Original Article

Overweight, the major determinant of metabolic syndrome among industrial workers in Kerala, India: Results of a cross-sectional study

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A B S T R A C T

Aim: To determine the prevalence and associated risk factors of metabolic syndrome (MS) among industrial workers in Kerala, India.
Materials and methods: We measured fasting plasma glucose (FPG), triglycerides, high density lipoprotein cholesterol, waist circumference, systolic blood pressure and diastolic blood pressure among 2287 industrial workers (mean age 46 years, men 70%) from selected industries of two southern most Kerala districts using standard protocol in 2009. MS was defined according to international diabetes federation (IDF), Adult Treatment Panel (ATP-III) and American Heart Association(AHA)/National Heart Lung and Blood Institute (NHLBI) criteria (Harmonization). Age-standardized prevalence of MS was assessed for men and women. Multivariable logistic regression models were developed to find the associated factors of MS.
Results: Age-standardized prevalence of MS was 14% (men 14%, women 15%), 19% (men 19%, women 21%) and 27% (men 30%, women 21%) as per IDF, ATP-III and Harmonization criteria respectively. Overweight adults were nine times (OR 9.41, 95% CI 7.34–12.06), twelve times (OR 11.80 CI 9.38–14.84), and four times (OR 3.56, CI 2.94–4.29) more likely to have MS compared to their counterparts according to IDF, ATP-III and Harmonization criteria respectively. Older adults and current alcohol users were more likely to have MS compared to their counterparts. Women were more likely to have MS as per IDF and ATP-III criteria.
Conclusions: MS prevalence was high among Industrial workers who generally have good access to health care. Overweight and other predictors of MS need to be addressed to reduce MS prevalence in this population.

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1. Introduction

The metabolic syndrome (MS) is a constellation of endogenous risk factors that increase the risk of developing both atherosclerotic cardiovascular diseases (ASCVD) and type 2 diabetes mellitus [1]. Various international agencies such as World Health Organization (WHO), International Diabetes Federation (IDF) and the third report of the national cholesterol education program's adult treatment panel (NCEP ATP III) define MS differently. Currently, the most commonly used definitions for MS are ATP III and IDF [2]. ATP III-

defines metabolic syndrome as the presence of at least three of the five risk factors (waist circumference, serum triglycerides, serum high density lipoprotein (HDL) cholesterol, blood pressure and fasting glucose level) in an individual [3]. IDF defines MS as the presence of central obesity and any two of the above mentioned four risk factors. Because of the inappropriate cut off for central obesity which underestimates MS, ATP III was modified for Asians with central obesity as waist circumference >=80 cm in women and >=90 cm in men [4].

MS was reported to be significantly associated with diabetes [5] and cardiovascular diseases [6–10]. High level of cardiovascular mortality was reported in many studies among non-resident Indians with MS [11–13]. The INTERHEART study and a study from Spain, reported more than a 2.5-fold risk of acute myocardial infarction among people with MS using either the WHO or IDF definition [14,15].

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MS prevalence among adults aged 18 years and above was reported as 9.3% in rural [16] and 30% in urban India [17] according to harmonization criteria. Another study from South India reported a prevalence of 41% among adults aged 20–75 years in urban Tamil Nadu State [18]. MS prevalence of 36% [19] was reported among university employees in Jordan, 31% among Iranian professional drivers [20], 33% among day time electronics manufacturing workers and 43% among the same group of night time workers in Taiwan [21]. The prevalence in different areas was found to be different and not strictly comparable since the definitions used were different. A crude MS prevalence of 18.5% was reported among urban men industrial workers in Rajasthan state of India [22]. This study reported the crude prevalence of MS using IDF definition using a sample of 651 men who came for the annual medical examination at the occupational health centre.

Kerala state is reported to have the highest prevalence of non-communicable diseases (NCDs) and their risk factors in India [23] and is reported as the most advanced Indian state in epidemiologic transition [24]. A recent study from Kerala reported an age-adjusted MS prevalence of 24%, 29% and 33% in a state representative sample of 5063 general population using ATP III, IDF and Harmonization criteria [25]. However, data on MS prevalence and its correlates among industrial workers who generally have better access to health care compared to the general population in Kerala are limited. The objectives of our study were to assess the MS prevalence and associated risk factors among industrial workers in Kerala, India.

2. Materials and methods

This study was part of a large multi-country study on Community based Interventions for Health (CIH), with an objective to find the effectiveness of culturally adapted community-based interventions on prevalence of three major NCD risk factors: tobacco use, unhealthy diet and physical inactivity in different settings. This was conducted in three places; Kerala in India, Hangzhou city in China and Mexico City in Mexico, in four different settings: health centers, workplace, schools, and community. Detailed methodology [26] and main outcomes of CIH [27] were published earlier.

In this manuscript, we analyzed workplace data from the Kerala state of India. Using a quasi-experimental study design, two major industries were selected from two southern districts of Kerala. The sample size was fixed as 2000 for the industry setting in each country as previously reported in the methodology paper [26]. At least 1000 workers were selected from each of the control and intervention industries making a total of at least 2000 workers in the sample. In this manuscript, we report the baseline prevalence and risk factors of MS in the combined sample of both intervention and control industries.

Using the WHO STEPS approach, we collected data from 2426 workers aged 18–64 years from the two selected industries in Kerala. Age, sex, education, tobacco use and alcohol consumption were collected using interview schedule. We measured fasting plasma glucose (FPG), triglycerides (TG) and high-density lipoprotein (HDL) cholesterol using Cholestech LDX system [28]. Waist circumference, weight, height, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using WHO STEPS protocol [29]. During analysis, data of 139 workers were discarded due to incomplete information. Thus, finally we analyzed data of 2287 (92.7%) workers for the present study.

We used three definitions for metabolic syndrome: International Diabetes Federation (IDF) [30], Third report of the national cholesterol education program's Adult Treatment Panel (ATP III) [31] and American Heart Association(AHA)/National Heart Lung and Blood Institute (NHLBI) criteria (Harmonization) [32]. World Health Organization definition on metabolic syndrome was not used since we did not collect the urinary albumin, an essential component of the WHO criteria, due to limited resources.

MS was defined according to International Diabetes Federation criteria as: central obesity (defined as waist circumference ≥90 cm for men and ≥80 cm for women, plus any two of the following four factors: Raised TG level (≥150 mg/dl or on treatment for lipid abnormality), reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women or on treatment for lipid abnormality), raised blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or on treatment for hypertension), raised fasting plasma glucose (FPG) (FPG≥100 mg/dl or on treatment for diabetes).

MS was defined according to ATP III criteria as central obesity: waist circumference >=90 cm for men and >=80 cm for women and any two of the following four factors: triglycerides >=150 mg/dl, reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality; SBP≥130 or DBP≥85 or on medication for hypertension) and raised fasting plasma glucose (FPG≥100 mg/dl or on medication or diabetes).

MS was defined according to Harmonization criteria as the presence of three or more of the following five risk factors: (1) waist circumference ≥90 cm for men and ≥80 for women, (2) triglycerides ≥150 mg/dl or on treatment for lipid abnormality, (3) reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality, (4) systolic blood pressure (SBP) ≥130 or diastolic blood pressure (DBP) ≥85 or on medication for hypertension and (5) raised fasting plasma glucose (FPG) ≥100 mg/dl) or on medication for diabetes.

Statistical analysis was done using IBM SPSS Statistics for Windows, Version 21.0. (Armonk, NY: IBM Corp. Chicago, IL). Bivariate and multivariate analysis were done to find out the correlates of MS. The minimum statistical significance level was fixed as $p < 0.05$. Using direct standardization method, age standardization was done using World Health Organization (WHO) standard population for 2000–2025 aged 15–64 years [33]. A five-year interval with a total of ten strata was used.

The study was approved by the Institutional Ethics Committee (IEC) of Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum. Written informed consent was obtained from all the participants before the study.

3. Results

3.1. Demographics

Mean age of the sample was 46 years (SD:10). Seventy percent were men. Eighteen percent of the sample had less than high school education and 60% were high school or higher secondary completed and 22% had college education. Current tobacco use was reported by 24% and alcohol consumption by 31%.

3.2. Prevalence of individual risk factors of metabolic syndrome

Prevalence of individual risk factors of metabolic syndrome by sex is presented in Table 1. Raised TG level, raised BP and raised FPG were significantly higher for men than women whereas central obesity was significantly higher for women than men. The most common risk factor of MS was reduced HDL cholesterol (66.7%), followed by high blood pressure (53.3%), elevated triglycerides (34.0%), central obesity (37.7%) and elevated FPG (49.5%). Prevalence of raised TG level among men exceeded double than that of the prevalence among women. Mean and standard deviation (SD) of anthropometric and biochemical variables are presented in Table 2. Prevalence of individual risk factors of metabolic syndrome

Table 1
Prevalence of individual risk factors for metabolic syndrome by sex.

Risk factors	Men (N = 1609) n(%)	Women(N = 678) n(%)	Total(N = 2287) n(%)
Central Obesity[a]*	488(30.3)	374(55.2)	862(37.7)
Raised TG level[b]*	670(41.6)	107(15.8)	777(34.0)
Reduced HDL cholesterol[c]	1065(66.2)	461(68.0)	1526(66.7)
Raised blood pressure[d]*	933(58.0)	287(42.3)	1220(53.3)
Raised FPG[e]*	894(55.6)	237(35.0)	1131(49.5)

*$p < 0.05$.
[a] Waist circumference ≥90 cm for men and ≥80 for women.
[b] Triglycerides (TG) ≥150 mg/dl or specific treatment for this lipid abnormality.
[c] HDL<40 mg/dl in men and <50 mg/dL in women or specific treatment for this lipid abnormality.
[d] SBP≥130 or DBP≥85 or on medication for hypertension.
[e] Raised fasting plasma glucose (FPG) ≥100 mg/dL or on medication for diabetes.

Table 2
Mean (SD) of continuous variables.

Variables	Mean ± SD	Range
Weight (kg)	63 ± 11	28−158
Height (cm)	162 ± 9	130−190
Waist circumference (cm)	84 ± 10	50−120
Systolic BP (mm Hg)	130 ± 19	53−226
Diastolic BP (mm Hg)	80 ± 11	36−133
Fasting plasma glucose (mg/dl)	112 ± 43	36−459
Triglycerides (mg/dl)	123 ± 74	45−612
HDL cholesterol (mg/dl)	40 ± 12	15−89

SD: Standard Deviation.

by background characteristics is presented in Table 3.

3.3. Prevalence and risk factors of metabolic syndrome

The age standardized prevalence of metabolic syndrome by sex according to different criteria is presented in Table 4. Prevalence of MS based on IDF criteria was 14% (men 14%, women 15%), 19% based on ATP III criteria (men 19%, women 21%) and 26% based on Harmonization criteria (men 30%, women 21%).

Table 4
Crude and age standardized prevalence (per 100) of metabolic syndrome by sex according to different criteria.

Criteria for metabolic syndrome	Men	Women	Total
IDF			
Crude	21.0	24.3	22.0
Standardized	14.9	15.4	14.4
ATP III *			
Crude	26.5	33.9	28.7
Standardized	19.1	21.8	19.4
Harmonization criteria*			
Crude	44.6	33.5	41.3
Standardized	30.2	21.5	26.5

IDF: International Diabetes Federation, ATP: Adult Treatment Panel, MS: Metabolic Syndrome.
*$p < 0.05$.

Number of MS risk factors present in our sample population for men and women is provided in Table 5. Majority of workers had at least one component of metabolic syndrome. More men were having three or more components of metabolic syndrome than women (44% vs 33%).

Results of multivariable logistic regression analysis according to

Table 3
Prevalence of individual risk factors of metabolic syndrome by background characteristics.

Variables	Total N = 2287	Over weight[a] %	Central Obesity[b] %	Raised blood pressure[c] %	Raised Fasting blood sugar (FBS)[d] %	Raised TG level[e] %	Reduced HDL cholesterol[f] %
Age group (years)		*	*	*	*	*	*
18-34	370	87(23.5)	64(17.3)	84(22.7)	10(2.7)	57(15.4)	224(60.5)
35-44	449	192(42.8)	189(42.1)	199(44.3)	57(12.7)	112(24.9)	292(65.0)
45-54	1011	448(44.3)	401(39.7)	615(60.8)	264(26.1)	428(42.3)	698(69.0)
55-64	457	182(39.8)	208(45.5)	322(70.5)	159(34.8)	180(39.4)	312(68.3)
Sex			*	*	*	*	
Men	1609	620(38.5)	488(30.3)	933(58.0)	386(24.0)	670(41.6)	1065(66.2)
Women	678	289(42.6)	374(55.2)	287(42.3)	104(15.3)	107(15.8)	461(68.0)
Education		*			*	*	
<High school (HS) education	402	119(29.6)	141(35.1)	200(49.8)	69(17.2)	96(23.9)	266(66.2)
HS & higher secondary completed	1377	575(41.8)	542(39.4)	766(55.6)	337(24.5)	500(36.3)	915(66.4)
College Education	508	215(42.3)	179(35.2)	254(50.0)	84(16.5)	181(35.6)	345(67.9)
Current Tobacco Use			*			*	
Yes	537	199(37.1)	167(31.1)	297(55.3)	115(21.4)	223(41.5)	351(65.4)
No	1750	710(40.6)	695(39.7)	923(52.7)	375(21.4)	554(31.7)	1175(67.1)
Current Alcohol use		*		*	*	*	*
Yes	712	301(42.3)	255(35.8)	441(61.9)	170(23.9)	330(46.3)	430(60.4)
No	1575	608(38.6)	607(38.5)	779(49.5)	320(20.3)	447(28.4)	1096(69.6)

*$p < 0.05$.
[a] Body mass index (BMI) ≥25 kg/m².
[b] Waist circumference ≥90 cm for men and ≥80 for women.
[c] SBP≥130 or DBP≥85 or on medication for hypertension.
[d] Raised fasting plasma glucose (FPG) ≥100 mg/dL or on medication for diabetes.
[e] Triglycerides ≥150 mg/dl or on treatment for lipid abnormality.
[f] Reduced HDL cholesterol (<40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality.

Table 5
Risk factor clustering of metabolic syndrome in study participants by age and sex.

Sex/Age group	Number of risk factors present			
	0	1	2	3 or more
Men				
18-24	29(32.2)	43(47.8)	13(14.4)	4(4.4)
25-34	30(20.8)	46(31.9)	30(20.8)	25(17.4)
35-44	27(11.0)	67(27.3)	63(25.7)	52(21.2)
45-54	38(4.7)	124(15.4)	231(28.6)	222(27.5)
55-64	20(6.2)	40(12.4)	91(28.2)	81(25.1)
Total	**144(8.9)**	**320(19.9)**	**428(26.6)**	**717(44.6)**
Women				
18-24	18(45.0)	18(45.0)	3(7.5)	1(2.5)
25-34	29(30.2)	36(37.5)	26(27.1)	3(3.1)
35-44	19(9.3)	56(27.5)	75(36.8)	32(15.7)
45-54	11(5.4)	37(18.1)	68(33.3)	59(28.6)
55-64	7(5.2)	17(12.7)	31(23.1)	39(29.1)
Total	**84(12.4)**	**164(24.2)**	**203(29.9)**	**227(33.5)**

various definitions of MS are presented in Table 6. The findings indicated that odds of metabolic syndrome increased with increase in age. MS was higher among women according to two criteria (IDF and ATP III) and higher for men as per Harmonization criteria. Metabolic syndrome was higher among current alcohol users. Overweight was the strongest predictor of MS. Being overweight increased the risk of MS more than thrice according to Harmonization criteria and more than nine times in case of IDF criteria and more than eleven times as per ATP III criteria.

4. Discussion

In this study age adjusted prevalence of MS was estimated using ATP III, IDF and Harmonization criteria and the prevalence was 19%, 14% and 26% respectively, which was lower than the corresponding prevalence figures reported among general population in the state of Kerala [25]. MS prevalence according to ATP III in our study was lower than that of the 25% MS prevalence reported among general population in another part of India [17]. Age adjusted prevalence of MS in our study according to harmonization criteria for Asian Indians was lower than that was reported among general population in urban India [34]. The unadjusted prevalence in our study (22%) was higher than the unadjusted prevalence of 19% among industrial

workers in India [22] and was lower than the unadjusted findings in Chennai (26%) and unadjusted prevalence based on a community-based sample from Kerala (35%). In Asia, the prevalence of metabolic syndrome varied from 15% in Philippines to 35% in Pakistan according to IDF definition [35]. In India, comparable studies on prevalence of MS using different definitions are limited. A study from south India [36] reported MS prevalence of 25.8% by IDF and 18.3% using ATP-III definition.

Women, older adults and those with overweight were more likely to have metabolic syndrome similar to the findings from general population in the Indian state of Kerala [25] as well as the findings from urban India [34].

Several studies reported a higher prevalence of metabolic syndrome among women than men [14,17,25]. However in our study women were less likely to have MS compared to men as per the harmonization criteria which was similar to the findings reported from rural India [37] and other parts of the world [38–42]. This high prevalence of MS among men may be associated with the higher proportion of three or more risk factors present among men compared to women (see Table 5).

The contribution of aging population to the growing prevalence of the MS was well-known [43,44]. MS was more prevalent among women as seen in earlier studies [45–48]. This difference was associated with the difference in sexual hormones in men and women [49]. Risk factors of MS were different for men and women. For example, the major risk factor for women was central obesity where as raised triglycerides, blood pressure and fasting blood glucose were the major risk factors among men.

Similar to the findings from a prospective study in Korea [50], the prevalence of MS in our study was higher among alcohol users. However, this needs to be further studied with the level of alcohol consumption which was not captured in this study.

Clustering of metabolic syndrome among overweight individuals was reported from very early times [51]. The prevalence of metabolic syndrome is likely to rise in future since the prevalence of overweight is on the rise. Nearly one third (32%) of adult women and 29% of adult men in the state were overweight or obese [52]. The rise in MS will have major effect on the future CAD prevalence in an ageing society like Kerala because of the association between MS and CAD as reported in the recent study from Kerala [25]. Intervention strategies to reduce over weight should be strengthened for adults in India and particularly in the industrial population

Table 6
Factors associated with metabolic syndrome: Results of multivariable logistic regression analysis.

Variables	Criteria for metabolic syndrome		
	IDF	ATP III criteria	Harmonization criteria
Age group			
18-34	Reference	Reference	Reference
35-44	2.26(1.35–3.79)	2.43(1.55–3.79)	2.57(1.76–3.74)
45-54	3.76(2.34–6.04)	2.56(2.36–5.37)	5.31(3.79–7.46)
55-64	6.50(3.94–10.72)	5.71(3.67–8.90)	7.58(5.24–10.97)
Sex			
Men	Reference	Reference	Reference
Women	1.44(1.09–1.92)	1.94(1.47–2.55)	0.76(0.60–0.96)
Education			
<High School (HS)	Reference	Reference	Reference
HS & higher secondary completed	1.08(0.78–1.49)	1.08(0.80–1.47)	1.45(1.12–1.88)
College Education	0.88(0.60–1.30)	0.88(0.61–1.27)	1.24(0.91–1.69)
Current alcohol use			
No	Reference	Reference	Reference
Yes	1.30(1.00–1.70)	1.52(1.18–1.97)	1.27(1.03–1.58)
Over weight[a]			
No	Reference	Reference	Reference
Yes	9.41(7.34–12.06)	11.80(9.38–14.84)	3.56(2.94–4.29)

IDF: International Diabetes Federation, ATP: Adult Treatment Panel.
[a] Body mass index (BMI) ≥25 kg/m^2.

in order to reduce MS prevalence. Most industries have better access to health care compared to the general population. This facility should be utilized for the prevention and control of MS in this population.

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Conflicts of interest

None Declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.dsx.2018.07.009.

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