Original Article

The prevalence of metabolic syndrome and its components among South Indian Chenchu tribal adults

Casey Morgan Luc[1,], Kara Herrera[1,]*, Ramesh Allam[2], Sabitha Gandhamalla[2], Ramkishan Dharmakari[3], Manjunath Dinaker[4], Vijay Yeldandi[1,4]*

[1]The University of Illinois, Chicago, Illinois, USA, [2]SHARE INDIA, Medchal District, Telangana, [3]Government General Hospital, Mahabubnagar, [4]International Center Human Health Advancement Foundation, Hyderabad, Telangana, India

*have shared co-first authorship and contributed equally on manuscripts.

ABSTRACT

Background: Dietary patterns are paramount in the prevention and management of metabolic syndrome (MetS) yet the definition and criteria for MetS diagnosis varies. This analysis aims to estimate the prevalence of MetS among the adult Chenchu tribal population comparing International Diabetes Federation (IDF) and Adult Treatment Panel (ATP) definitions of MetS and assess the relationship between dietary patterns and MetS. **Materials and Methods:** Demographics, medical history, nutrition, and physical activity were collected among 337 South Indian Chenchu tribal adults. The prevalence ratios and 95% confidence intervals of MetS using ATP and IDF definitions were estimated and associations between individual components of the MetS definitions, demographics, and dietary patterns were assessed. Pearson correlation coefficients (r) were calculated between the Modified Finnish Diabetic Risk Score (FINDRISC)-Bahasa Indonesia instrument and MetS definitions. **Results:** The prevalence of MetS was low by IDF (25, 7.4%) and ATP (22, 6.5%) definitions, while reporting vigorous physical activity (202, 59.9%) and a "vegetarian" dietary pattern (173, 51.3%) were high. Increasing age, high mutton consumption, and "empty-calorie" dietary pattern were associated with an increased prevalence of MetS, while vigorous physical activity and "vegetarian" dietary pattern were protective of MetS. The modified FINDRISC was not highly correlated with IDF MetS ($r = 0.47$; $P < 0.0001$) or ATP MetS ($r = 0.11$; $P = 0.0683$). **Conclusions:** Healthy behaviors, such as vigorous physical activity and high vegetable consumption, may contribute to the low prevalence of MetS in Chenchu tribal adults. Future efforts should continue to monitor dietary patterns and the prevalence of MetS in the understudied South Indian Chenchu tribal population.

Keywords: Dietary patterns, metabolic syndrome, South Indian Chenchu tribal population

Introduction

Metabolic syndrome (MetS) is a cluster of metabolic abnormalities which increase the risk of cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM). These conditions are interrelated, sharing underlying mediators; thus, understanding these common pathways is imperative for intervention development and therapies. Approximately one fourth of the world's adult population have MetS and these individuals are three times as likely to develop CVD and at five-fold greater risk of developing T2DM.[1] The main components of MetS include central obesity, hypertriglyceridemia, lower high-density lipoprotein (HDL) cholesterol, higher low-density lipoprotein (LDL) cholesterol, hyperglycemia, and hypertension.[2] The prevalence of MetS varies with

Access this article online	
Website: https://journals.lww.com/ijnc	**Quick Response Code**
DOI: 10.4103/jncd.jncd_38_23	

Address for correspondence: Mr. Casey Morgan Luc, 1707 Kiest Avenue, Northbrook, Illinois 60062, USA.
E-mail: cluc2@uic.edu

How to cite this article: Luc CM, Herrera K, Allam R, Gandhamalla S, Dharmakari R, Dinaker M, *et al*. The prevalence of metabolic syndrome and its components among South Indian Chenchu tribal adults. Int J Non-Commun Dis 2023;8:97-103.

Submitted: 12-Apr-2023 **Accepted:** 28-Apr-2023
Published: 27-Jun-2023

age, ethnicity, and with the criterion used to diagnose MetS.[3,4]

While there are many definitions for MetS, the two most widely used are those given by the National Cholesterol Education Program, Adult Treatment Panel III (ATP), and the International Diabetes Federation (IDF).[5,6] While the ATP definition incorporates the key features of hyperglycemia, visceral obesity, atherogenic dyslipidemia, and hypertension, a major limitation of this definition is that there is no guidance on cut points for circumference for the Asian Indian population.

The prevalence of MetS has been increasing in India. A population‑based study on Indian adults aged 20–75 years estimated that the prevalence of MetS using ATP criteria was 41% and that the prevalence of MetS increased with age.[7] Another study targeting urban adults reported a prevalence of 32% using the ATP criteria.[8] Both studies showed an increased prevalence among women. Asian Indians are also at high risk for T2DM and CVD and have an insulin‑resistant phenotype, characterized by low muscle mass, upper body adiposity, and high percent body fat.[9-11]

With different populations, ethnicities, and nationalities having different distributions for body weight and waist circumference, the IDF recommended a new MetS definition with population‑specific cutpoints. The IDF definition uses central obesity, or waist circumference, as the major criterion. Its cut off is ethnic‑specific and is lower for Indians as compared to the ATP definition. Secondly, the IDF definition has a lower cut point for fasting blood sugar, which is >100 mg/dL as compared to >110 mg/dL in the ATP definition. There are limited population‑based studies which evaluated the IDF definition of MetS among Asian Indians, suggesting its applicability to optimally identify MetS in Asian Indians to be unclear. Among a population of adult Indians, a study by Wasir *et al*. identified that more cases of MetS were detected with the decision to include body mass index (BMI) and change waist circumference to nonobligatory in the criterion.[12] Wasir *et al*. also concluded that defining waist circumference as a mandatory variable in the definition of the MetS would lead to noninclusion of nearly 11% cases who would otherwise be diagnosed as MetS according to the modified ATP definition.[12]

Among South Asians, the tribal population constitutes 6.6% of the total population of Andhra Pradesh and Telangana State and have a unique nutrition profile.[13] There are 12 primitive tribal groups (PTGs) that inhabit the state and Chenchu is one of the PTG recognized by the government of India. Chenchus mainly inhabit Nallamala forest range in the districts of Nargarkunool, Nalgonda, Mahaboobnagar, Vikarabad, Guntar, Kurnool, Nanded, Ongole.[13] Several studies have documented that the nutritional status of tribal populations is influenced by their habitat and socioeconomic conditions, with a higher prevalence of undernutrition compared to the nontribal populations.[14-16] Cereals, and in particular rice, form the bulk of the diet. The consumption of green leafy vegetables, other vegetables such as roots and tubers, and milk/milk products is very low, as compared to the recommended dietary intake. The consumption of fats and oils is marginally lower than recommended and the average intake of sugar and jaggery is lower than recommended. Additionally, It was observed that about 41% of adult men had chronic energy deficiency and 13% were overweight or obese. Comparing other tribal and rural populations in Andhra Pradesh, one study noted a higher overall crude death rate (11.7/100) among the Chenchu population,[17] but less is known about risk factors, particularly the unique nutritional profile of the Chenchu population, that contribute to MetS risk.

While the increase in CVD and T2DM leading to MetS in the general population is well documented, there is a paucity of literature among tribal populations, who have varied dietary and anthropometric metrics. This analysis aims to estimate the prevalence of MetS among the adult Chenchu population by comparing the IDF and ATP definitions, to assess the role of individual components in predicting MetS, and determine dietary patterns associated with MetS. A secondary objective is to estimate the correlation between MetS and the Modified Finnish Diabetic Risk Score (FINDRISC) utilizing the Bahasa Indonesia Instrument.

Materials and Methods

Study design

This is an observational study among South Indian Chenchu tribal adults describing the prevalence and exploring predictors of MetS. Chenchu tribal adults were recruited from high population villages in the Mandals or local subdivisions of Lingal, Aurangabad, Padra and Balmoor using a simple random sampling technique by utilizing household information from the Integrated Tribal Development Agency, Mahabubabad. Participants were eligible if they (1) identified as belonging to the Chenchu tribe and (2) consented to participate in completing the survey. Participants were deemed ineligible if they were (1) physically challenged (2) women who were pregnant or lactating (3) not fasting 10 h prior to survey completion or (4) not consented to participate.

Questionnaires were administered for 15 min in Telugu. Demographics, medical history, and risk factors for MetS, including dietary patterns and physical activity, were collected. Anthropometric measurements and blood pressure (BP) recordings were taken by a trained nurse or physician. A trained phlebotomist completed blood sampling to collect relevant biochemical measurements. Fasting blood sugar was recorded. Data was collected in two phases: March 22, 2018–March 25, 2018, and December 12, 2019–December 15, 2019.

Measures

Demographics including age, gender, medical history, nutrition, and physical activity were collected. Questions from the Modified FINDRISC-Bahasa Indonesia instrument were included to assess correlation of diabetes risk to MetS prevalence. Anthropometric measurements included BP (mmHg), waist circumference (cm), height (cm), and weight (kg). Biochemical measurements include triglycerides, LDL, HDL, total cholesterol, and glycosylated hemoglobin (HbA1C).

Three separate dietary patterns (“empty-calorie,” “western,” and “vegetarian”) and individual foods were described. “Empty-calorie” dietary pattern was defined as <4 servings of vegetables a day, and daily intake of any “nonvegetarian” animal protein source or any food/snacks with high fat or high carbohydrate/sugar content.[18] “Western” dietary pattern was defined as daily intake of any animal protein source or any food/snacks with high fat or high carbohydrate/sugar content, regardless of vegetable intake.[18] Additionally, “vegetarian” dietary pattern was defined as having at least four servings of vegetables a day and less than daily animal protein intake. Fruit intake was not included in dietary patterns due to missingness in reporting among this cohort.

MetS, the outcome of interest, was defined using the (1) ATP and (2) IDF definitions. ATP MetS was defined as having any three of the following: (1) waist circumference: >102 cm for men and >88 cm for women, (2) triglycerides: >150 mg/dL, (3) HDL: <40 mg/dL for men and <50 mg/dL for women, (4) BP: >130/>85 mmHg, and (5) HbA1C: ≥6%. For IDF, ethnic specific values for South Asians, based on Chinese, Malay, and Asian-Indian populations, were used for the waist circumference criteria for MetS. IDF MetS was defined as having a waist circumference ≥90 cm for men and ≥80 cm for women and any two of the following four factors: (1) raised triglycerides: ≥150 mg/dL (1.7 mmol/L), or on specific treatment, (2) reduced HDL cholesterol: <40 mg/dL (1.03 mmol/L) for men, <50 mg/dL (1.29 mmol/L) for women, or on specific treatment for this lipid abnormality, (3) raised BP: Systolic BP ≥ 130 or diastolic BP ≥85 mm Hg, or on treatment for previously diagnosed hypertension, and (4) raised HbA1C: >6%, or previously diagnosed T2DM.

The Modified FINDRISC-Bahasa Indonesia instrument was utilized to create a total risk score for T2DM within 10 years and categorized as very low, low, moderate, high, very high.[19]

Data analysis

Descriptive statistics for demographics and dietary patterns were calculated. Mean and standard deviations for continuous variables and absolute numbers (N) and percentages (%) for categorical variables were calculated and presented in this study population. Prevalence ratios (PRs) and 95% confidence intervals (CIs) were calculated for the associations between individual components of the MetS definition, demographics as well as dietary patterns and MetS with the ATP and IDF definitions. Pearson correlation coefficients (r) were calculated between the Modified FINDRISC-Bahasa Indonesia instrument and MetS definitions with a threshold of $r = 0.70$ considered highly correlated.

The analyses were performed using STATA 16.1 (Stata, College Station, TX, USA) software.

Results

The prevalence of MetS in this adult Chenchu population was low and comparable by the ATP (22, 6.5%) and IDF (25, 7.4%) definitions [Table 1a]. The mean age was 41.6 ± 15.6 years and nearly two-thirds were assigned female sex at birth (215, 63.8%). The mean BMI was 20.5 ± 3.9 with the majority (269, 79.8%) having a BMI of <25 kg/m^2. Correspondingly, the majority (202, 59.9%) self-reported daily vigorous physical or recreational activities. Self-reported T2DM (12, 3.6%) and hypertension (15, 4.5%) diagnoses were rare. However, a greater proportion (21, 6.2%) of T2DM diagnosis were identified with HbA1C >6.5%. Among persons with an HbA1C <6.0%, nearly all (307, 91.1%) had a low risk modified FINDRISC score of <7, with an estimated 1 in 100 developing T2DM within 10 years. On average, vegetables were consumed 5.6 ± 2.1 days/

week and fruits 1.4 ± 0.5 days/week [Table 1a]. The largest portion of respondents never consumed butter/ghee (111, 32.9%), fried food (125, 37.1%), soda (107, 31.8%), other sweetened drinks (134, 39.8%), burger or fries (174, 51.6%), or cakes and pastries (140, 41.5%) [Table 1b]. Protein consumption was more prevalent with the majority consuming mutton (245, 72.7%), chicken (262, 77.7%), and fish (247, 73.3%) at least once a week. One quarter (84, 24.9%) consumed chips or popcorn occasionally or rarely.

When assessing the individual components of ATP and IDF MetS definitions, increasing triglycerides level, BMI, T2DM diagnosis, and hypertension diagnosis were associated with an increase in the prevalence of MetS [Table 2]. Additionally, increasing waist circumference was associated with an increase in the prevalence of MetS among women (ATP PR: 1.06, 95% CI: 1.03, 1.09; IDF PR: 1.08, 95% CI: 1.06, 1.10) and only IDF MetS among men (PR: 1.17, 95% CI: 1.12, 1.22). Among men, decreasing HDL was associated with an increase in the prevalence of MetS (ATP PR: 0.98, 95% CI: 0.97, 0.99; IDF PR: 0.95, 95% CI: 0.92, 0.99). Increasing BP, both systolic (PR: 1.02, 95% CI: 1.00, 1.04) and diastolic (PR: 1.02, 95% CI: 1.00, 1.03), were associated with an increase in the prevalence of only IDF MetS. Increasing HbA1C level was associated with an increase in the prevalence of only ATP MetS (PR: 1.50, 95% CI: 1.36, 1.64).

Increasing age was associated with an increased prevalence of ATP (PR: 1.04, 95% CI: 1.02, 1.06) and IDF MetS (PR: 1.04, 95% CI: 1.02, 1.06) [Table 3]. Reporting vigorous physical or recreational activities was associated with a decrease in both ATP (PR: 0.44, 95% CI: 0.18, 1.12) and IDF MetS (PR: 0.38, 95% CI: 0.17, 0.85). Tobacco use was associated with an 84% decrease in prevalence of IDF MetS (PR: 0.16, 95% CI: 0.06, 0.46). "Vegetarian" dietary pattern was associated with a 59% decrease in ATP MetS (PR: 0.41, 95% CI: 0.16, 1.04). "Empty-calorie" dietary pattern was associated with an increase in both ATP (PR: 2.56, 95% CI: 0.96, 6.81) and IDF MetS (PR: 7.61, 95% CI: 2.81, 20.60). Increasing fruit (PR: 0.18, 95% CI: 0.05, 0.64) and vegetable consumption (PR: 0.63, 95% CI: 0.52, 0.75) was associated with a decrease in IDF MetS. High mutton consumption was associated with the largest increase in prevalence of MetS compared to all other animal protein sources (ATP PR: 2.67, 95% CI: 1.04, 6.87; IDF PR: 8.23, 95% CI: 3.02, 22.46).

Among those with an HbA1C <6.0%, the modified FINDRISC was not highly correlated with IDF MetS ($r = 0.47$; $P < 0.0001$) or ATP MetS ($r = 0.11$; $P = 0.0683$) definitions.

Table 1a: Distribution of demographics and dietary patterns among Chenchu adults (2018–2019) (*n*=337)

	n* (%)
MetS	
National Cholesterol Education Program, ATP III definition	22 (6.5)
IDF definition	25 (7.4)
Modified FINDRISC-Bahasa Indonesia	
Very low (<7)	235 (91.1)
Low (7–<12)	21 (8.1)
Moderate (12–<15)	2 (0.8)
High (15–20)	0
Very high (>20)	0
Age (mean±SD)	41.6±15.6
Female sex	215 (63.8)
BMI (mean±SD)	20.5±3.9
Tobacco use: Yes	128 (38.0)
Self-reported T2DM diagnosis	12 (3.6)
HbA1c >6.5%	18 (5.3)
Self-reported hypertension diagnosis	15 (4.5)
Vigorous physical or recreational activities: Yes	202 (59.9)
Fruit consumption (days/week), mean±SD	1.4±0.5
Vegetable consumption (days/week), mean±SD	5.6±2.1
"Empty-Calorie" pattern	68 (20.2)
"Western" dietary pattern	244 (72.4)
"Vegetarian" pattern	173 (51.3)

*Column (%) may not sum to study population (*n*) due to missingness. SD - Standard deviation, BMI - Body mass index, HbA1c - Glycosylated hemoglobin, FINDRISC - Finnish diabetic risk score, IDF - International Diabetes Federation, MetS - Metabolic syndrome, T2DM - Type 2 diabetes mellitus, ATP - Adult Treatment Panel

Discussion

This is the first descriptive analysis of MetS and related components among the South Indian Chenchu tribal population, expanding on other studies limited to the nutritional profile of the Chenchu tribe[17] and similar tribal populations.[14-16] Further, this study explored factors associated with MetS to identify mechanisms to improve the nutritional profile of a population with a documented but understudied high prevalence of undernutrition and low life expectancy.[17]

This study had a number of notable findings. First, the prevalence of MetS in this Chenchu tribal study population was low. A systematic review published in 2020 identified that almost one in three adults in India have MetS,[20] whereas our study population of the Chenchu tribal population had a prevalence of 6.5% for ATP MetS and 7.4% for IDF MetS. Additionally, T2DM and hypertension were low, which may be explained by high vigorous physical activity and "vegetarian" dietary patterns.

Table 1b: Distribution of specific food consumption among Chenchu adults (2018–2019) (*n*=337)

Food consumption	Daily, *n* (%)	At least once per week, *n* (%)	Once per month, *n* (%)	Occasionally or rarely, *n* (%)	Never, *n* (%)	Missing, *n* (%)
Butter/ghee	0	2 (0.6)	2 (0.6)	59 (17.5)	111 (32.9)	163 (48.4)
Fried food	0	42 (12.5)	0	13 (3.9)	125 (37.1)	157 (46.6)
Mutton	58 (17.2)	187 (55.5)	2 (0.6)	0	10 (3.0)	80 (23.7)
Chicken	75 (22.3)	187 (55.5)	0	3 (0.9)	9 (2.7)	63 (18.7)
Fish	65 (19.3)	182 (54.0)	3 (0.9)	3 (0.9)	10 (3.0)	74 (22.0)
Soda	22 (6.5)	45 (13.4)	2 (0.6)	40 (11.9)	107 (31.8)	121 (35.9)
Other sweetened drinks	1 (0.3)	34 (10.1)	1 (0.3)	8 (2.4)	134 (39.8)	159 (47.2)
Burger/fries	0	1 (0.3)	1 (0.3)	1 (0.3)	174 (51.6)	160 (47.5)
Cake/pastries	1 (0.3)	29 (8.6)	0	7 (2.1)	140 (41.5)	160 (47.5)
Chip/popcorn	0	35 (10.4)	0	84 (24.9)	58 (17.2)	160 (47.5)

Table 2: Unadjusted prevalence ratios of individual components of metabolic syndrome definition by total metabolic syndrome definition among Chenchu adults (2018–2019)

	National Cholesterol Education Program, ATP III definition			IDF definition		
	***n* (%) with MetS**	**PR (95% CI)**	**Wald χ^2, *P***	***n* (%) with MetS**	**PR (95% CI)**	**Wald χ^2, *P***
Waist circumference						
Men	50.4±36.6	1.01 (0.98–1.03)	0.645	95.2±6.1	1.17 (1.12–1.22)	<0.001
Women	80.0±23.9	1.06 (1.03–1.09)	<0.001	88.3±8.9	1.08 (1.06–1.10)	<0.001
Triglycerides level	259.0±141.1	1.01 (1.01–1.01)	<0.001	166.5±126.3	1.00 (1.00–1.01)	<0.001
HDL						
Men	33.2±6.0	0.98 (0.97–0.99)	0.005	21.0±19.2	0.95 (0.92–0.99)	0.006
Women	37.5±13.4	1.00 (0.98–1.02)	0.844	35.3±18.9	0.99 (0.97–1.01)	0.446
Systolic blood pressure	130.0±60.4	1.02 (0.99–1.04)	0.123	134.0±49.7	1.02 (1.00–1.04)	0.013
Diastolic blood pressure	84.5±38.2	1.02 (0.99–1.04)	0.128	84.4±29.5	1.02 (1.00–1.03)	0.041
HbA1c	7.4±3.1	1.50 (1.36–1.64)	<0.001	5.5±3.4	1.15 (0.88–1.49)	0.310
BMI (mean±SD)	24.0±4.4	1.17 (1.10–1.25)	<0.001	25.5±4.7	1.23 (1.16–1.31)	<0.001
T2DM diagnosis	4 (33.3)	5.97 (2.3–15.8)	<0.001	3 (25.0)	2.56 (0.88–7.41)	0.083
Hypertension diagnosis	4 (26.7)	3.22 (1.2–8.9)	0.024	6 (40.0)	2.80 (1.32–5.92)	0.007

BMI - Body mass index, HbA1c - Glycosylated hemoglobin, MetS - Metabolic syndrome, CI - Confidence interval, SD - Standard deviation, PR - Prevalence ratio, IDF - International Diabetes Federation, T2DM - Type 2 diabetes mellitus, HDL - High-density lipoprotein, ATP - Adult Treatment Panel

Differences were identified between components of each definition. HbA1C levels and self-reported diagnosis of T2DM were associated with ATP MetS, whereas systolic and diastolic BP, and waist circumference for men were associated with IDF MetS. For the overall definition of MetS, IDF was slightly more sensitive compared to ATP MetS with three more subjects being classified as having MetS with the IDF definition. Additionally, the modified FINDRISC was not highly correlated with either ATP or IDF MetS definitions. Due to these differences, we recommend that ATP and IDF MetS definitions as well as the modified FINDRISC should not be used interchangeably. Based on the prevalence of each individual component, researchefrs should take special consideration when measuring MetS in their studied populations.

Consistent with MetS literature, reporting vigorous physical activity and a "vegetarian" dietary pattern were protective of having MetS. Characterized by the consumption of vegetables, fruits, grains, legumes, nuts, vegetable oils, dairy products and/or eggs with reduced or eliminated consumption of animal products,[21] "vegetarian" dietary patterns have been suggested to be associated with a lower risk for developing T2DM, hypertension, specific cancers, and MetS.[21] Conversely, reporting "empty calorie" or "western" dietary patterns increased the prevalence of MetS in this analysis. This finding is critical due to the high prevalence of a "western" dietary pattern in this study population.

Limitations

Our study had a number of limitations. First, a large proportion of missingness was identified among dietary consumption variables, particularly among animal protein sources high with saturated fat like mutton, resulting in underpowered or incalculable associations between dietary patterns and MetS. Another limitation was generalizability of these results. Females may have been overrepresented

Table 3: Unadjusted prevalence ratios of demographics and dietary patterns by metabolic syndrome definition among Chenchu adults (2018–2019)

	National Cholesterol Education Program, ATP III definition		IDF definition	
	n (%) with MetS	PR (95% CI)	*n* (%) with MetS	PR (95% CI)
Age (mean±SD)	51.1±10.8	1.04 (1.02–1.06)	50.8±10.9	1.04 (1.02–1.06)
Female sex	12 (5.6)	0.68 (0.30–1.53)	20 (9.3)	2.27 (0.87–5.90)
Tobacco use	8 (4.4)	0.48 (0.21–1.12)	4 (2.2)	0.16 (0.06–0.46)
Vigorous physical or recreational activities, yes	8 (4.0)	0.44 (0.18–1.12)	10 (5.0)	0.38 (0.17–0.85)
Dietary patterns				
“Empty-calorie” pattern	7 (10.3)	2.56 (0.96–6.81)	13 (19.1)	7.61 (2.81–20.60)
“Western” dietary pattern	13 (5.3)	0.91 (0.21–3.85)	18 (7.4)	Incalculable*
“Vegetarian” pattern	7 (4.1)	0.41 (0.16–1.04)	0	Incalculable†
Fruit/vegetable consumption				
Fruit consumption (days), mean±SD	1.4±0.5	0.99 (0.38–2.57)	1.1±0.5	0.18 (0.05–0.64)
Vegetable consumption (days), mean±SD	4.7±2.3	0.84 (0.70–1.00)	3.1±2.0	0.63 (0.52–0.75)
Animal protein sources				
High mutton consumption (daily vs. less than daily/never)	7 (12.1)	2.67 (1.04–6.87)	12 (20.7)	8.23 (3.02–22.46)
High eggs consumption	5 (6.4)	1.27 (0.45–3.60)	14 (18.0)	7.11 (2.64–19.10)
High chicken consumption	4 (5.3)	1.06 (0.34–3.29)	13 (17.3)	6.90 (2.54–18.72)
High fish consumption	6 (9.2)	2.03 (0.75–5.50)	12 (18.5)	7.31 (2.67–20.01)

*All observations with nonmissing data with IDF MetS reported a “Western” dietary pattern, †All observations with nonmissing data with IDF MetS did not report a “Vegetarian” dietary pattern. IDF - International Diabetes Federation, SD - Standard deviation, CI - Confidence interval, MetS - Metabolic syndrome, PR - Prevalence ratio, ATP - Adult Treatment Panel

because sampling was conducted during hunting hours, so men were less likely to be available for recruitment. However, a substantial increase in MetS prevalence among females was not identified in this analysis. Lastly, the correlation results are prone to measurement error due to categorizations delineating from the Modified FINDRISC-Bahasa Indonesia instrument during data collection. Those with any family history of T2DM were assigned a “3.” Similarly, the length of physical activity collected (10 min vigorous physical activity daily) differed from the Modified FINDRISC-Bahasa Indonesia instrument (30 min daily). However, the measurement bias is toward the null.

Conclusions

MetS prevalence in this adult Chenchu tribal study population was lower than urban Indian populations, likely explained by the high prevalence of reporting vigorous physical activity and “vegetarian” dietary patterns. Compared to the ATP MetS definition, IDF MetS captured more MetS diagnoses with differences between components of each definition. The MetS definitions should not be used interchangeably in this cohort. Future efforts should continue to monitor dietary patterns and the prevalence of MetS in the understudied South Indian Chenchu tribal population.

Ethical approval

The research design and procedures of this study were reviewed and approved by the institutional review board of the Indian Institute of Public Health-Hyderabad (IIPH-Hyderabad).

Financial support and sponsorship

Research reported in this publication was supported by the International Center Human Health Advancement Foundation (ICHHA). The content is solely the responsibility of the authors and does not necessarily represent the official views of the ICHHA.

Conflicts of interest

There are no conflicts of interest.

References

1. IDF (International Diabetes Federation) Worldwide Definition of the Metabolic Syndrome. IDF Website. Available from: http://www.idf.org/metabolic-syndrome. [Last accessed on 2011 Aug 19].
2. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: Prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition examination survey, 1988-1994. Arch Intern Med 2003;163:427-36.
3. Banerjee D, Misra A. Does using ethnic specific criteria improve the usefulness of the term metabolic syndrome? Controversies and suggestions. Int J Obes (Lond) 2007;31:1340-9.
4. Misra A, Misra R, Wijesuriya M. The metabolic syndrome in South Asians. In: Mohan V, Rao GH, editors. Type 2 Diabetes in South Asians: Epidemiology, Risk Factors and Prevention. New Delhi: Jaypee Brothers; 2007. p. 76-96.
5. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in

adults (adult treatment panel III). JAMA 2001;285:2486-97.
6. International Diabetes Federation. The IDF Consensus Worldwide Definition of the Metabolic Syndrome. Available from: http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf. [Last accessed on 2011 Jul 11].
7. Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V. Metabolic syndrome in urban Asian Indian adults – A population study using modified ATP III criteria. Diabetes Res Clin Pract 2003;60:199-204.
8. Gupta R, Deedwania PC, Gupta A, Rastogi S, Panwar RB, Kothari K. Prevalence of metabolic syndrome in an Indian urban population. Int J Cardiol 2004;97:257-61.
9. McKeigue PM, Ferrie JE, Pierpoint T, Marmot MG. Association of early-onset coronary heart disease in South Asian men with glucose intolerance and hyperinsulinemia. Circulation 1993;87:152-61.
10. Ramachandran A, Snehalatha C, Vijay V. Low risk threshold for acquired diabetogenic factors in Asian Indians. Diabetes Res Clin Pract 2004;65:189-95.
11. Vikram NK, Misra A, Pandey RM, Luthra K, Wasir JS, Dhingra V. Heterogeneous phenotypes of insulin resistance and its implications for defining metabolic syndrome in Asian Indian adolescents. Atherosclerosis 2006;186:193-9.
12. Wasir JS, Misra A, Vikram NK, Pandey RM, Gupta R. Comparison of definitions of the metabolic syndrome in adult Asian Indians. J Assoc Physicians India 2008;56:158-64.
13. Ministry of Tribal Affairs. 7. Statistical Profile of Scheduled Tribes in India. Ministry of Tribal Affairs, Statistics division, Government of India; 2013. Available from: www.tribal.nic.in. [Last accessed on 2014 Jun 15].
14. Rao DH, Rao KM. Levels of malnutrition and socioeconomic conditions among Maria Gonds. J Hum Ecol 1994;5:185-90.
15. Vithal CP. Socio-economic transformation of a primitive tribal group: A study of Chenchus in Andhra Pradesh. Man India 1992;72:189-206.
16. Rao DH, Brahmam GN, Rao KM, Reddy GC, Rao NP. Certain Indian tribes. In: Samal PK, editor. Proceedings of the National Seminar on Tribal Development. Nainital: Gyanodaya Prakasham; 1996.
17. Rao KM, Kumar RH, Krishna KS, Bhaskar V, Laxmaiah A. Diet & nutrition profile of Chenchu population – A vulnerable tribe in Telangana & Andhra Pradesh, India. Indian J Med Res 2015;141:688-96.
18. Al-Qawasmeh RH, Tayyem RF. Dietary and lifestyle risk factors and metabolic syndrome: Literature review. Curr Res Nutr Food Sci J 2018;6:594-608.
19. Rokhman MR, Arifin B, Zulkarnain Z, Satibi S, Perwitasari DA, Boersma C, *et al.* Translation and performance of the Finnish Diabetes Risk Score for detecting undiagnosed diabetes and dysglycaemia in the Indonesian population. PLoS One 2022;17:e0269853.
20. Krishnamoorthy Y, Rajaa S, Murali S, Rehman T, Sahoo J, Kar SS. Prevalence of metabolic syndrome among adult population in India: A systematic review and meta-analysis. PLoS One 2020;15:e0240971.
21. Sabaté J, Wien M. A perspective on vegetarian dietary patterns and risk of metabolic syndrome. Br J Nutr 2015;113:S136-43.