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Metabolic Syndrome and the Frequency of Occurrence of Its Components in Urban South Indian Population

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Authors' contributions

This work was carried out in collaboration between all authors. Author MR conceived and designed the study, performed statistical analysis, wrote the protocol, involved in the laboratory analysis, managed the literature searches and the first draft of the manuscript. Author RC was central in writing the manuscript and critically revising the paper. Author PVB was central to the conception and critically revised the paper. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To study the frequency of occurrence of the components of Metabolic Syndrome [MetS] among MetS patients in urban south Indian population, with a view to suggest preventive measures.
Study Design: Descriptive hospital based study.
Place and Duration of Study: This study was done at a tertiary care teaching institution at Kozhikode, which is an urban area in south India, between September 2007 and February 2008.
Methodology: Subjects aged 20 years and above attending the general health check-up clinic (953 people) were screened and people meeting National Cholesterol Education Program Adult Treatment Panel III [NCEP ATP III] criterion for MetS (257 people) were enrolled for the study. In addition to history taking and clinical examination, relevant laboratory investigations were done. Pearson chi-square test was used for statistical analysis. A *P* value of $\leq$0.05 was considered as statistically significant.

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Results: The prevalence of MetS in the screened population was 27%, more in females (28.1%) than in males (26.4%) and was found to increase with increasing age, in both genders. The most frequently occurring component of MetS in this study was increased abdominal girth [AG]. The other components in the decreasing order of frequency were low high density lipoproteins [HDL], elevated fasting blood glucose [FBG], raised blood pressure [BP] and raised triglycerides [TG]. In males the most frequently occurring component of MetS was reduced HDL, whereas in females it was increased abdominal girth. The other components in the decreasing order of frequency in males were raised TG, increased AG, elevated FBG and raised BP, whereas in females it was low HDL, elevated FBG, raised BP and raised TG. Presence of increased abdominal girth (*P*<.001) and low HDL (*P*=.030) was significantly more in females, whereas raised TG (*P*<.001) was more in males.

Conclusions: Increased AG, which is the most frequently occurring component of MetS in this study, is an easily measurable parameter and may be taken as a proxy indicator for the prevalence of MetS in the population. Presence of increased AG is an indicator to check for the presence of other components of MetS and to advise necessary lifestyle changes to prevent the occurrence of MetS and to reduce the cardio vascular disease (CVD) burden in the population.

Keywords: Metabolic syndrome; urban south Indian population; components of metabolic syndrome; abdominal girth.

ABBREVIATIONS

MetS- Metabolic Syndrome; AG- Abdominal Girth; HDL- High Density Lipoproteins; TG- Triglycerides; FBG- Fasting Blood Glucose; BP- Blood Pressure; NCEP ATP- National Cholesterol Education Program- Adult Treatment Panel; CVD- Cardio Vascular Diseases; WHO- World Health Organisation.

1. INTRODUCTION

Metabolic Syndrome (MetS) is defined by a constellation of interconnected physiological, biochemical, clinical and metabolic factors that directly increases the risk of cardio vascular disease (CVD), type 2 diabetes mellitus and all cause mortality. Insulin resistance, visceral adiposity, atherogenic dyslipidemia, endothelial dysfunction, genetic susceptibility, elevated blood pressure (BP), hypercoagulable state and chronic stress are the several factors which constitute the syndrome [1]. This 'clustering' of metabolic abnormalities that occur in the same individual appear to confer a substantial additional CVD risk, over and above the sum of the risk associated with each abnormality [2]. MetS confers a 5-fold increase in the risk of type 2 diabetes mellitus and 2-fold the risk of developing CVD over the next 5 to 10 years [3]. Further, patients with the MetS are at 2- to 4-fold increased risk of stroke, a 3- to 4-fold increased risk of myocardial infarction, and 2-fold the risk of dying from such an event compared with those without the syndrome [4] regardless of a previous history of cardiovascular events [5].

A number of expert groups have developed clinical criteria for MetS, including the World Health Organization (WHO), the National Cholesterol Education Program-Adult Treatment Panel III (NCEP ATP III) [6,7], International Diabetes Federation (IDF) [8] and the European Group for the Study of Insulin Resistance (EGIR) [9]. Although there are divergent criteria for

the identification of the MetS, they all tend to agree that the MetS core components include obesity, insulin resistance, dyslipidemia, and hypertension [8]. The Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) presents the National Cholesterol Education Program's updated recommendations for cholesterol testing and management. It focuses on the role of the clinical approach to prevention of coronary heart disease. This report also gives a criterion for the diagnosis of MetS. The NCEP ATP III criterion is practical for physicians to use, since the variables defining MetS are commonly available in clinical practice. The components of NCEP ATP III criterion includes increased abdominal girth (AG), elevated BP, raised triglycerides(TG), raised fasting blood glucose (FBG) and low high density lipoprotein (HDL). Worldwide prevalence of MetS ranges from <10% to as much as 84%, depending on the region, urban or rural environment, composition (sex, age, race, and ethnicity) of the population studied, and the definition of the syndrome used [10,11]. The underlying cause of MetS continues to challenge the experts but both insulin resistance and central obesity are considered significant factors [12,13]. Higher socioeconomic status, sedentary lifestyle, and high body mass index (BMI) are significantly associated with MetS. Cameron et al. have concluded that the differences in genetic background, diet, levels of physical activity, smoking, family history of diabetes, and education all influence the prevalence of MetS and its components [14].

South Asians have an unusually high tendency to develop type 2 diabetes mellitus and coronary heart disease [15,16]. These diseases are escalating due to marked shift in lifestyle in South Asian countries caused by economic growth, affluence, urbanization and dietary changes. Clustering of cardiovascular risk factors in South Asians was initially reported from U.K [17,18]. In a large U.K. population-based study south Asians had the highest prevalence of MetS (29% in men and 32% in women using the NCEP definition) and European women had the lowest (14%) [19].

Prevalence of MetS as defined by NCEP ATP III and other criteria ranges from about 11 to 41 per cent in different regions of India [20-23]. Studies showed a high prevalence of MetS in urban Indian population. There was a significant age-related increase in its prevalence [24]. A previous study done in urban Indian adults showed low HDL as the most frequently occurring component (65.5%) and raised FBG as the least frequently occurring component (26.7%) of MetS [23].

Although it is unclear whether there is a unifying pathophysiological mechanism resulting in the MetS, abdominal adiposity and insulin resistance appear to be central to the MetS and its individual components. Lifestyle modification and weight loss should, therefore, be at the core for treatment or prevention of MetS and its components. In addition, there is a general consensus that other cardiac risk factors should be aggressively managed in individuals with the MetS [25]. Regular health check up can be helpful for identifying people with components of MetS. This study was designed to find out the prevalence of MetS in an urban south Indian population and to study the frequency of occurrence of the components of MetS in these subjects, with a view to suggest preventive measures and to emphasize further the importance of a healthy lifestyle in reducing the risk.

2. MATERIALS AND METHODS

This descriptive study was done at a tertiary care teaching institution, at Kozhikode, which is an urban area in south India. Prior to the commencement of the study, approval was obtained from the institution ethics committee. All people aged 20 years and above (957

subjects) , excluding pregnant ladies and patients with as cites due to any pathophysiology, who attended the general health check up clinic at the hospital, during the study period of 6 months, between September 2007 and February 2008, were included in the study. Written informed consent was obtained from the patients. The general health check up clinic in this institution is run by the department of Family Medicine and the department of Internal Medicine. It has six out patient days a week and an average of eight persons per day come for general health check up. Clinical data was collected using standard questionnaire and physical examination at baseline. Name, age, sex, occupation, history regarding whether the patient is on treatment for diabetes, hypertension or dyslipidemia, whether the patient has family history of diabetes, hypertension or dyslipidemia was noted. Patients' height, weight, body mass index, abdominal girth and blood pressure measured. Laboratory tests included fasting blood glucose, fasting triglyceride level and fasting HDL cholesterol.

Abdominal girth was measured midway between lowest rib and iliac crest as described in the WHO and International Diabetes Federation guidelines [26,27]. The bony landmarks of the lowest rib and the iliac crest were located at the level of the mid axillary line. The measurement was made transversely midway between the iliac crest and lower rib margin in the mid axillary line, at the end of normal expiration with a non elastic plastic tape adjacent to, but not compressing the skin and the participant standing well erect. Special attention was paid to ensure the tape was parallel to the floor. Blood pressure recorded by auscultatory method using sphygmomanometer. Average of two readings, taken at interval of two minutes, after the patient was comfortably seated for ten minutes.

Blood samples were collected after overnight fasting (12hrs) and blood analysis done. FBG was measured on fully automated chemistry analyzer using the principle of enzymatic hexokinase method. Measurement of TG and HDL cholesterol was done on a fully automated chemistry analyzer (Dade Behring RxL). The principle used for TG measurement is enzymatic method of lipase-glycerol kinase followed by trinder reaction. HDL measurement is by direct HDL cholesterol method.

Screening was done to identify those with MetS, using the Modified National Cholesterol Education Program Adult Treatment Panel III criterion (Table 1) [28], including specifications to the people of south Asian origin (ATP III south Asian specific (SAS), 2009) [29]. NCEP-ATP III criterion for fasting blood glucose was revised in 2005 to meet American Diabetes Association (ADA) recommendations [30]. The cut-off value for fasting blood glucose was therefore lowered from 6.1mmol/l (110mg/dl) to 5.6mmol/l (100mg/dl) for both men and women.

NCEP ATPIII criterion diagnose MetS if "any 3 or more of 5"components are present.

The obtained data was analysed. 253 subjects out of 957 screened were found to have MetS. Advise regarding a healthy lifestyle including healthy diet, regular exercise, importance of stopping smoking and alcoholism and treatment for specific disorders like diabetes, hypertension and dyslipidemia, were given to the screened subjects.

Statistical analysis was done using the SSPS Ver. 12 software. The graph was produced using Microsoft Excel. The Pearson Chi-square test was used to test if the proportion of subjects with abnormal values was significantly different between the two sexes and different age groups. The significance was determined at the 5% level.

Table 1. Modified national cholesterol education program adult treatment panel III criterion for clinical diagnosis of metabolic syndrome

Any 3 or more of the following components	Modifications
Central obesity (abdominal girth*) >102cms in males >88cms in females	 ≥90cms in male(south Asians) ≥80cms in female(south Asians)
Raised TG level Triglycerides ≥150mg/dl (1.69mmol/L) or on specific medication for elevated triglycerides.	
Low HDL cholesterol: <40mg/dl (1.04mmol/L)-males <50mg/dl (1.29mmol/L)–females or on specific medication for low HDL.	
Hypertension: Blood pressure≥130mm of Hg systolic blood pressure Or ≥85mm of Hg diastolic blood pressure Or on specific medication for elevated blood pressure or history of hypertension.	
Fasting blood glucose Glucose ≥100mg/dl (5.6mmol/L) Or on specific medication for diabetes Or previously diagnosed type 2 diabetes.	NCEP-ATP III criterion for impaired fasting glucose was revised in 2005 to meet American Diabetes Association (ADA) recommendations. The cut-off value was therefore lowered from 6.1mmol/l (110mg/dl) to 5.6mmol/l (100mg/dl) for both men and women (or drug treatment for elevated fasting glucose).

**Ethnic specific values for abdominal girth applies (29)*

3. RESULTS

Of the 953 people screened, (626 males and 327 females), 257 (27%) persons were found to have MetS as per the modified NCEP ATP III diagnostic criterion. Gender wise, 165 males (26.4%) and 92 females (28.1%) were having MetS (*P*=.557), with no significant difference. The study subjects had a mean age of 44.11 yrs (SD+9.7). The median age was 43 yrs. The youngest subject was 22 years and the oldest 67 yrs old.

Studying the age group wise distribution of MetS subjects, it was found that the frequency of occurrence of MetS increases as age advances, in males (*P*<.001), females (*P*<.001) and in the combined population (*P*<.001) and this is statistically significant (Table 2). An obvious increase in the occurrence of MetS among females is seen in the age group 40-49 years, where as in males this increase is seen in the age group 50-59 years.

Table 2. Age group wise distribution of MetS in urban south Indian population

Age group (years)	Combined population	Males	Females
20-29	10.2%	9%	12.9%
30-39	19.4%	22.7%	15%
40-49	29.5%	25.1%	40.7%
50-59	51.8%	50%	52.8%
60 & above	65.5%	60%	71.4%
P value	<.001	<.001	<.001

Increase in abdominal girth (76.7%) was the most frequently occurring component of MetS in the study group. The other components in the decreasing order of frequency were low HDL (74.7%), increased FBG (64.6%), elevated BP (60.7%) and increased TG levels (55.6%) (Table 3).

Table 3. Frequency of occurrence of components of MetS in urban south Indian population

Variable	Frequency	Percentage (%)
Increased abdominal girth	197	76.7%
Low high density lipoprotein	192	74.7%
Increased fasting blood glucose	166	64.6%
Elevated blood pressure	156	60.7%
Increased triglycerides	143	55.6%

Gender wise frequency of occurrence of components of MetS was studied in this group. Decrease in HDL (70.3%) was the most frequently occurring component of MetS in male population, whereas in females it was increased abdominal girth (96.7%) (Table 4). The difference in the proportion of frequency of occurrence of increased abdominal girth (*P*<.001), raised TG (*P*<.001) and low HDL level (*P*=.030) in males and females was found to be statistically significant. Presence of increased abdominal girth and low HDL values was significantly more among females, whereas raised TG levels was more among males (Table 4).

Table 4. Gender wise frequency of occurrence of components of MetS in urban south Indian population

Variable	Gender		*P* value
	Male	Female	
Increased abdominal girth	108(65.5%)	89(96.7%)	<.001
Elevated blood pressure	99(60.0%)	57(62.0%)	.758
Increased triglycerides	110(66.7%)	33(35.9%)	<.001
Low high density lipoprotein	116(70.3%)	76(82.6%)	.030
Increased fasting blood glucose	108(65.4%)	58(63.0%)	.698

As age group advances an increase in the prevalence of elevated blood pressure levels (*P*=.023) and raised fasting blood glucose levels (*P*=.048) was observed and this is statistically significant.

While studying the association between increased abdominal girth and other components of Mets (Fig. 1), it was seen that there was statistically significant association between AG and TG levels. The proportion of patients with increased TG levels was more in those with normal AG (*P*<.001). No statistically significant association was found between AG and raised BP (*P*=.668), raised FBG (*P*=.106) or low HDL (*P*=.281).

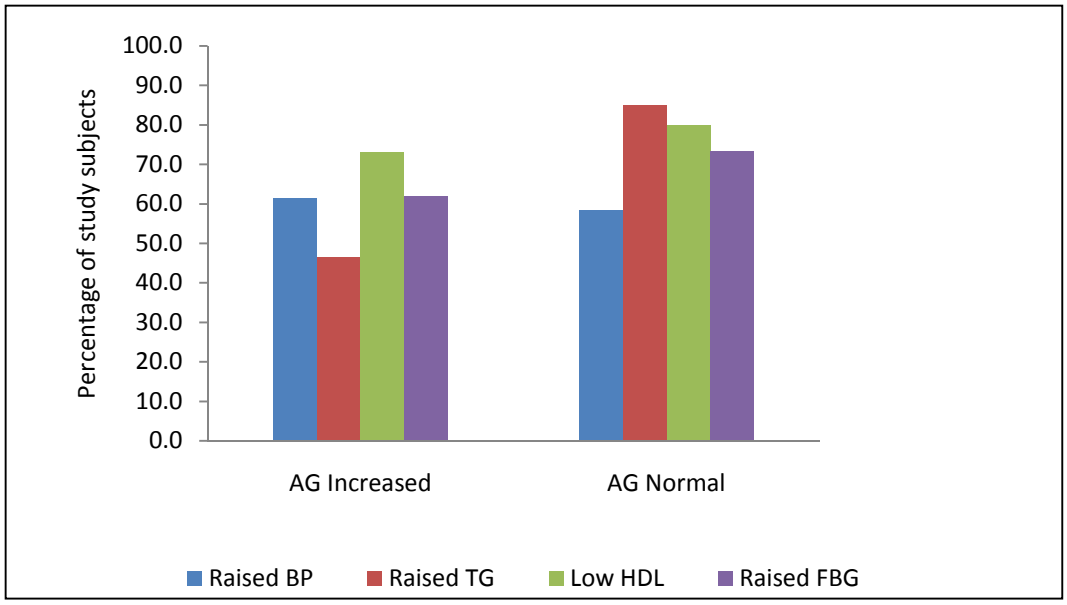

Fig. 1. Association between increased abdominal girth and other components of MetS in urban south Indian population

(AG- Abdominal girth, BP- Blood pressure, TG- Triglyceride, HDL- High density lipoprotein, FBG- Fasting blood glucose)

The proportion of patients with raised FBG and raised BP was more in those with low HDL (*P*=.031 and *P*=.027 respectively) in the study group. There was a significant association between proportion of people having family H/O diabetes and elevated FBG levels (*P*=.020). The proportion of MetS patients with family history of diabetes was found to be more among those with raised FBG levels than in patients with normal FBG values. No significant association was found between family history of HTN among MetS subjects, and raised BP (*P*=.898), and also family history of dyslipidemia among MetS patients, and raised TG (*P*=.436) or low HDL levels (*P*=.057).

4. DISCUSSION

The MetS is being recognized as a constellation of factors associated with an increased CVD risk. South Asians have been found to have a predilection for development of this syndrome. The prevalence of MetS in Asian Indians varies according to region, extent of urbanization, lifestyle patterns, and socioeconomic/cultural factors [31]. Recent data show that about one-third of the urban population in large cities in India have MetS [23,32] and one previous study from south India has shown that significant differences exist in the prevalence of various components of the MetS even within an urban environment [20].

This cross sectional study was done to assess the prevalence of MetS and to analyze the frequency of occurrence of its components, among subjects with MetS in an urban population from Kozhikode, in south India. Out of 953 people screened during a 6 month period, 257 persons were found to have MetS as per modified NCEP ATPIII diagnostic criterion. The prevalence of MetS in our study group was 27%. Earlier studies done in urban Indian population [20-23] had showed prevalence ranging from 11 to 41% in different regions of India. In our study the frequency of occurrence of MetS was found to be more in females (28.1%) than in males (26.4%), though this difference was not statistically significant. A previous population study in urban Asian Indian adults using the same diagnostic criterion for MetS, showed a prevalence of 41.1% in the population, more in women 46.5% than in men 36.4% (P=.03) [23]. The present study was hospital based on people who voluntarily came forward for screening. As 27% patients could be detected to have Mets in the present study, it emphasizes that routine hospital based screening programmes may be beneficial in detecting persons having MetS.

There was a significant age related increase in prevalence of MetS in this study population. The prevalence was 10.2% among 20-29 year old adults and 65.5% among those 60 years of age and older, as compared to a previous study among U.S. adults based on the data of the third National Health and Nutrition Examination Survey [33] which showed prevalence 6.75% among 20-29 year old adults to 43.5% for those aged 60-69 years of age. Another study by Park et al. [34] showed that there is an increase in the prevalence of MetS from 20 years old through the sixth and seventh decade of life for males and females, respectively. In this study group also a significant age related increase in the prevalence of MetS was seen both for males and females, from 20 years old through the sixth decade of life and older.

There was an obvious increase in the occurrence of MetS among females in the age group 40-49 years, where as in males this increase was seen in the age group 50-59 years. This finding needs to be further explored in future population studies. It may be related to the menopausal changes in females. Pre-menopausal women have quantitatively more lipoprotein lipase (LPL) and higher LPL activity in the gluteal and femoral subcutaneous regions, which contain fat cells larger than those in men, but these differences, disappear after menopause [35]. Ponholzer et al. reported that there was high prevalence of MetS among postmenopausal women, which varies from 32.6% to 41.5% [36].

In this study population, increase in AG was the most frequently occurring component of MetS followed by low HDL levels, elevated FBG, raised BP and raised TG in the decreasing order of frequency. A previous study done in urban Asian Indian adults showed frequency distribution of the components of MetS as low HDL in 65.5%, raised BP in 55.4%, increased TG in 45.6%,increased abdominal girth in 31.4%,and raised FBG in 26.7% [23]. Compared to this in our study, we have found that low HDL was the most frequently occurring component of MetS in the male population, but in females increase in AG was the most frequently occurring component of MetS.

The difference in the proportion of frequency of occurrence of increased AG, raised TG and low HDL level in males and females was found to be statistically significant in our study population. Presence of increased AG and low HDL values were significantly more among females, whereas raised TG level was more among males. A study done in American adults of Asian Indian origin showed low HDL, increased AG and high BP most prevalent in women, while hypertriglyceridemia, low HDL and high BP were more prevalent in men [37]. A significant increase in the prevalence of elevated BP and increased FBG levels were found, as age advances. There are previous studies showing similar data [38,39]. Another

finding observed in this study was, a statistically significant inverse association was present between AG and TG levels. The proportion of patients with increased TG levels was more in those with AG below the cut off value stated in the criterion for diagnosis of MetS. This finding needs to be further studied in the population. No significant association was found between AG and raised BP, raised FBG or low HDL. Contrarily, a previous study done in American adults of Asian Indian origin showed that increased AG was significantly associated with raised FBG, raised TG and low HDL [37].

Another significant association seen in this study was between low HDL value and raised BP and elevated FBG. The proportion of patients with raised FBG and raised BP was more in those with low HDL. A study done by Jeppesen J et al. in hypertensive subjects with low HDL cholesterol/high TG showed that, BP control alone is not enough, it is also important to normalize low HDL cholesterol and the other components of MetS, in order to lower the risk of ischemic heart disease and stroke [40].

The proportion of MetS patients with family history of diabetes was found to be more among those with raised FBG levels than in patients with normal FBG values. This association was statistically significant. This is in accordance with a study by Van der Sande et al. which states that risk of diabetes was increased in individuals with a family history of diabetes [41]. In this study no significant association was found between family history of hypertension among MetS patients and raised BP, and also between family history of dyslipidemia among MetS patients and raised TG or low HDL levels. This finding is contradictory to some observations made in previous studies [41], which states that a family history of hypertension, obesity, diabetes, or stroke was a significant risk factor for hypertension, obesity, diabetes and hyperlipidaemia.

Abdominal girth which was found to be the most frequently occurring component of MetS, is an easily measurable parameter and numerous clinical studies have shown that abdominal girth can provide good prediction of type 2 diabetes and coronary heart disease [42,43].

This study re-emphasises the importance of measuring abdominal girth as a cheap and easy tool for screening in MetS. This is very relevant, to optimally use the health resources as there is an increase in epidemic of diabetes and CVD globally. This provides a window of opportunity for appropriate early intervention. If there is any one or more of the components of MetS, aggressive lifestyle changes can delay the development of MetS and its associated conditions. Any intervention that is successful in reducing the prevalence of MetS will have a tremendous impact in reducing the rate of diabetes, CVD and related socio-economic burden to the society.

There are some limitations in the present study. This study was done in an urban hospital setting, on people coming to the general health checkup clinic. This selection bias limits the extend to which the results can be projected for the general population. A causal relationship cannot be established between exposure variables (age, gender) with MetS or its components, since we have used a cross sectional methodology.

5. CONCLUSION

Increased abdominal girth is the most frequently occurring component of MetS. This is an easily measurable parameter and may be taken as an indicator for the occurrence of MetS in the population and a guide to check for the presence of other components of MetS. Low HDL is the most prevalent risk factor in male population in this study where as in females it is

increased AG. Another major finding is a significant age related increase in prevalence of MetS in this study population. With MetS driving the twin global epidemics of type 2 diabetes and CVD there is an overwhelming need to identify those individuals with MetS early, so that lifestyle modification therapy and if needed pharmacological treatment is initiated to prevent the development of type 2 diabetes and/or CVD. Routine health checkup programmes are beneficial in detecting patients having MetS.

CONSENT

Permission was sought and obtained from the hospital management before the commencement of this study. Written informed consent was obtained from the patients after briefing them about the study and its significance.

ETHICAL APPROVAL

Prior to the commencement of this study, ethical approval was obtained from the institution ethics committee.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jaspinder Kaur. A comprehensive review on metabolic syndrome. Cardiology Research and Practice. 2014;21. Article ID 943162.
2. Golden SH, Folsom AR, Coresh J, Sharrett AR, Szklo M, Brancati F. Risk factor grouping related to insulin resistance and their synergistic effects on subclinical atherosclerosis: The atherosclerosis risk in communities study. Diabetes. 2002;51(10):3069-3076.
3. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: A joint interim statement of the international diabetes federation task force on epidemiology and prevention; National heart, lung, and blood institute; American heart association; World heart federation; International atherosclerosis society; and international association for the study of obesity. Circulation. 2009;120(16):1640-1645.
4. Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome—a new worldwide definition. The Lancet. 2005;366(9491):1059-1062.
5. Olijhoek JK, Van Der Graaf Y, Banga JD, Algra A, Rabelink TJ, Visseren FL. The Metabolic Syndrome is associated with advanced vascular damage in patients with coronary heart disease, stroke, peripheral arterial disease or abdominal aortic aneurysm. European Heart Journal. 2004;25(4):342-348.

6. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part I: Diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med. 1998;15:539-553.
7. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA. 2001;285:2486-2497.
8. Alberti KG, Zimmet P, Shaw J: Metabolic syndrome: A new world-wide definition: A consensus statement from the International Diabetes Federation. Diabet Med. 2006;23:469-480.
9. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation: European Group for the Study of Insulin Resistance (EGIR). Diabet Med. 1999;16:442-443.
10. Desroches S, Lamarche B. The evolving definitions and increasing prevalence of the metabolic syndrome. Applied Physiology, Nutrition and Metabolism. 2007;32(1):23–32.
11. Kolovou GD, Anagnostopoulou KK, Salpea KD, Mikhailidis DP. The prevalence of metabolic syndrome in various populations. The American Journal of the Medical Sciences. 2007;333(6):362-371.
12. Hu G, Qiao Q, Tuomilehto J, Eliasson M, Feskens EJ, Pyörälä K. Plasma insulin and cardiovascular mortality in non-diabetic European men and women: A meta-analysis of data from eleven prospective studies. The DECODE Insulin Study Group. Diabetologia. 2004;47(7):1245–1256.
13. Carr DB, Utzschneider KM, Hull RL, Kodama K, Retzlaff BM, Brunzell JD, et al. Intra-abdominal fat is a major determinant of the National Cholesterol Education Program Adult Treatment Panel III criteria for the metabolic syndrome. Diabetes. 2004;53(8):2087-2094.
14. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: Prevalence in worldwide populations. Endocrinology and Metabolism Clinics of North America. 2004;33(2):351-375.
15. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: Prevalence, numerical estimates and projections. Diabetes Care. 1998;21(9):1414-1431.
16. Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation.1998;97(6):596-601.
17. McKeigue PM, Pierpoint T, Ferrie JE, Marmot MG. Relationship of glucose intolerance and hyperinsulinaemia to body fat pattern in south Asians and Europeans. Diabetologia. 1992;35(8):785-791.
18. McKeigue PM, Marmot MG, Syndercombe Court YD, Cottier DE, Rahman S, Riemersma RA. Diabetes, hyperinsulinaemia and coronary risk factors in Bangladeshis in east London. Br Heart J. 1988;60(5):390-396.
19. Tillin T, Forhouhi N, Johnston DG, McKeigue PM, Chaturvedi N, Godsland IF. Metabolic syndrome and coronary heart disease in South Asians, Africans, Carribbeans and white Europeans: A UK population based cross-sectional study. Diabetologia. 2005;48(4):649-656.
20. Mohan V, Shanthirani S, Deepa R, Premalatha G, Sastry NG, Saroja R. Intra-urban differences in the prevalence of the metabolic syndrome in southern India-the Chennai Urban Population Study (CUPS No. 4). Diabet Med. 2001;18(4):280-287.
21. Gupta A, Gupta R, Sarna M, Rastogi S, Gupta VP, Kothari K. Prevalence of diabetes, impaired fasting glucose and insulin resistance syndrome in an urban Indian population. Diabetes Res Clin Pract. 2003;61(1):69-76.

22. Deepa R, Shanthirani CS, Premalatha G, Sastry NG, Mohan V. Prevalence of insulin resistance syndrome in a selected south Indian population-the Chennai urban population study-7 [CUPS-7]. Indian J Med Res. 2002;115:118-127.
23. Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Metabolic syndrome in urban Asian Indian adults-a population study using modified ATP III criteria. Diabetes Res Clin Pract. 2003;60(3):199-204.
24. Rajeev Gupta, Prakash C, Deedwania, Arvind Gupta, Shweta Rastogi, Raja B. Panwar, et al. International Journal of Cardiology. 2004;97(2):257-261.
25. Marc-Andre Cornier, Dana Dabelea, Teri L. Hernandez, Rachel C. Lindstrom, Amy J. Steig, Nicole R. Stob, et al. The Metabolic Syndrome. Endocrine Reviews. 2008;29(7):777–822.
26. Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome-a new worldwide definition. Lancet. 2005;366(9491):1059–1062.
27. Physical status. The use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser. 1995;854:1–452.
28. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. American Heart Association; National Heart, Lung, and Blood Institute. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation. 2005;112(17):2735–2752.
29. Tan CE, Ma S, Wai D, Chew SK, Tai ES. Can we apply the National Cholesterol Education Program Adult Treatment Panel definition of the metabolic syndrome to Asians? Diabetes Care. 2004;27:1182-1186.
30. Genuth S. Lowering the criterion for impaired fasting glucose is in order. Diabetes Care. 2003;26(12):3331-3332.
31. Misra A, Khurana L. The metabolic syndrome in South Asians: Epidemiology, determinants, and prevention. Metab Syndr Relat Disord. 2009;7(6):497–514.
32. Misra A, Misra R, Wijesuriya M, Banerjee D. The metabolic syndrome in South Asians: Continuing escalation and possible solutions. Indian J Med Res. 2007;125(3):345–354.
33. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among U.S. adults: Findings from the third National Health and Nutrition Examination Survey. JAMA. 2002;287(3):356-359.
34. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: Prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey,1988-1994. Archives of Internal Medicine. 2003;163(4):427-436.
35. Obesity: Preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ. Tech. Rep. Ser. 2000;894(1– 12):1–253.
36. Ponholzer A, Temml C, Rauchenwald M, Marszalek M, Madersbacher S. Is the metabolic syndrome a risk factor for female sexual dysfunction in sexually active women? International Journal of Impotence Research. 2008;20(1):100-104.
37. Misra KB, Endemann SW, Ayer M. Measures of obesity and metabolic syndrome in Indian Americans in northern California. Ethn Dis. 2006;16(2):331-337.
38. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047-1053.
39. Mohan V, Deepa M, Farooq S, Datta M, Deepa R. Prevalence, awareness and control of hypertension in Chennai-The Chennai Urban Rural Epidemiology Study (CURES-52). J Assoc Physicians India. 2007;55:326-332.

40. Jeppesen J, Hein HO, Suadicani P, Gyntelberg F. High triglycerides/low high-density lipoprotein cholesterol, ischemic electrocardiogram changes, and risk of ischemic heart disease. Am Heart J. 2003;145(1):103-108.
41. Van der Sande MA, Walraven GE, Milligan PJ, Banya WA, Ceesay SM, Nyan OA, et al. Family history: an opportunity for early interventions and improved control of hypertension, obesity and diabetes. Bull World Health Organ. 2001;79(4):321-328.
42. Reijo Siren, Johan G Eriksson, Hannu Vanhanen. Waist circumference a good indicator of future risk for type 2 diabetes and cardiovascular disease. BMC Public Health. 2012;12:631.
43. Jean-Pierre Després. Abdominal obesity: The most prevalent cause of the metabolic syndrome and related cardiometabolic risk. Eur Heart J Suppl. 2006;8(suppl B):B4-B12.

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