Research Article

Metabolic syndrome in an adult population of rural Karnataka

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Abstract

Background: Metabolic syndrome is a group of abnormalities that confers an increased risk of developing atherosclerotic cardiovascular diseases and type 2 diabetes mellitus. **Aim:** To determine the prevalence of metabolic syndrome in adults aged ≥18 years in a rural population, to find the prevalence of various risk factors of metabolic syndrome and to determine the factors significantly contributing to metabolic syndrome in the same population. **Materials and Methods**: A cross-sectional study was undertaken in Jangamsheegehally village of Chintamani taluk in Karnataka. A detailed personal and clinical history, blood pressure, anthropometric measurements were recorded and a fasting blood sample was drawn from each of the 188 subjects. The serum samples were analyzed for Fasting Blood Sugar and lipid profile. **Results:** the prevalence of metabolic syndrome in adults aged ≥18 years, using the updated AHA/NHLBI statement criteria was 42 (22.3%). At least one metabolic abnormality was seen in 87.23% subjects (90% of females and 84% of the males). The commonest abnormality in females was low HDL (79%), Central obesity (29%) and hyperglycemia (12%). In males, low HDL (67%) was also the most common abnormality followed by high triglycerides (40.9%) and hyperglycemia (18.1%). The most significant independent risk factors for developing metabolic syndrome were found to be Hypertriglyceridemia (OR 21.07, CI 8.48-52.35, p<0.001), Low HDL levels (OR 20.71, CI 1.78- 101.0, p= 0.001) and Central obesity (OR 15.75, CI 7.40-38.69, p<0.001). **Conclusion:** The prevalence of metabolic syndrome was highest in the age group of 31-40 years with low HDL levels, hypertriglyceridemia and central obesity being independent risk factors. Efforts should be aimed at educating the rural masses regarding lifestyle modifications including suggestions on improving eating habits, the importance of a regular exercise regimen, social support and stress management strategies in order to alleviate the metabolic abnormalities that could increase the risk of Metabolic syndrome.

Keywords: Metabolic Syndrome, rural population, cardiovascular risk, low HDL, triglycerides and type 2 diabetes mellitus

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INTRODUCTION

Metabolic syndrome (MS) is a group of abnormalities (abdominal obesity, atherogenic dyslipidemia, raised blood pressure, insulin resistance and/or glucose intolerance, proinflammatory state, and prothrombotic state) that confers an increased risk of developing atherosclerotic cardiovascular diseases (CVD) and also type 2 diabetes mellitus (T2DM). Almost all these factors are associated with increased morbidity and mortality in general and CVD in particular[1]. This syndrome is seen in about 20-30% of the adult population worldwide[2]. The pathogenesis remains unclear and is a complex interaction of sedentary lifestyle, socioeconomic transitions, stress,

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urbanisation, migration, obesity, rapid nutritional changes and genetic factors[2]. Numerous definitions have been proposed for metabolic syndrome[3-7]. The most recent definition is from the Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; the National Heart, Lung, and Blood Institute (AHA/NHLBI); the American Heart Association; the World Heart Federation; the International Atherosclerosis Society; and the International Association for the Study of Obesity[8] and also a Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians[9]. As per these concensus statements, the presence of three or more of the following five parameters could be considered as presence of MS.

1. Elevated waist circumference: ≥90 cm in men and ≥80 cm in women
2. Elevated triglycerides: ≥150 mg/dL or on drug treatment (example-fibrates, nicotinic acid) for elevated triglycerides
3. Reduced HDL-C: <40 mg/dL in men and <50 mg/dL in women, or on drug treatment for reduced HDL-C (example-fibrates, nicotinic acid),
4. Elevated blood pressure: ≥130 mm Hg systolic blood pressure and/or ≥85 mm Hg diastolic blood pressure or on antihypertensive drug treatment in a patient with a history of hypertension,
5. Elevated fasting glucose: ≥100 mg/dL or on drug treatment for elevated glucose.

Many studies in India have reported a high prevalence of metabolic syndrome, that continues to rise[10-13]. However, these studies were carried out mainly in urban areas and used different criteria to diagnose metabolic syndrome. Very little information is available about the magnitude of metabolic syndrome in Indian rural areas. Hence the present study was undertaken in Jangamshegehally, a rural area of Chikkaballapur District in Karnataka state of south India, with the following objectives:

1. To determine the prevalence of metabolic syndrome in adults aged ≥18 years, using the updated AHA/NHLBI statement criteria in a rural population.
2. To find the prevalence of various risk factors of metabolic syndrome using the updated AHA/NHLBI statement criteria
3. To determine the factors significantly contributing to metabolic syndrome amongst the rural population

MATERIALS AND METHODS

This cross sectional study is part of the pilot study of, "A study to evaluate the effect of an intervention module on modifiable risk factors for select non-communicable diseases (NCD's) in a rural community", which was undertaken by the Department of Community Medicine and Department of Biochemistry, M S Ramaiah Medical college and hospitals in a rural area of Kaiwara Primary Health Centre (PHC), Chintamani Taluk of Karnataka State, India. Ethical clearance was obtained from the institutional ethics committee. One village (Jangamsheegehally) was selected randomly from a list of 36 villages covered by the Kaiwara PHC. All adults ≥ 18 years of age in 218 households in the village with a population of 722 were included and pregnant females were excluded. After establishment of a rapport with the villagers, an awareness programme regarding the purpose of the study was carried out. Written informed consent of the participants was obtained. A pretested semi-structured questionnaire which included questions relating to socio demographic details, dietary habits, physical activity, personal habits, socioeconomic status and medical history of diabetes, hypertension, including family history and other risk factors for NCDs was used. A training manual which provided information on the questionnaire and methodology for recording of blood pressure and anthropometric measurements was developed based on the manual of the MONICA study[14]. The manual contained definitions used in the study, details of method of data collection, drawing of blood sample, centrifugation, storage, and transportation of blood samples to the tertiary laboratory for analysis. One day training was conducted for all the medical personnel, field workers, and technicians involved in data collection. The study was conducted between the months of September 2010 to November 2010. A house-to-house survey was done, during which each eligible subject (≥ 18 years of age) identified in the house was given a unique identification number in serial order. Each of the eligible subjects was interviewed with the questionnaire. Following the interview, blood bpressure and anthropometric measurements were recorded with standardized instruments [14]. These instruments were subjected to appropriate quality control checks. Height was measured without footwear with a non-stretchable standardized measuring scale with an accuracy of up to 0•5 cm. Weight was measured with a standard 'Indian Standards Organization' certified weighing scale with minimum clothes and without footwear with an accuracy of up to 100 gms. The weighing scale was set to zero and checked with a known weight every day. Waist and hip measurements were taken with a non-stretchable plastic tape and rounded off to the nearest 0•5 cms. Waist and

hip measurements of female subjects was done by female investigators. Waist, and hip measurements were taken twice with a five minute interval and the average of the two measurements was recorded as the final measurement. Body mass index (BMI) was calculated as weight in kilograms divided by squared height in meter. After 5 minutes of rest, left arm systolic (SBP) and diastolic (DBP) blood pressure measurements were taken twice using a mercury sphygmomanometer and stethoscope to the nearest 2mm Hg and were averaged for the analyses. A third measurement was taken only when the difference between the two measurements was ≥ 5 mmHg. Prior medical records for blood pressure were also taken into consideration. Sample Size Estimation: Sample size estimation: Studies on chronic illness carried out in rural areas in India have reported that the prevalence of select chronic diseases was nearly 30%[15]. With an absolute precision of 5% and a confidence level of 99%, the estimated sample size was 559. Due to cost constraints, laboratory investigations were done on a random sample of the respondents. Hence, sample size for laboratory investigations was estimated based on the prevalence of dyslipidemia among normotensives in a rural area, as 48%[16]. A relative precision of 15% with alpha error of 5%, the required sample size was 185. At the end of the survey (2 months), 204 randomly selected subjects were asked to come for laboratory investigations to a village school. Subjects were informed orally as well as with an information pamphlet in the local language, about blood collection for estimation of glucose and lipid profile and the importance to remain fasting for 12 hours. The number of subjects who came for laboratory investigations were 188. A blood sample was collected, with due asceptic precautions, after an overnight fast of 8-12 hours from each study subject. The blood samples were collected, by a trained laboratory technician, in plain, gel vacutainers, allowed to clot and centrifuged at the place of collection to separate the serum. The separated serum was stored at 2-8°C in refrigerators for a maximum period of 2 hours in the field area and then transported with ice packs to the diagnostic laboratory of M S Ramaiah Hospitals for the estimation of fasting blood sugar (by glucose oxidase method), complete lipid profile (serum total cholesterol- enzymatic colorimetric method using cholesterol oxidase, serum triglyceride- enzymatic colorimetric method using glycerol phosphate oxidase, serum high density lipoprotein- enzymatic colorimetric method using cholesterol oxidase and esterase and low density lipoprotein using Friedwalds equation) on Cobas 6000c501 RXL MAX TM, fully automated analyzer, as per standard specifications[17]. The presence of the metabolic syndrome was determined using the updated present AHA/NHLBI statement- the presence of any three of the five modifiable cardiovascular risk factors confers a clinical diagnosis of metabolic syndrome[6,8,9].

STATISTICAL ANALYSIS

Data was analyzed using the SPSS Version 18•0. Descriptive statistics such as proportions / mean, standard deviations were calculated. Chi square test was employed to test for differences in the various parameters. Prevalence rates of risk factors were estimated. Considering Fasting Blood Sugar <100 mg/dL, Serum Triglyceride<150 mg/dL, Serum HDL ≥40 mg/dL in men and ≥ 50 mg/dL in women, Blood Pressure(<130 mm Hg systolic blood pressure and/or < 85 mm Hg diastolic blood pressure) and Waist circumference < 90 cm in men and <80 cm in women as reference categories, univariate odd's ratios were estimated along with 95% confidence intervals separately for Metabolic Syndrome and Non-Metabolic syndrome categories.

RESULTS

Of the 188 subjects who participated in the study, 88 were males and 100 were females. Age, gender distribution of the subjects and prevalence of metabolic syndrome as per the updated AHA/NHLBI statement criteria is shown in table1. The overall prevalence of metabolic syndrome as per the updated AHA/NHLBI statement criteria was 22.3% (n=42) with 22 out of 88 males (25%) and 20 out of 100 (20%) females, showing no significant differences in gender wise prevalence of MS. The prevalence of MS was found to be highest in the age group 18-39 years (40.47%). In the age group 40-59 years and ≥ 60 years, the prevalence of MS was found to be 28.57% and 30.95% respectively. Table 2 shows the age and gender-wise prevalence of the five criteria of metabolic syndrome amongst the study subjects. Among the study subjects, 87.23% subjects (90% of female subjects and 84% of the male subjects) had at least one risk factor for metabolic syndrome. Only 16% of all the males and 10% of all the females amongst the study subjects were without any metabolic abnormality. Table 3 shows that amongst females, the commonest abnormality was low HDL (79%), followed by Central obesity (29%). Hyperglycemia (12%) was the least common abnormality amongst female subjects. In males, low HDL (67%) was also the most common abnormality followed by high triglycerides (40.9%). Hyperglycemia was the least common (18.1%) abnormality amongst male subjects. Multivariate logistic regression analysis was used to identify the independent risk factors for MS (Table 4). Advancing age was a significant risk factor for the development of MS. The mean age of subjects with MS was found to be significantly higher than the mean age of

controls. There was no significant difference in terms of predisposition in developing MS with regards to gender, educational, socioeconomic status (individuals belonging to various educational and socioeconomic strata were evenly distributed in both the groups) or physical activity (data not shown). Hypertriglyceridemia (OR 21.07, CI 8.48-52.35, p<0.001), Low HDL levels (OR 20.71, CI 1.78- 101.0, p= 0.001), Central obesity (OR 15.75, CI 7.40-38.69, p<0.001), Hypertension (OR 10.86, CI 4.45-21.0, p<0.001) and Hyperglycemia (OR 8.34, CI 3.94-23.45, p<0.001), were the significant risk factors for developing MS.

Table 1: Age and gender distribution of the study subjects

Baseline Variables	Non MS n=146 (77.6%)	MS n=42 (22.3%)	Total n=188 (100%)	p value
Age in years				
18-39	76 (81.7%)	17(18.3%)	93	
40-59	46 (79.3%)	12 (20.7%)	58	0.107
≥ 60	24 (64.9%)	13 (35.1%)	37	
Gender				
Male	66 (75%)	22(25%)	88	0.411
Female	80(80%)	20(20%)	100	

Table 2: Age and gender-wise prevalence of the five criteria of metabolic syndrome according to the updated AHA/NHLBI statement amongst the study subjects

Age Group in years	Males n=88 (%)				Females n=100 (%)			
	No abnormality	One abnormality	Two abnormalities	Metabolic syndrome (Three or more abnormalities)	No abnormality	One abnormality	Two abnormalities	Metabolic syndrome (Three or more abnormalities)
18-39 (n=93)	10	14	8	10	4	29	11	7
40-59 (n=58)	2	13	9	7	5	7	10	5
≥ 60 (n=37)	2	2	6	5	1	4	9	8
Total (n=188)	14 (16% of males)	29 (33% of males)	23 (26% of males)	22 (25% of males)	10 (10% of females)	40 (40% of females)	30 (30% of females)	20 (20% of females)

Table 3: Comparison of the proportion of subjects who are characterized with various components of metabolic syndrome

Components	Whole study Population n=188 [%of all study subjects]	Males [88] [% of male subjects]	Females [100] [% of female subjects]	p value
Hyperglycemia (Fasting Blood Sugar ≥100 mg/dL)	28 [14.9]	16 [18.1]	12 [12.0]	0.235
Hypertriglyceridemia (Serum Triglyceride ≥150 mg/dL)	63 [33.5]	36 [40.9]	27 [27.0]	0.044*
Decreased HDL (<40 mg/dL in men and <50 mg/dL in women)	138 [73.4]	59 [67]	79 [79.0]	0.064
Hypertension (≥130 mm Hg systolic blood pressure and/or ≥85 mm Hg diastolic blood pressure)	47 [25]	23 [26.1]	24 [24]	0.083
Central Obesity (Waist circumference ≥90 cm in men and ≥80 cm in women)	50 [26.5]	21 [23.8]	29 [29]	0.426

* Moderate statistical significance (p value: 0.01≤ 0.05)

Table 4: Multivariate logistic regression analysis for risk factors for metabolic syndrome (MS)

Variables	Non MS n=146	MS n=42	Total n=188	Odds Ratio (OR at 95% CI)	p value
Mean age in years	40.82±16.45	46.67±14.87	42.12±16.26	-	0.039*
Number of males	66(45.2% of non MS subjects)	22(52.4% of MS subjects)	88(46.8% of all study subjects)	Reference	0.411
Number of females	80(54.8% of non MS subjects)	20(47.6% of MS subjects)	100(53.2% of all study subjects)	0.75	
Subjects with Central Obesity (Waist circumference ≥90 cm in men and ≥80 cm in women)	20(13.6% of non MS subjects)	30(71.4% of MS subjects)	50(26% of all study subjects)	15.75 (6.9-35.7)	<0.001**
Subjects with Hypertension (≥130 mm Hg systolic blood pressure and/or ≥85 mm Hg diastolic blood pressure)	21(14.4% of non MS subjects)	26(61.9% of MS subjects)	47(25% of all study subjects)	10.86 (4.9-23.8)	<0.001**
Subjects with Hyperglycemia (Fasting Blood Sugar ≥100 mg/dL)	11(7.5% of non MS subjects)	17(40.4% of MS subjects)	28(14.8% of all study subjects)	8.34 (3.4-19.9)	<0.001**
Subjects with Hypertriglyceridemia (Triglycerides≥150 mg/dL)	28(19.2% of non MS subjects)	35(83.3% of MS subjects)	63(33.5% of all study subjects)	21.07 (8.4-52.3)	<0.001**
Subjects with Decreased HDL (<40 mg/dL in men and <50 mg/dL in women)	97(66.4% of non MS subjects)	41(97.6% of MS subjects)	138(73.4% of all study subjects)	20.71 (2.7-155.0)	0.001**

* Moderate statistical significance(p value:0.01≤ 0.05); ** Strong statistical significance (p value : ≤0.01)

DISCUSSION

The metabolic syndrome (MS) encompasses a group of interrelated physiological, biochemical, clinical, and metabolic factors that increase the risk of atherosclerotic cardiovascular disease, Type 2 Diabetes Mellitus, and all cause mortality[6]. A person with MS has a 5 fold risk of developing type 2 diabetes mellitus, 2-fold risk of developing cardiovascular disease over the next 5 to 10 years[8], 2- to 4-fold increased risk of stroke, a 3- to 4-fold increased risk of myocardial infarction (MI), and 2-fold the risk of dying from such an event compared with those without the syndrome[18] regardless of a previous history of cardiovascular events. The prevalence of metabolic syndrome has increased worldwide[8], and it has become a major public health concern in many countries, including both urban and rural India[11,19]. The present study was undertaken to determine the prevalence of metabolic syndrome, the prevalence of various risk factors of metabolic syndrome and to determine the factors significantly contributing to metabolic syndrome amongst a rural population in Karnataka. The prevalence of metabolic syndrome was found to be 22.3% amongst the rural population of Jangamsheegehally village, Chintamani Taluk, Chikkaballapur District in Karnataka, as per the updated AHA/NHLBI statement criteria. Other studies in rural Andhra Pradesh and central India using the ATPIII criteria[4] found the prevalence of MS to be 28.2% and 9.3% respectively. A similar study done by Chow *et al*[20] in rural Andhra Pradesh, found the prevalence of metabolic syndrome to be 28.2%. A study done between 2007 and 2008 by Kamble *et al*.,[21] in a rural area of Wardha district, central India, found the prevalence of metabloic syndrome to be 9.3% using the ATPIII criteria[4]. In a study done in urban eastern India, the overall prevalence of MS was 33.5%[12] and 19.52% in a study done in Mumbai[11]. Rural populations residing in villages are expected to have a low prevalence of metabolic syndrome as they are not exposed to urbanisation or industrialisation. Today, life in rural areas is undergoing extensive changes. Adoption of an urban lifestyle, mechanization, decreasing labour intensive work, decreasing food scarcity, availibility and consumption of energy dense foods, increased intake of fats, salt and sugar, advent of new technologies in farming with less energy expenditure are the probable reasons for the high prevalence of metabolic syndrome in the rural population of India. Sarkar *et al*[19] reported 30-50 per cent prevalence of MS in Bhutia tribe, with no rural-urban difference. Among the Toto tribe, in the same study, the rural community prevalence was as low as 4-9 per cent. The authors proposed that metabolic syndrome (or its contributing variables) could be a major health problem even in traditional rural ethnic groups and that MS may not necessarily be a result of modernization or urbanization but could also be due to genetic factors[19]. In the present study, the prevalence of MS was marginally higher in males (52.4%) than in the females (47.6%), though not statistically significant. Other studies done in India, have shown increased prevalence of MS was in males[11,20] or females [12,21]. The age group 18-39 years (40.47%) was found to have the highest prevalence of MS in the present study. The incidence of Coronary Artery

Disease (CAD) in the young has been reported to be 12%–16% amongst Indians[22]. Heart diseases affect Indians 5 to 10 years earlier than in other populations around the world[23,24]. The age group 18-39 years represents the productive workforce of the population, and therefore, to retard the progress of preventable cardiovascular diseases, major initiatives like promotion of healthy dietary habits, physical activity, generation of awareness among both genders, or development of guidelines for risk factors and therapeutic and surgical strategies are needed. A large proportion (87.23%) of subjects in our study had atleast one metabolic abnormality (90% of female subjects and 84% of the male subjects) as shown in table 2. A study done in Mumbai found atleast one metabolic abnormality in 95% of the urban study subjects[11]. This could probably indicate that a large number of individuals amongst the rural population are already progressing towards increased risk of diabetes and cardiovascular disease similar to an urban population. In the present study, hypertriglyceridemia (OR 21.07, CI 8.48-52.35, p<0.001) significantly increased the risk of developing metabolic syndrome, followed by subjects with low HDL levels and central obesity. The most prevalent metabolic abnormality amongst all the study subjects was a low HDL level (<40mg/dL in males and <50mg/dL in females), found in 73.4% of the study population (67% in males and 79% in females). It was also the most prevalent abnormality (97.6%) in subjects with MS. A low HDL level was also the only isolated abnormality in 30% of all females and 25% of all the male study subjects. This finding is similar to that of Joshi S *et al*.done in three states and one union territory of India[25] and to that of Zahid N *et al*., [26] done in rural Pakistan where, low HDL-C was the most common lipid abnormality in 72.3% and 79.6% of the population, respectively. It is known that a strong inverse association exists between HDL concentrations with increased risk of coronary artery disease. The risk for CAD increases by 2-3% for every mg/dl decrease in HDL[27]. Low HDL levels may be due to low physical activity, alcohol ingestion, smoking, environmental as well as dietary habits. Attempts at increasing Serum HDL levels with dietary and lifestyle modifications along with treatment using drugs like statins, niacin, fibrates or torcetrapib have evoked varied responses, leading to suggestions that HDL particle functionality could be as important as HDL-C levels[28]. Asian Indians have a genetic predisposition to low HDL levels, have a decreased rate of production of apolipoprotein A-I and are also more prone to develop features of the insulin resistance syndrome[29]. Apoprotein A-1 (APO A-1), a major protein component of HDL, is responsible for the cardioprotective nature of HDL and is essential for maintaining the anti-oxidant and reverse cholesterol transport function of HDL. Low levels of APO A-1 have been associated with occurrence of cardiovascular disease (Henkhaus 2011) (Dodani S 2011). Recent studies in South Asians and Indians have studied APOA1 single nucleotide polymorphisms (SNPs) and their effects (Henkhaus 2011) (Dodani S 2011). South Asians and Indians showed higher frequencies for certain types of SNPs of APOA1 gene that could result in low Apo A1 levels, ineffective Apo A1 that has low antioxidant and high pro-oxidant activity, low HDL levels and high levels of dysfunctional HDL that could explain the increased risk of CAD in these populations[30,31]. Hypertriglyceridemia (serum triglyceride ≥150 mg/dL) was the second most common metabolic abnormality in 33.5% of the study population, found in 40.9% of male, 27% of female subjects and 83.3% of subjects with MS. In The ICMR–INDIAB Study[25], 29.5% of all study subjects had hypertriglyceridemia and the highest and lowest rates of hypertriglyceridemia were found in Chandigarh (38.6%) and Maharastra (22.8%) respectively with a greater prevalence in males. This is similar to the prevalence of hypertriglyceridemia in the present study (33.5%). An elevated triglyceride level is marker of cardiovascular risk due to its direct influence on LDL and HDL composition, functionality[32] and increased atherogenic particles in circulation[33]. Serum triglyceride levels are influenced by nutritional intake (high carbohydrate food, low nutrient energy dense food), insulin resistance, physical activity, and cigarette smoking and alcohol consumption[34]. Insulin resistance also leads to hypertriglyceridemia by increasing lipolysis, resulting in increased free fatty acid (FFA) levels, which in the liver, leads to increased synthesis of triglycerides and increased very low density lipoprotein (VLDL) secretion[35]. The activity of lipoprotein lipase, a major mediator of very low density lipoprotein (VLDL) clearance, is also mediated by insulin[35]. Educating the rural masses towards lowering elevated triglyceride levels should focus on reduction in body weight, increased aerobic activity, reduced intake of added sugars, fructose, trans fats and increased intake unsaturated fat and marine-based omega-3 products[34]. In the present study central obesity (indicated by a waist circumference ≥90 cm in men and ≥80 cm in women) was the third most common abnormality (26 %) of the study population (24% of the males and 29% of the female subjects). 71% of the study subjects with MS also had central obesity. Our findings are similar to that of Beigh *et al*, where prevalence of Central Obesity was 29% in all study subjects[13]. In a study done in a rural population in rural Wardha, Central India, the prevalence of central obesity was 28.2% in females and 16% in male subjects[21]. Central obesity is an important parameter in the diagnosis of the metabolic

syndrome and is associated with 2 to 5 fold increased risks of diabetes, cardiovascular diseases and/or mortality[4]. Studies have shown that Asian Indians (people of Indian origin) have a greater amount of fat and lesser muscle mass as compared to other ethnic groups[36]. Cardiovascular risk factors and Type 2 diabetes mellitus occur at lower levels of obesity in Asian Indians than in other non Asian Indian populations[36]. Therefore, a Consensus Group from India formulated revised guidelines for diagnosis of abdominal obesity for Asian Indians[37]. Accordingly, the waist circumference cut-offs for Asian Indians is ≥90cms in males and ≥ 80cms in females[37] whereas it is ≥102 cms in males and ≥88 cms in females as per the prevalent International criteria[4]. Since the present study was a cross sectional one, the cause and effect relationship between various risk factors of metabolic syndrome and a cardiovscular event could not be explored. The strengths of the study are that it was done on a rural population, with a large sample size. This study also shows that the rural population too has an increased risk for developing NCD's.

CONCLUSION

The present study shows that prevalence of metabolic syndrome in the rural population is highest in the age group of 31-40 years and is relatively high in other age groups with low HDL levels, hypertriglyceridemia and central obesity being independent risk factors in the adults. The number of adults with atleast one metabolic abnormality was also high. Efforts should be aimed at educating the rural masses regarding lifestyle modifications including suggestions on improving eating habits, the importance of a regular exercise regimen, social support and stress management strategies in order to alleviate the metabolic abnormalities that could increase the risk of Metabolic syndrome.

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REFERENCES

1. Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation. 2004: 27; 109(3):433-8.
2. Grundy SM. Metabolic syndrome pandemic. Arterioscler Thromb Vasc 2008, 28(4):629-36.
3. Alberti KG, Zimmet PZ: Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus, provisional report of a WHO Consultation. Diabet Med 1998; 15:539- 53.
4. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 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) final report. Circulation. 2002; 106:3143–3421.
5. Kahn R, Buse J, Ferrannini E, Stern M. The Metabolic Syndrome: Time for a Critical Appraisal Joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care 2005; 28:2289-304.
6. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ,Smith SC Jr, Spertus JA, Costa F; 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: 2735-2752
7. International Diabetes Federation. Worldwide definition of the metabolic syndrome Available at: http://www.idf.org/webdata/docs/IDF_ Metasyndrome_ definition.pdf. Accessed June 11, 2011
8. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart JC, James WP, Loria CM, Smith SC Jr; International Diabetes Federation Task Force on Epidemiology and Prevention; Hational Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; International Association for the Study of Obesity. 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 Oct 20; 120(16):1640-1645.
9. Misra A, Wasir JS, Pandey RM. An Evaluation of candidate definitions of the Metabolic syndrome in adult Asian Indians. Diabetes Care, 2005; 28:398–403.
10. Kanjilal S, Shanker J, Rao VS, Khadrinarasimhaih NB, Mukherjee M, Iyengar SS, Kakkar VV. Prevalence and component analysis of metabolic syndrome: An Indian atherosclerosis research study perspective. Vascular Health and Risk Management 2008:4(1) 189–197.
11. Sawant A, Mankeshwar R, Shah S, Raghavan R, Dhongde G, Raje H *et al*. Prevalence of Metabolic Syndrome in Urban India. Cholesterol. 2011; 2011: 920983, 7 pages.
12. Prasad DS, Kabir Z, Dash AK, Das BC. Prevalence and risk factors for metabolic syndrome in Asian Indians: A community study from urban Eastern India. J Cardiovasc Dis Res. 2012 Jul;3(3):204-211.
13. Beigh SH, Jain S. Prevalence of metabolic syndrome and gender differences. 2012; Bioinformation 8(13): 613-616.
14. WHO Monica Project http://www.ktl.fi/publications/monica/manual/index.htm

Monica Manual Section 2, Part III. {internet},1998.Available:URL:http://www.thl.fi/publications/monica/monograph_cd/docs/manual/part3/iii-2.htm#s3 (Accessed Feb 13, 2014).
15. Shah B, Mathur P. Surveillance of cardiovascular disease risk factors in India: The need and scope. Indian J Med Res 132, November 2010, 634-642
16. P Malhotra, Savita Kumari, S Singh, S Varma. Isolated Lipid Abnormalities in Rural and Urban Normotensive and Hypertensive North-West Indians. Journal of Association of Physicians of India 2003; 51, 459-63.
17. Tietz Textbook of Clinical Chemistry. Carl A Burtis, Edward R Ashwood. W B Saunders Company, 3rd ed., 1999. Philadelphia.
18. Alberti KG, Zimmet P, Shaw J, IDF Epidemiology Task Force Consensus Group. The metabolic syndrome--a new worldwide definition. Lancet. 2005 Sep 24-30; 366(9491):1059-1062.
19. Sarkar S, Das M, Mukhopadhyay B, Chakrabarti CS, Majumder PP. High prevalence of metabolic syndrome and its correlates in two tribal populations of India and the impact of urbanization. Indian J Med Res. 2006; 123, May: 679-686.
20. Chow CK, Naidu S, Raju K, Raju R, Joshi R, Sullivan D, Celermajer DS, Neal BC. Significant lipid, adiposity and metabolic abnormalities amongst 4535 Indians from a developing region of rural Andhra Pradesh. Atherosclerosis. 2008. 196:943–952.
21. Kamble P, Deshmukh PR, Garg N. Metabolic syndrome in adult population of rural Wardha, central India. Indian J Med Res. 2010. December 132; 701-705
22. Mammi MV, Pavithran K, Abdu Rahiman P, Pisharody R, Sugathan K. Acute myocardial infarction in north Kerala--a 20 year hospital based study. Indian Heart J. 1991 Mar-Apr; 43(2):93-6.
23. Hughes LO, Raval U, Raftery EB. First myocardial infarctions in Asian and white men. BMJ. 1989 May 20; 298(6684):1345-50.
24. Enas EA, Dhawan J, Petkar S. Coronary artery disease in Asian Indians: lessons learnt and the role of lipoprotein (a). Indian Heart J. 1997 Jan-Feb; 49(1):25-34.
25. Joshi SR, Anjana RM, Deepa M, Pradeepa R, Bhansali A, Dhandania VK, Joshi PP, Unnikrishnan R, Nirmal E, Subashini R, Madhu SV, Rao PV, Das AK, Kaur T, Shukla DK, Mohan V; ICMR– INDIAB Collaborative Study Group. Prevalence of Dyslipidemia in Urban and Rural India: The ICMR-INDIAB Study. PLoS One. 2014 May 9; 9(5): e96808. doi:10.1371/journal.pone.0096808
26. Zahid N, Claussen B, Hussain A. High prevalence of obesity, dyslipidemia and metabolic syndrome in a rural area in Pakistan. Diabetes and Metabolic Syndrome: Clinical Research and Reviews. 2008; 2: 13–19.
27. Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, Halsey J, Qizilbash N, Peto R, Collins R. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. Lancet 2007, 370:1829-1839.
28. Ali KM, Wonnerth A, Huber K, Wojta J. Cardiovascular disease risk reduction by raising HDL cholesterol - Current therapies and future opportunities. British Journal of Pharmacology. 2012; 167(6):1177-1194.
29. Tai ES, Emmanuel SC, Chew SK, Tan BY, Tan CE. Isolated low HDL cholesterol: an insulin-resistant state only in the presence of fasting hypertriglyceridemia. Diabetes. 1999 May; 48(5):1088-92.
30. Dodani S, Henkhaus R, Wick J, Vacek J, Gupta K, Dong L, Butler MG. Metabolic syndrome in South Asian immigrants: more than low HDL requiring aggressive management. Lipids Health Dis. 2011 Mar 16; 10:45. doi: 10.1186/1476-511X-10-45.
31. Henkhaus RS, Dodani S, Manzardo AM, Butler MG. APOA1 gene polymorphisms in the South Asian immigrant population in the United States. *Indian J Hum Genet* 2011; 17: 194-200.
32. Skeggs JW, Morton RE. LDL and HDL enriched in triglyceride promote abnormal cholesterol transport. J Lipid Res. 2002; 43: 1264–1274.
33. Ip S, Lichtenstein AH, Chung M, Lau J, Balk EM. Systematic review: association of low-density lipoprotein subfractions with cardiovascular outcomes. Ann Intern Med. 2009; 150: 474–484.
34. Miller M, Stone NJ, Ballantyne C, Bittner V, Criqui MH, Ginsberg HN, Goldberg AC, Howard WJ, Jacobson MS, Kris-Etherton PM, Lennie TA, Levi M, Mazzone T, Pennathur S; American Heart Association Clinical Lipidology, Thrombosis, and Prevention Committee of the Council on Nutrition, Physical Activity, and Metabolism; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular Nursing; Council on the Kidney in Cardiovascular Disease. Triglycerides and cardiovascular disease: a scientific statement from the American Heart Association.Circulation. 2011 May 24; 123(20):2292-333.
35. Dunn FL. Hyperlipidemia in diabetes mellitus. Diabetes Metab Rev. 1990; 6: 47–61.
36. Bodicoat DH, Gray LJ, Henson J, Webb D, Guru A, Misra A, Gupta R, Vikram N, Sattar N, Davies MJ, Khunti K. Body mass index and waist circumference cut-points in multi-ethnic populations from the UK and India: the ADDITION-Leicester, Jaipur heart watch and New Delhi cross-sectional studies. PloS One. 2014 Mar 5; 9(3):e90813. doi: 10.1371/journal.pone.0090813. eCollection 2014.
37. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, *et al*. Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians and Recommendations for Physical Activity, Medical and Surgical Management. Journal of Associations of Physicians of India. 2009; 57:163- 170.

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