with the (metabolic syndrome) MetS the median hs-CRP was 2.2 mg/L (IQR 1.2-4.0), compared to 1.7 mg/L (IQR 1.0-3.4) in the group without the MetS ($p < 0.001$) [37]. Even though our subjects were of younger age group (19+1.7), subjects with BMI >24 had hsCRP levels which are similar to those found in subjects with metabolic syndrome [36]. Our study has demonstrated that there is association between BMI and hsCRP, as BMI increases hsCRP also increases significantly. The importance of hsCRP in Sub classifying individuals into low and high risk groups within the BMI groups was also observed.

Measuring waist circumference also helps screen for possible health risks that come with overweight and obesity. Subjects with Fat around the waist rather than at hips, are at a higher risk for heart disease and type 2 diabetes. This risk goes up with a waist size that is greater than 35 inches for women or greater than 40 inches for men. The BMI of 62.5% of the health Indian adults range from 18.5-24.99, this can empirical be applied as internationally recommended BMI cut-off points. The higher BMI, the higher is the risk for certain diseases such as heart disease, high blood pressure, type 2 diabetes, gallstones, breathing problems, and certain cancers. For Indian subjects BMI is termed Underweight Below 18.5, Normal18.5–24.9, Overweight 25.0–29.9, Obesity 30.0 and above. Our health study subjects had a mean BMI of 22.3+4.08, hsCRP 1.43+2.1.

The WHO Expert Consultation concluded that the proportion of Asian people with a high risk of type 2 diabetes and cardiovascular disease is substantial at BMI's lower than the existing WHO cut-off point for overweight (= 25 kg/m2). However, the cut-off point for observed risk varies from 22 kg/m2 to 25 kg/m2in different Asian populations and for high risk, it varies from 26 kg/m2 to 31 kg/m2. In addition, sub-classify subjects into high and low risk within Normal or lower BMI levels using hs-CRP was evaluated in our study. This finding of our study has important implications for obesity screening in community surveys [38].

Deniz Gokalp et al evaluated 117 healthy subjects aged with 20–68 yr, normal weight (BMI 18.5–25.0 kg/m2, n: 35), overweight (BMI: 25–30 kg/m2, n: 27) and obese (BMI ≥30.0, n: 55). Mean serum hs-CRP levels of obese group determined with BMI were higher than overweight and normal weight groups (7.3±5.46, 2.5±3.13, 0.66±1.1, respectively, P=0.0001). hs-CRP levels were positively correlated with BMI. They concluded that hs-CRP levels were high in obese patients and there was close relationship between BMI and HS-CRP serum levels, similar to our findings [39].

Yang SP et al, in a study of 70 obese children and adolescents (age 8 - 17 years) and 30 non-obese healthy controls (12.6 years), found that there was significant increase of serum hs-CRP level in obese children and adolescents, the median was 2.44 (0.01 - 14.6) mg/L; the level of control group was 0.1 (0.01 - 2.1) mg/L. Multiple linear regression analysis showed that body mass index (BMI) was the only indicator which had correlation with hs-CRP. They opined that there may be a chronic low-grade inflammation and insulin resistance in obese subjects and the level of hs-CRP might be independently correlated with BMI in children [40]. A similar correlation was found in our study subjects, their IR and hsCRP levels were found to significantly increase as BMI increases even in the Low and high BMI groups at various cutoff values. Subjects in lower BMI quartiles also showed an increase in IS values / hsCRP as BMI increased but within near normal ranges of less than 1.5 hsCRP, higher quartile subjects always showed hsCRP values > 1.5.

Ying-Li Liao et al in their study of 144 diabetic subjects showed that waist circumference is a better predictor of insulin resistance in type 2 diabetes than BMI [41-42]. In our study significant increase in IR values was seen with increasing BMI. Waist Circumference was not significantly associated with IR / IS parameters. The finding of this study point to a significant role BMI plays in the early detection of future metabolic syndromes. The result of this study strongly indicates that BMI and not waist circumference is a key predictor of insulin resistance in normoglycemic. BMI can be easily measured by the healthcare worker or the patient.

Conclusion

Body Mass Index (BMI) is a useful tool in evaluating obesity. BMI is a better predictor of Insulin Resistance and risk stratification than waist circumference in normoglycemic subjects. BMI can be used as a key screening tool in normoglycemic subjects.

References

1. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *JAMA* 1999; 282:1523-1529.
2. Kopelman PG. Obesity as a medical problem. *Nature* 2000; 404:635-643.
3. Ambika GU, Kalra S and Garg MK. Preventing obesity in India: Weighing the options. *Indian J Endocrinol Metab.* 2012; 16(1): 4-6.
4. Ramachandran A, Snehalatha C, Vijay V. Low risk threshold for acquired diabetogenic factors in Asian Indians. *Diabetes Res Clin Pract.* 2004; 65(3):189-95.
5. WHO. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. WHO Technical Report Series 894. Geneva: *World Health Organization,* 2000.
6. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva, *World Health Organization,* 1995.
7. Seidell JC, Perusse L, Despres JP, Bouchard C. Waist and hip circumferences have independenct and opposite effects on cardiovascular disease risk factors: the Quebec Family Study. *Am J Clin Nutr* 2001;74:315-321
8. Han TS, van Leer EM, Scidell JC, Lean ME. Waist circumference action levels in the identification cardiovascular disease risk factors: prevalence study in a random sample. *BMJ* 1995; 311:1401-1405.
9. McLaughlin T, Abbasi E, Chcal K, Chu J, Lamendola G, Reven G. Use of metabolic markers to identify overweight individuals who are insulin resistance. *Ann Intern Med* 2003; 139: 802-809.
10. Thomas GN, Ho SY, Lam KS, Janus ED, Hedley AJ, Lam TH. Impact of obesity and body fat distribution on cardiovascular risk factors in Hong Kong Chinese. *Obesity Research* 2004; 12:1905-1812.
11. Racette SB, Evans EM, Weiss EP, Hagberg JM, Holloszy JO. Abdominal adiposity is a stronger predictor of insulin resistance than fitness among 50-95 year olds. *Diabetes Care* 2006; 29:673-678.
12. Kohrt WM, Kirwan JP, Statern MA, Bourey RE, King DS, Holloszy JO. Insulin resistance in aging is related to abdominal obesity. *Diabetes* 1993; 42:273-281.
13. Reeder BA, Senthilselvan A, Despres JP, Angel A, Liu L, Wang H, Rabkin SW. The association of cardiovascular disease risk factors with abdominal obesity in Canada. Canadian Heart Health Surveys Research Group. *CMAJ* 1997;157(Suppl 1):39-45.
14. Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay, Nadeau A, Lupien PJ. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexs of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *Am J Cardiol* 1994;73:460-468
15. Lear SA. Waist circumference is simpler than body mass index (letter). *Clin Chem* 2005; 51:1082-1083.
16. National Obesity Observatory. Body Mass Index as a measure of obesity. June 2009. *NHS. http://www.noo.org.uk/uploads/doc789_40_noo_BMI.pdf*
17. Mei Z, Grummer-Strawn LM, Pietrobelli A, Goulding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. *American Journal of Clinical Nutrition* 2002; 7597-985.
18. Garrow JS and Webster J. Quetelet's index (W/H2) as a measure of fatness. *International Journal of Obesity* 1985; 9:147-153.
19. Prentice AM and Jebb SA. Beyond Body Mass Index. *Obesity Reviews.* 2001; 2(3):141-7.
20. Ul-Haq Z, Mackay DF, Martin D, Smith DJ, Gill JM, Nicholl BI, Cullen B, Evans J, Roberts B, Deary IJ, Gallacher J, Hotopf M, Craddock N, Pell JP. Heaviness, health and happiness: a cross-sectional study of 163066 UK Biobank participants. *J Epidemiol Community Health.* 2014; 68(4):340-8.
21. Gallagher D, et al. How useful is BMI for comparison of body fatness across age, sex and ethnic groups? *American Journal of Epidemiology* 1996; 143:228-239.
22. Ambady R and Chamukuttan S. Rising Burden of Obesity in Asia. J Obes. 2010; 2010: 868573.
23. Hak AE, Stehouwer CD, Bots ML, Polderman KH, Schalkwijk CG, Westendorp IC, Hofman A, Witteman JC. Associations of C-reactive protein with measures of obesity, insulin resistance, and subclinical atherosclerosis in healthy, middle-aged women. *Arterioscler Thromb Vasc Biol* 1999; 19:1986-1991.
24. Chambers JC, Eda S, Bassett P, Karim Y, Thompson SG, Gallimore JR, Pepys MB, Kooner JS: C-reactive protein, insulin resistance, central obesity, and coronary heart disease risk in Indian Asians from the United Kingdom compared with European whites. *Circulation* 2001; 104:145-150.
25. Mendall MA, Patel P, Ballam L, Strachan D, Northfield TC. C reactive protein and its relation to cardiovascular risk factors: a population based cross sectional study. *BMJ* 1996; 312:1061-1065.
26. Greenfield JR, Samaras K, Jenkins AB, Kelly PJ, Spector TD, Gallimore JR, Pepys MB, Campbell LV. Obesity is an important determinant of baseline serum C-reactive protein concentration in monozygotic twins, independent of genetic influences. *Circulation* 2004; 109:3022-3028.
27. Kitsios Konstantinos, Papadopoulou Maria, Kosta Konstantina, Kadoglou Nikolaos, Papagianni Maria, Tsiroukidou Kiriaki. High-Sensitivity C-Reactive Protein Levels and Metabolic Disorders in

Obese and Overweight Children and Adolescents. *J Clin Res Pediatr Endocrinol.* 2013; 5(1): 44-49.
28. Emanuela Lapice, Simona Maione, Lidia Patti, Paola Cipriano. Abdominal Adiposity Is Associated With Elevated C-Reactive Protein Independent of BMI in Healthy Nonobese People. *Diabetes Care* 2009; 32:1734-1736.
29. Thorand B, Baumert J, Doring A, Herder C, Kolb H, Rathmann W, Giani G, Koenig W: Sex differences in the relation of body composition to markers of inflammation. *Atherosclerosis* 2006; 184:216-224.
30. Festa A, D'Agostino R, Williams K, Karter AJ, Mayer-Davis EJ, Tracy RP, Haffner SM: The relation of body fat mass and distribution to markers of chronic inflammation. *International Journal of Obesity* 2001; 25:1407-1415.
31. Santos AC, Lopes C, Guimaraes JT, Barros H. Central obesity as a major determinant of increased high-sensitivity C-reactive protein in metabolic syndrome. *Int. J. Obes.* 2005; 29:1452-1456.
32. Shemesh T, Rowley KG, Jenkins A, Brimblecombe J, Best JD, O'Dea K. Differential association of C-reactive protein with adiposity in men and women in an Aboriginal community in northeast Arnhem Land of Australia. *Int. J. Obes.* 2007; 31:103-108.
33. Onat A, Can G, Hergenc G. Serum C-reactive protein is an independent risk factor predicting cardiometabolic risk. *Metab. Clin. Experim.* 2008; 57:207-214.
34. Oliveira A, Lopes C, Severo M, Rodríguez-Artalejo F, Barros H. Body fat distribution and C-reactive protein-a principal component analysis. *Nutrition, Metabolism & Cardiovascular Diseases,* 2011; 21(5):347-354.
35. Hatem Hamed El-shorbagy, Ibraheim Abdel-aziz Ghoname. High-sensitivity C-reactive protein as a marker of cardiovascular risk in obese children and adolescents. *Health* 2010; 2(9):1078-1084.
36. Corine den Engelsen, Paula S Koekkoek, Kees J Gorter, Maureen van den Donk, Philippe L Salomé and Guy E Rutten. High-sensitivity C-reactive protein to detect metabolic syndrome in a centrally obese population: a cross-sectional analysis. *Cardiovascular Diabetology* 2012; 11:25.
37. Engelsen CE, Koekkoek PS, Gorter KJ, Donk MVN, Salomé PL and Rutten GE. High-sensitivity C-reactive protein to detect metabolic syndrome in a centrally obese population: a cross-sectional analysis. *Cardiovascular Diabetology* 2012; 11:25.
38. WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *The Lancet,* 2004; 157-163.
39. Gokalp D, Tuzcu A, AkayH, Arikan S & Mithat. The association of high sensitivity C-reactive protein levels with body fat mass and body fat distribution Endocrine Abstracts. *Bio Scientifica.* 2007; 14:238.
40. Yang SP, Gong CX, Cao BY, Yan C. Relationship between serum high-sensitivity C-reactive protein and obesity and impaired glycose metabolism in children and adolescents. *Zhonghua Er Ke Za Zhi.* 2006; 44(12):933-6.
41. Ying-Li Liao, Su-Ching Lin, Chung-Hua Hsu. Waist circumference is a better predictor than body mass index of insulin resistance in type 2 diabetes. *Int J Diabetes & Metab* 2011; 19:35-40.
42. Brenner DR, Tepylo K, Eny KM, Leah E Cahilland Ahmed El-Sohemy. Comparison of body mass index and waist circumference as predictors of cardiometabolic health in a population of young Canadian adults. *Diabetology & Metabolic Syndrome* 2010; 2:28.

*All correspondences to: Dr. Bangalore LakshmanaGowda Preethi, Associate Professor, Department of Physiology, M.S. Ramaiah Medical College & Teaching Hospitals, MSRIT Post, MSR Nagar, Bangalore-560054 Karnataka, India. E-mail: blpreethi97@gmail.com