

Adverse Cardiometabolic Phenotypes among Meena Tribal Population: A Cross-Section Study from Delhi

¹VED PRAKASH*, ¹IMNAMEREN LONGKUMER†, ²RUPALIKA‡ & ¹KALLUR NAVA SARASWATHY†

¹Department of Anthropology, University of Delhi, Delhi 110007

²Department of Pulmonary, Critical Care & Sleep Medicine, AIIMS, New Delhi 110029

Email: knsaraswathy@yahoo.com

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ABSTRACT: Non-communicable diseases (NCDs) have become a major concern for global health. Cardiovascular diseases (CVDs) contribute 48% of the total deaths due to NCDs in India. Though several studies have been conducted in urban and rural areas, there is limited evidence on tribal communities. Therefore, the aim of the present study is to examine cardiometabolic risk factors with respect to obesity, hypertension and dyslipidemia among Meena tribal population residing in Delhi. The present cross-sectional study was conducted among 90 Meena tribal individuals of either sex, aged between 20 and 65 years, from New Delhi district, India. From the recruited participants, detailed socio-demographic information was collected. Fasting blood samples were collected to determine serum lipid estimated using spectrophotometry technique. Anthropometric and physiological data were also collected to determine obesity and hypertension status, respectively. The observed high prevalence of cardiometabolic risk factors among a single tribal community demonstrates rising public health concern which needs an immediate health intervention. These findings have been discussed presently in this paper.

INTRODUCTION

Cardiovascular diseases (CVDs) are the leading cause of disease burden and deaths globally (Prabhakaran *et al.*, 2018). In 2019, WHO reported around 17.9 million (32% of total deaths) people died on account of CVDs globally (WHO, 2009). The United Nations, alarmed by the increasing burden of non-communicable diseases (NCDs) and high disease severity and case-fatality in low socio-economic and middle socio-economic countries compared with high

socio-economic countries, recognized in 2012 that the rising burden of NCDs was one of the major intimidation to sustainable development in the 21st century (Clark, 2013; Joshi *et al.*, 2007; Ralston *et al.*, 2016; Yusuf *et al.*, 2014). Currently in India, about 63% of the total deaths are due to non-communicable diseases (NCDs), of which 27% are attributed to CVDs (WHO Health Topics, 2019). Several previous studies reported the increasing burden of cardiovascular diseases and their risk factors over time in India (WHO, G, 2011). Further other studies reported that most of the risk factor attributed to CVDs in India include poor dietary intake with increasing prevalence

† Professor, corresponding author

‡ Scientist (AIIMS)

* Research Scholar

of obesity, hypertension and dyslipidemia (Dandona *et al.*, 2017; Mensah *et al.*, 2019; Prabhakaran *et al.*, 2018). In India, Luhar *et al.* (2018) observed that the prevalence of overweight and obesity is increasing faster than worldwide average and on the basis of this observation they predicted a doubling in overweight and obesity by 2040 (Luhar *et al.*, 2018). Moreover, lipid abnormalities are correlated with an increasing risk of adverse cardiovascular disease including coronary heart disease, stroke and myocardial infarction (Ciffone *et al.*, 2019; Pol *et al.*, 2018). Thus, reporting of these risk factors may help in policy intervention and treatments to reduce early death due to CVDs.

India with 1.3 billion people having cultural, demographic and lifestyle diversities, huge variations in the prevalence of obesity, hypertension and dyslipidemia have been observed in different population as well as rural-urban variation (Anchala *et al.*, 2014; Gupta *et al.*, 2016; Kumar *et al.*, 2013; Prabhakaran *et al.*, 2016). A further aspect accounting for diversity in the country is the tribal populations, which is more than 8.6% of the total population (Government of India, 2013). Some studies reported that chronic diseases have been described to the wealthy societies because of changing lifestyles in expression of dietary habits and sedentary lifestyle (Popkin *et al.*, 1995; Sobal *et al.*, 1989). However, rising number of studies has shown a developing trend in lifestyle diseases like obesity, hypertension, dyslipidemia and other CVDs among tribal populations in different states of India (Meshram *et al.*, 2014; Rengma *et al.*, 2015). On the other hand, remaining to differential ethnic backgrounds, dietary habits and geographic areas etc, tribal populations may have community-specific risk factors (Mishra *et al.*, 2021). However, it is essential that lifestyle determinants relating treatment and management of CVD risk factor should be an important component of a national strategy to reduce the increasing burden of CVD in India.

Meena is a tribal community inhabiting the Indian states of Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Delhi, Karnataka and Chhattisgarh (Government of India, 2013). Because of migration from rural to urban areas and both nutritional and epidemiological transitions, Meena tribal population

is expected to be burdened with lifestyle disorders. Thus, the aim of the present study was to examine cardiometabolic related risk factors with respect to obesity, hypertension and dyslipidemia, among the individuals of Meena tribe from Delhi who migrated from Rajasthan.

MATERIALS & METHODS

The present cross-sectional study was conducted among 90 Meena tribal individuals of either sex, aged between 20 and 65 years, from New Delhi district, New Delhi, India. The study was approved by the Ethical Committee, Department of Anthropology (University of Delhi). Pre-informed written consent transcribed in local language was obtained from each individual prior to recruitment and data collection. Detailed data on socio-demographic (name, sex, age, migration history, household composition, education, occupation, income) variables were collected using pretested interview schedules. Kuppuswamy scale was used for categorization of the socioeconomic status (Saleem *et al.*, 2021). Anthropometric variables, i.e., height vertex, body weight, waist circumference (WC), and hip circumference, were measured following standard protocol established by the International Society for the Advancement of Kinanthropometry (ISAK) (Silva *et al.*, 2020). Blood pressure was measured in the left arm of the participant in sitting position using digital Blood Pressure machine (OMRON-8719) and total three measurements were taken to minimize the error.

Overweight was defined as body mass index (BMI) $\geq 23.0 \text{ kg/m}^2$ but $< 25.0 \text{ kg/m}^2$ while generalized obesity was defined as BMI $\geq 25.0 \text{ kg/m}^2$ and underweight as BMI $< 18.5 \text{ kg/m}^2$ based on World Health Organization and Asia Pacific Guidelines (WHO, Expert Consultation, 2004).

Hypertension was categorized according to the American College of Cardiology/American Heart Association (ACC/AHA) guideline on the basis of systolic blood pressure (SBP) and diastolic blood pressure (DBP) into normal (SBP $< 120 \text{ mmHg}$ and DBP $< 80 \text{ mmHg}$), elevated (SBP 120-129 mmHg and DBP $< 80 \text{ mmHg}$), Hypertension Stage-1 (SBP 130-139 mmHg and DBP 80-89 mmHg) and Hypertension stage-2 (SBP $\geq 140 \text{ mmHg}$ and/or DBP $\geq 90 \text{ mmHg}$) (Whelton *et al.*, 2018).

Abdominal obesity was defined as WC ≥ 90 cm for male and ≥ 80 for female (WHO Expert Consultation, 2008). High waist-hip ratio (WHR) was categorized as ≥ 0.90 for male and ≥ 0.80 for female and measured as WC (in cm) divided by hip circumference (in cm) (WHO Expert Consultation, Geneva, 2008). High waist-height ratio (WHtR) was categorized as ≥ 0.5 and measured as WC (in cm) divided by height (in cm) (Ashwell et al., 2016). Cluster sampling method was used to select participants. Cluster sampling method is the whole population is subdivided into clusters or groups and random samples are then collected from each group (Lohr, 2019). For clustering analysis, the cluster of 0 to ≥ 9 cardiometabolic risk factors were determined in the overall study population. Next, the percentage of the study population with 0 to ≥ 9 CVD risk factors was determined by age in years with range.

Biochemical Analysis

Overnight fasting intravenous blood (2.5ml) was collected into non-Ethylenediamine tetraacetic acid (non-EDTA) coated vacutainers by trained personnel. Serum was separated from each sample. Serum total cholesterol (TC), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C) were assayed with the help of spectrophotometer (Dialab instrument) using commercial kits (Randox, USA). Low-density lipoprotein cholesterol (LDL-C) was calculated using Friedewald equation and very low-density lipoprotein (VLDL) was calculated as TG/5 using Friedewald equation (Friedewald *et al.*, 1972).

Dyslipidemia was classified according to National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATPIII) guidelines as (Mishra *et al.*, 2005).

- Hypercholesterolemia—serum cholesterol levels ≥ 200 mg/dl (≥ 5.2 mmol/l).
- Hypertriglyceridemia—serum triglyceride levels ≥ 150 mg/dl (≥ 1.7 mmol/l).
- Low HDL-C—serum HDL-C < 40 mg/dl (< 1.04 mmol/l) for men and < 50 mg/dl (< 1.3 mmol/l) for women.
- High VLDL-C- serum VLDL-C ≥ 30 mg/dl (< 0.77 mmol/l)
- High LDL-C—LDL-C levels ≥ 130 mg/dl (≥ 3.4 mmol/l)

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics v22.0 (SPSS Inc. Chicago, IL, USA). Prevalence was reported as number with percent and values for male and female have been analyzed separately. Chi-square test as used to perform test for difference in categorical variables. As the data of the present study were found to be normally distributed, hence the data were expressed in terms of Mean \pm SD. We calculated correlation analysis and calculated Pearson's correlation coefficient. A p-value ≤ 0.05 was considered statistically significant for all tests.

RESULTS

A total sample of ninety (90) individuals were included in the present study, 62 females (68.9% of the studied population) and 28 males (31.1% of the studied population). Mean age of the studied population was 36.55 (± 9.10) years. 93.7% individuals in the studied population were migrated from different villages of Rajasthan to Delhi, out of which 72.4% individuals have migrated 10-20 years and above 20 years ago and 27.6% individuals have migrated recently or ≤ 5 years ago. Literate individuals were higher (71.1%) as compared non-literate (28.8%). On the basis of socioeconomic status, upper lower class (47.8%) individuals were higher as compared to upper middle class (23.3%), lower middle class (6.7%) and lower class (22.2%). (Table 1)

Individuals in studied population with generalized obesity (overweight + obese BMI) were found to be around 37.8%. Prevalence of abdominal obesity was much higher with 53.3% of studied population having high WC; more than three fourth of the studied population had high WHR (82.2%) and more than half of the population had high WHtR (58.9%). Hypertension (Stage 1+Stage 2) among the study population was found to be 18.9%. Dyslipidemia in the present studied population varied especially with lowest prevalence consisting of high LDL-C and high TC (23.3% and 17.8% respectively), while the highest prevalence of abnormal lipid variable was found to be abnormal TG (32.2%) and low HDL-C (32.2%). Moreover, abnormal VLDL was 31.1%, respectively in the present studied population (see Table 2).

TABLE 1

General characteristics of socio-demographic variables of the studied population

General characteristics	Mean \pm S.D	Meena population
Age (years)		36.55 \pm 9.10
Sex n (%)	Male	28(31.1)
	Female	62(68.9)
Marital status n (%)	Unmarried	3(3.3)
	Married	87(96.7)
Migration n (%)	Yes	62(93.1)
	No	4(6.1)
Total year of migration n (%)	Recent or \leq 5 years	16(27.6)
	10-20 years and above	42(72.4)
Cause of migration n (%)	Job	19(28.8)
	Marriage	42(63.6)
	Both	1(1.5)
	No	4(6.1)
Education n (%)	Non-literate	26(28.9)
	Literate	64(71.1)
Occupation n (%)	Housewife	56(63.6)
	Employed	29(32.9)
	Dependent	3(3.5)
Socioeconomic status n (%)	Upper middle	21(23.3)
	Lower middle	6(6.7)
	Upper lower	43(47.8)
	Lower	20(22.2)

TABLE 2

Overall and sex-wisedistribution of cardiovascular variables among the study population

Variables	Total (%)	Female (%)	Male (%)	P-value
BMI	Underweight	13(14.4)	9(14.5)	0.831 ^a
	Normal	43(47.8)	30(48.4)	
	Overweight	15(16.7)	7(11.3)	
	Obese	19(21.1)	16(25.8)	
WC	Normal	42(46.7)	24(38.7)	0.02 ^{a*}
	At risk	48(53.3)	38(61.3)	
WHR	Normal	16(17.8)	6(9.7)	0.003 ^{a*}
	At risk	74(82.2)	56(90.3)	
WhtR	Normal	37(41.1)	24(38.7)	0.491 ^a
	At risk	53(58.9)	38(61.3)	
BP	Normal	62(68.9)	48(77.4)	0.115 ^a
	Elevated	11(12.2)	5(8.1)	
	Stage-1	9(10.0)	4(6.5)	
	Stage-2	8(8.9)	5(8.1)	
TC	Normal	74(82.2)	52(83.9)	0.543 ^a
	At risk	16(17.8)	10(16.1)	
TG	Normal	61(67.8)	46(74.2)	0.05 ^{a*}
	At risk	29(32.2)	16(25.8)	
HDL-C	Normal	61(67.8)	50(80.6)	<0.001 ^{a*}
	At risk	29(32.2)	12(19.4)	
VLDL-C	Normal	62(68.9)	46(74.2)	0.106 ^a
	At risk	27(31.1)	16(25.8)	
LDL-C	Normal	66(76.7)	45(72.6)	0.173 ^a
	At risk	21(23.3)	17(27.4)	

The sex-wise prevalence of cardiometabolic risk factors was considered (Table 2), females were found to be significantly more obese in form of abdominal

obesity (WC=61.3%, WHR= 90.3% and WHtR= 61.3%) as compared to that of males (WC=35.7%, WHR= 64.3% and WHtR= 53.6%). However, the

prevalence of generalized obesity was found to be quite higher in males (39.3%) as compared to that of females (37.1%). Hypertensive is more common among males (28.6%) as compared to that of females (14.6%). Low HDL-C, high TG and high VLDL which were found to be the most prevalent form of dyslipidemia in the present population and were significantly higher among males (low HDL-C= 60.7%, TG= 46.4% and VLDL= 42.9%) as compared to females (low HDL-

C= 19.4%, TG= 25.8% and VLDL=25.8%). Intriguing, females had higher prevalence of high LDL (27.4%) as compared to males (14.3%). The clustering of cardiovascular risk factors in the study population showed that individuals with ≥ 3 cluster (17.8%, 22-50 years) and ≥ 4 cluster (16.7%, 24-62 years) were highest among studied population and the cluster of risk decreases after ≥ 4 cluster (Figure 1).

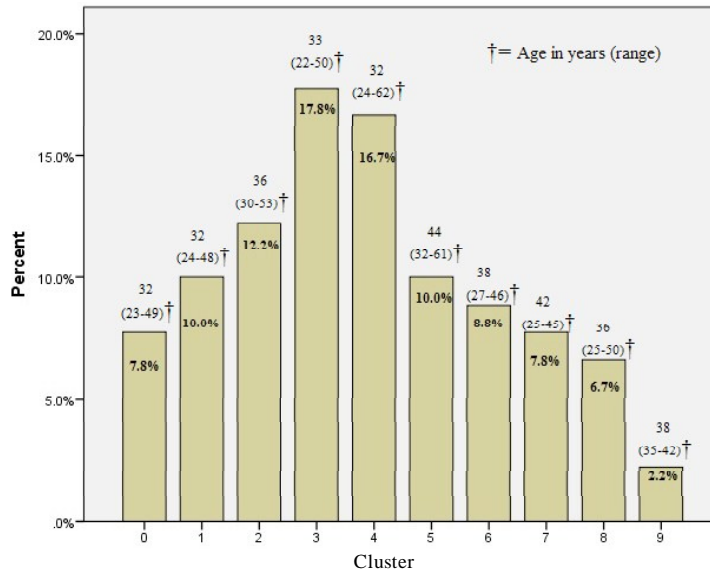


Figure 1: Age-wise clustering of cardio vascular risk factors among the study population

In Table 3, Pearson’s correlation analysis revealed that the BMI was positively correlated with WC (r=0.591, P<0.001), WHR (r=0.302, P<0.01) and WHtR (r=0.511, P<0.001). Whereas, the WC was positively correlated with WHR (r=0.489, P<0.001), WHtR (r=0.803, P<0.001) and LDL-C (r=0.253, P<0.05). WHR was significantly negative correlated with HDL-C (r= -0.239, P<0.05) and positively correlated with WHtR (r=0.438, P<0.001), TC (r=0.216,

P<0.05) and LDL-C (r=0.257, P<0.05). Further, WHtR was showed that positive correlation with TC (r=0.270, P<0.05) and LDL-C (r=0.301, P<0.05) respectively. TC was positively correlated with LDL-C (r=0.705, P<0.001) respectively. TG was positively correlated with HDL-C (r= 0.389, P<0.001) and VLDL-C (r=0.975, P<0.001). However, HDL-C was positively correlated VLDL-C (r=0.410, P<0.001) and BP (r=0.275, P<0.01).

TABLE 3

Correlation between BMI, WC, WHR, WHtR, BP, Cholesterol, TG, HDL, VLDL and LDL in the study population

Variables	BMI	BP	WC	WHR	WHtR	TC	TG	HDL-C	VLDL-C
BP	.034								
WC	.591**	.110							
WHR	.302**	.150	.439**						
WHtR	.511**	.057	.803**	.438**					
TC	.117	-.002	.144	.216*	.270**				
TG	.051	.092	.168	.010	.141	.177			
HDL-C	-.047	.275**	-.118	-.239*	-.149	-.072	.389**		

VLDL-C	.070	.105	.196	-.001	.122	.127	.975**	.410**	
LDL-C	.112	-.065	.253*	.257*	.301**	.705**	.069	-.156	.026

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

There is extensive heterogeneity in the prevalence of cardiovascular risk factors in different areas of India; while CVD has emerged as the leading cause of death in all parts of country (Mishra *et al.*, 2021). Therefore, recognizing community- specific risk factors and their underlying mechanisms can help in targeted disease intervention and prevention. The findings in this study provide CVD related risk factors with respect to obesity and dyslipidemia among the individuals of Meena tribal population from New Delhi district, Delhi, India. Alarming high prevalence of general obesity was observed in conjunction with high prevalence of abdominal obesity and low HDL-C. A study reported that migration impacts on CVD and its risk factor in developing countries like India (Jeemon *et al.*, 2009). Many people are migrating from rural to urban areas due to employment and demographic pressure, due to which their environment, dietary patterns and lifestyle are getting affected, so their CVD risk factor can increase due to this affect (Jeemon *et al.*, 2009). In expeditiously growing economics like India, the notion that overweight and obesity usually exhibit among higher socioeconomic position (SEP) has become more of a fallacy, as growing body of evidence shows a rise in overweight and obesity among lower SEP (Luhar *et al.*, 2018 and 2019). Comparative analysis of the National Family Health Surveys (NFHS) 2, 3, and 4 from 1998 to 2016, assessing the prevalence of overweight and obesity, showed an increasing trend, irrespective of SEP (Luhar *et al.*, 2018). Although these national representative studies exhibit an increasing burden of overweight/obesity in rural populations, unfortunately, there is no such data on tribal populations in India, except for one conducted by the National Nutrition Monitoring Bureau which reported an overweight prevalence of 2–3% among Indian tribes (Mishra *et al.*, 2021).

The present study demonstrated high prevalence of generalized obesity (overweight and obese) around 35.8% and even higher abdominal obesity with respect to WC, WHR and WHtR as 53.3%, 81.1% and

58.9% respectively, among Meena/Mina tribal population. In 2016, one study reported a cumulative 12.8% prevalence of overweight and obesity among nine tribal population of India (Kshatriya *et al.*, 2016). Various other studies on tribal population reported similar high prevalence of obesity (Chhungi *et al.*, 2019; Kandpal *et al.*, 2016; Rengma *et al.*, 2015). Further, the present study found sex-wise variation in the prevalence of abdominal obesity, whereby females (WC=64.5%, WHR=90.3% and WHtR=61.3%) were found to be significantly higher as compared to males (WC=35.7%, WHR=60.7% and WHtR=46.4%). Some postulated that women are at a higher risk of developing abdominal obesity during post-menopausal period because of hormonal changes (Lumsden *et al.*, 2015). Thus, this aspect could be attributed to the high prevalence of abdominal obesity among females in this population. However, generalized obesity was quite high in males (39.3%) as compared to females (37.1%). Further, the present study also reported the prevalence of hypertension (Stage 1+Stage 2) was found to be higher in males (29.6%) as compared to females (14.6%). One study observed that the prevalence of hypertension was higher in males (28%) as compared to female (19%) (Meshram *et al.*, 2014). In India, the pattern of dyslipidemia tends to have lower hypercholesterolemia with high low HDL-C and triglyceride, more among tribal population (Gupta *et al.*, 2016; Ismail *et al.*, 2016). The present study reported high prevalence of low HDL-C (33.3%). Several previous studies have also found higher prevalence of low HDL-C among Indian tribes (Bhardwaj *et al.*, 2013; Ismail *et al.*, 2016). One study observed an exception among Mizo tribal population from North-East India with greater occurrence of hypercholesterolemia as compared to other lipid abnormalities (Chhungi *et al.*, 2019). A study on Bhils tribal population also observed high prevalence of low HDL-C as compared to other lipid abnormality (Mishra *et al.*, 2021). Present study has significantly high prevalence of low HDL-C in males (65.4%) as compared to females (19.7%). The high prevalence of low HDL-C in study population showed that dietary

micronutrient deficiency and under nutrition may be high in males as compared to females which can otherwise be attributed to occupation related lifestyle change (Delisle *et al.*, 2013).

Particularly, in the present study 32.2% of population found to be hypertriglyceridemia, whereas males (50.0%) were found to have higher prevalence of hypertriglyceride as compared to females (24.6%). Hypertriglyceridemia is commonly high in South Asians including Indian population because of consumption of carbohydrates highly in their diet (Misra *et al.*, 2005). Some studies on Bhil tribal population reported high consume from food items rich in carbohydrates including wheat and rice (Devi *et al.*, 2018). The high prevalence of triglyceride found in present study could be because of consumption of carbohydrate-rich diet. Furthermore, present study revealed that abdominal obesity was significantly related with LDL-C, although general obesity could not find any correlation with hypertriglyceridemia and other lipid abnormalities indicating that independent mechanism could affect their triglyceride level. However, WC, WHR and WHtR were found to be significant relation with LDL-C similar with other study (Mishra *et al.*, 2021). Even so, abdominal and general obesity seems to be major contributing factor to abnormal lipid levels among Meena population. Consequently, the need to improved awareness on controlling obesity should be the most important and promotion of healthy lifestyles to decrease obesity is significant. Taking into account, the high prevalence of low HDL-C and hypertriglyceridemia in the present tribal population with obesity and other demographic including socio-economic status, migration and their dietary habits as major causal factors and weight management with healthy dietary modification should be of predominant importance.

The clustering of cardiometabolic risk factors in present study showed that about 7.8% of participants in the study population have no cardiometabolic risk factor whereas 17.8% and 16.7% of the participants have 3 and 4 risk factors and after 3 and 4 cluster of risk factors, with increase in clustering of risk factors the percentage of individuals in each cluster declined progressively to about 2.2% whom had at least 9 risk factors (Figure 1). The abdominal obesity-hypertension-dyslipidemia and general and abdominal

obesity-hypertension-dyslipidemia cluster were associated with the highest in young adult, mid-adult and older with three or four risk factors. However, declining trend of higher clustering of cardiometabolic risk factor in the present study may also suggest that among participants who had more than 4 cardiometabolic risk factor they might have higher probability of early mortality, thus not capturing during the cross-sectional study. A study by Gu *et al.*, 2005 among Chinese adults population from the International Collaborative Study of Cardiovascular Disease in Asia (Inter-Asia) during 2000 to 2001 and compared these data with those of US adults from the National Health and Nutrition Examination Survey of 1999 to 2000. Overall, this study examined to 80.5%, 45.9%, and 17.2% of Chinese adults had ≥ 1 , ≥ 2 , and ≥ 3 modifiable CVD risk factors (dyslipidemia, hypertension, diabetes, cigarette smoking and overweight), respectively. By comparison, 93.1%, 73.0%, and 35.9% of US adults had ≥ 1 , ≥ 2 , and ≥ 3 of these risk factors, respectively (Gu *et al.*, 2005).

Major limitation of the present study is the smaller sample size. Therefore, the results of the present study need to be validated with a larger sample size.

CONCLUSION

The current study demonstrated high prevalence of obesity and dyslipidemia, especially low HDL and hypertriglyceridemia among a tribal population. Obesity and unbalanced dietary intake may raise dyslipidemia in Meena tribal population. There is clustering of cardiometabolic risk factors among the study population in which only about 7.8% were free from these risk factors but there is higher number of individuals in the age group 22-62 years with 3 and 4 risk factors, higher clustering of cardiometabolic risk factor in the present study may also suggest that among participants who had more than 4 cardiometabolic risk factor they might have higher probability of early mortality. Whereas lifestyle disorders can take the form of serious complications in all population, but the main cause may be different in different populations, especially India, in which found diverse ethnicity, culture and lifestyle. The observed high prevalence of cardiometabolic disease risk factors is a major public health concern which needs an immediate health intervention. Treatment and

management of CVD risk factors should be an important component of a national strategy to reduce the increasing burden of CVDs in India.

Abbreviations: NCDs—non-communicable diseases; CVD—cardiovascular diseases; WHO—World Health Organization; ISAK—International Society for the Advancement of Kinanthropometry; WC—waist circumference; BMI—body mass index; WHR—waist-hip ratio; WHtR, waist-height ratio; EDTA—ethylenediaminetetraacetic acid; TC—total cholesterol; TG—triglyceride; HDL-C—high-density lipoprotein cholesterol; LDL-C—lowdensity lipoprotein cholesterol; ACC/AHA—American College of Cardiology/American Heart Association; BP—Blood Pressure; SBP—Systolic Blood Pressure; DBP—Diastolic Blood Pressure; NCEP-ATP III—National Cholesterol Education Program-Adult Treatment Panel III; SPSS—Statistical Package for Social Sciences; SEP—socio-economic position; NFHS—National Family Health Survey.

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REFERENCES CITED

- Anchala, R., N. K. Kannuri, H. Pant, H. Khan, O. H. Franco, E. Di Angelantonio and D. Prabhakaran 2014. Hypertension in India: A systematic review and meta-analysis of prevalence, awareness, and control of hypertension. *Journal of Hypertension*, 32(6): 1170.
- Ashwell, M. and S. Gibson 2016. Waist-to-height ratio as an indicator of 'early health risk': Simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *British Medical Journal Open*, 6(3):e010159.
- Bhardwaj, A. K., D. Kumar, S. K. Raina, P. Bansal, S. Bhushan and V. Chander 2013. Community based assessment of biochemical risk factors for cardiovascular diseases in rural and tribal area of Himalayan Region India. *Biochemistry Research International*, 1-6.
- Chhungi, V., S. S. Ningombam, S. Yadav, H. S. Singh, N. K. Devi and S. Chandel 2019. Prevalence of cardiovascular risk factors among tribal and non-tribal populations with East Asian ancestry from North East India. *American Journal of Human Biology*, 31(5):e23263.
- Ciffone, N. A. and T. Copple 2019. Managing dyslipidemia for CVD prevention: a review of recent clinical practice guidelines. *The Nurse Practitioner*, 44(1):8-16.
- Clark, H. 2013. NCDs: A challenge to sustainable human development. *Lancet*, 381: 510-511.
- Dandona, L., R. Dandona, G. A. Kumar, D. K. Shukla, V. K. Paul and K. Balakrishnan 2017. Nations within a nation: variations in epidemiological transition across the states of India, 1990-2016 in the Global Burden of Disease Study. *Lancet*, 390(10111):2437-60.
- Delisle, H., G. Ntandou, R. Sodjinou, C. Couillard and J. P. Després 2013. At-risk serum cholesterol profile at both ends of the nutrition spectrum in West African adults? The Benin study. *Nutrients*, 5(4):1366-1383.
- Devi, N. K., I. Longkumer, S. Chandel, P. R. Mondal and K. N. Saraswathy. 2018. No effect of high physical activity on body mass index among Bhil tribal population in India. *Online Journal of Health and Allied Sciences*, 17(2):2.
- Friedewald, W. T., R. I. Levy and D. S. Fredrikson 1972. Estimation of the concentration of low-density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. *Clinical Chemistry*, 18: 499-502.
- Gu, D., A. Gupta, P. Muntner, S. Hu, X. Duan, J. Chen, R. F. Reynolds, P. K. Whelton and J. He 2005. Prevalence of cardiovascular disease risk factor clustering among the adult population of China: Results from the International Collaborative Study of Cardiovascular Disease in Asia (InterAsia). *Circulation*, 112(5):658-665.
- Gupta, R., I. Mohan and J. Narula 2016. Trends in coronary heart disease epidemiology in India. *Annals of Global Health*, 82:307-315.
- Government of India 2013. Statistical Profile of Scheduled Tribes in India. Ministry of Tribal Affairs. *Statistics Division, Government of India*. <https://tribal.nic.in/ST/StatisticalProfileofSTs2013.pdf>. [Accessed 17 June 2020].
- Ismail, I. M., K. Azeez, A. Antomy and S. V. Kunnummal 2016. Metabolic syndrome and its associated factors among the adult population residing in Kannavam tribal area of Kannur District, Kerala. *Tropical Journal of Medical Research*, 19(1):36.
- Jeemon, P., S. Neogi, D. Bhatnagar, K. J. Cruickshank and D. Prabhakaran 2009. The impact of migration on cardiovascular disease and its risk factors among people

- of Indian origin. *Current Science*, 97(3): 378-384.
- Joshi, P., S. Islam and P. Pais 2007. Risk factors for early myocardial infarction in South Asians compared with individuals in other countries. *Journal of the American Medical Association*, 297: 286-294.
- Kandpal, V., M. P. Sachdeva and K. N. Saraswathy 2016. An assessment study of CVD related risk factors in a tribal population of India. *BioMed Central Public Health*, 16(1): 434.
- Kshatriya, G. K. and S. K. Acharya 2016. Triple burden of obesity, under-nutrition, and cardiovascular disease risk among Indian tribes. *Public Library of Science One*, 11(1):e0147934.
- Kumar, R. K. and R. Tandon 2013. Rheumatic fever & rheumatic heart disease: The last 50 years. *Indian Journal of Medical Research*, 137: 643-658.
- Lohr, S. 2019. *Sampling: Design and Analysis* (Chapman & Hall/CRC Texts in Statistical Science) 2nd Edition. Routledge: London.
- Luhar, S., I. M. Timæus, R. Jones, S. Cunningham, S. A. Patel and S. Kinra 2020. Forecasting the prevalence of overweight and obesity in India to 2040. *Public Library of Science One*, 15(2):e0229438.
- Luhar, S., P. A. C. Mallinson, L. Clarke and S. Kinra 2018. Trends in the socioeconomic patterning of overweight/obesity in India: a repeated cross-sectional study using nationally representative data. *British Medical Journal Open*, 8(10):e023935.
- 2019. Do trends in the prevalence of overweight by socio-economic position differ between India's most and least economically developed states? *BioMed Central Public Health*, 19 (1):783.
- Lumsden, M. A., and K. Hor 2015. Impact of obesity on the health of women in midlife. *Obstetrics & Gynecology*, 17(3):201-208.
- Mensah, G. A., G. A. Roth and V. Fuster 2019. The global burden of cardiovascular diseases and risk factors: 2020 and beyond. *Journal of the American College of Cardiology*, 74:2529–2532.
- Meshram, I.I., and A. Laxmaiah. 2014. Prevalence of hypertension and its correlates among adult tribal population (e" 20 years) of Maharashtra State, India. *International Journal of Health Sciences and Research*, 4(1):130–9
- Mishra, D., I. Longkumer and K. N. Saraswathy 2021. Obesity and dyslipidemia among Bhil tribal population: A cross-sectional study from India. *International Journal of Diabetes in Developing Countries*.
- Misra, A., J. S. Wasir and N. K. Vikram 2005. Carbohydrate diets, postprandial hyperlipidaemia, abdominal obesity & Asian Indians: A recipe for atherogenic disaster. *Indian Journal of Medical Research*, 121(1):5.
- National Nutrition Monitoring Bureau 2003. Prevalence of Micronutrient Deficiencies. *Technical Report no. 22*. National Institute of Nutrition, Indian Council of Medical Research: Hyderabad. <https://www.nin.res.in/downloads/NNMBTribalReport.pdf>. [Accessed 8 June 2020]
- Pol, T., C. Held, J. Westerbergh, J. Lindbäck, J. H. Alexander, M. Alings 2018. Dyslipidemia and risk of cardiovascular events in patients with atrial fibrillation treated with oral anticoagulation therapy: insights from the ARISTOTLE (Apixaban for reduction in stroke and other thromboembolic events in atrial fibrillation) trial. *Journal of the American Heart Association*, 7(3):e007444.
- Popkin, B. M., S. Paeratakul, F. Zhai and K. Ge 1995. A review of dietary and environmental correlates of obesity with emphasis on developing countries. *Obesity Research*, 3:145s-53s.
- Prabhakaran, D., P. Jeemon and A. Roy 2016. Cardiovascular diseases in India: current epidemiology and future directions. *Circulation*, 133: 1605-20.
- Prabhakaran, D., P. Jeemon, M. Sharma, G. A. Roth, C. Johnson and S. Harikrishnan 2018. The changing patterns of cardiovascular diseases and their risk factors in the states of India: the Global Burden of Disease Study 1990-2016. *Lancet Global Health*, 6(12): e1339-51.
- Ralston, J., K. S. Reddy, V. Fuster and J. Narula 2016. Cardiovascular diseases on the global agenda: The United Nations high level meeting, Sustainable Development Goals, and the way forward. *Global Heart*, 11: 375-79.
- Rengma, M. S., J. Sen and N. Mondal 2015. Socio-economic, demographic and lifestyle determinants of overweight and obesity among adults of Northeast India. *Ethiopian Journal of Health Sciences*, 25(3):199-208. <https://doi.org/10.4314/ejhs.v25i3.2>.
- Saleem, S. M. and S. S. Jan. 2021. Modified Kuppuswamy socio-economic scale updated for the year 2021. *Indian Journal of Forensic and Community Medicine*, 8(1):1-3.
- Silva, V. S. D., and M. F. S. Vieira 2020. International society for the advancement of kinanthropometry (ISAK) global: International accreditation scheme of the competent anthropometrist. *Revista Brasileira de Cineantropometria & Desempenho Humano*, 22 e70517.
- Sobal, J. and A. J. Stunkard 1989. Socio-economic status and obesity: A review of the literature. *Psychological Bulletin*, 105(2):260-275.
- Whelton, P. K., R. M. Carey, W. S. Aronow, Jr. D. E. Casey, K. J. Collins and C. D. Himmelfarb 2018. GACC/AHA/ APA/ ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation and management of high blood pressure in adults Hypertension, 71: e13-e115.
- World Health Organization, Expert Consultation 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* (London, England), 363 (9403):157.

- World Health Organization 2009. Cardiovascular diseases (cvds). <http://www.who.int/mediacentre/factsheets/fs317/en/index.html>.
- World Health Organization 2011. Waist circumference and waist-hip ratio: Report of a WHO expert consultation, Geneva, 8-11 December 2008. WHO: Geneva.
- World Health Organization 2019. Health topics: Cardiovascular diseases. *Fact Sheet*. Available online: http://www.who.int/cardiovascular_diseases/en/ (Accessed on 11 December 2020). <https://www.who.int/india/health-topics/cardiovascular-diseases>
- WHO, G. 2011. Global Status Report on Non-communicable Diseases 2010. WHO: Geneva.
- Yusuf, S., S. Rangarajan and K. Teo 2014. Cardiovascular risk and events in 17 low-, middle-, and high-income countries. *The New England Journal of Medicine*, 371: 818-827.