Metabolic syndrome risk assessment among adults in Udupi District, Karnataka

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ABSTRACT

Background: It is estimated that around 20–25% of world's adult population have metabolic syndrome. Moreover, the prevalence is also high among south Asians and Indians and about one third of the urban population in large cities has varying degrees of Metabolic Syndrome.⁵

Objectives: To study the prevalence among adults who are at risk of metabolic syndrome, gender difference of the same. To study the association of socio-demographic factors, family history and personal history, biochemical parameters, lifestyle addictions, dietary pattern and adequacy with the risk of metabolic syndrome.

Methodology: A descriptive study was undertaken in Udupi District, Karnataka, India in which a total of 420 adults (aged > 20 years) from the general population were studied. Anthropometric measurement like height, weight, waist circumference, BMI waist hip ratio (WHR) was measured. Biochemical parameters like Blood Pressure, Fasting Glucose level, Post Prandial, HDL, LDL, TG, Triglyceride level from the existing records was recorded. Lifestyle addictions/habits like smoking, alcohol, Tobacco chewing and Drugs was assessed. Dietary assessment was done using 24-h recall in the diet software. Chi-square test, Correlation analysis and Paired *t*-test were used when appropriate using SPSS package.

Results and discussion: On the basis of metabolic syndrome risk assessment score of biochemical parameters, 50% of the samples are at moderate/at risk category, while 46.4% of the samples are at low/no risk and 3.6% of the samples showed the prevalence of metabolic syndrome. On the basis of lifestyle addiction, 73.1% of the samples were at moderate risk of metabolic syndrome while 13.8% were at high risk and 13.1% were at no/low risk of metabolic syndrome. This explains that more than 50% of the samples are at moderate risk group. The statistically significant risk factor for metabolic syndrome were females ($p = 0.000$), advancing age ($p < 0.001$, $r = 0.270^{**}$), low SES class ($p < 0.001$, $r = -0.129^{**}$), high Body mass index (BMI) waist hip ratio (WHR) waist circumference(WC) ($p < 0.001$, $r = 0.340^{**}$), ($p < 0.001$, $r = 0.423^{**}$), ($p < 0.001$, $r = 0.573^{**}$), Daily non-vegetarian pattern ($p = 0.004$) and coconut oil consumed ($p < 0.001$).

Conclusion: With urbanization and economic development, a nutritional transition characterized by improved dietary habits, improvements in socio-economic status and increasingly sedentary lifestyles have been observed which has contributed to the increasing prevalence of risk of metabolic syndrome among the population of Udupi, Karnataka.

1. Introduction

Metabolic syndrome is a constellation of metabolic abnormalities that increases the risk of heart diseases and type 2 diabetes. Metabolic syndrome is characterized by insulin resistance, abdominal obesity, high blood pressure and triglycerides levels, low levels of HDL

cholesterol, and impaired glucose tolerance. It is also called syndrome X and insulin resistance syndrome.⁴ Criteria used for the diagnosis of metabolic syndrome in this study: World Health Organization (WHO), National Cholesterol Education Program Adult Treatment Panel-III (ATP-III) and International Diabetes Federation (IDF) guidelines.

Based on the guidelines from the National Heart, Lung, and Blood

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Institute (NHLBI)¹⁰ and the American Heart Association (AHA), any three of the following traits in the same individual meet the criteria for the metabolic syndrome.¹

Americans has metabolic syndrome. The exact cause of metabolic syndrome is not known. Many features of the metabolic syndrome are associated with “insulin resistance.” Insulin resistance is a combination

Risk factor	Criteria set		
	WHO	ATP-III	IDF
Hypertension	Taking antihypertensive therapy and/or BP > 140/90 mmHg	Taking antihypertensive therapy or BP > 130/85 mmHg	Systolic BP ≥ 130 or diastolic BP ≥ 85 mmHg, or treatment of previously diagnosed hypertension
Dyslipidemia	Plasma TG > 1.7 mmol/L (150 mg/dL) and/or HDL < 0.9 mmol/L (35 mg/dL) in men and < 1.0 mmol/L (< 40 mg/dL) in women	Plasma TG > 150 mg/dL, HDL cholesterol < 40 mg/dL in men and < 50 mg/dL in women	Plasma TG > 150 mg/dL (1.7 mmol/L) or taking specific therapy for this lipid abnormality or low HDL-cholesterol < 40 mg/dL (1.03 mmol/L) in men and < 50 mg/dL (1.29 mmol/L) in women
Obesity	BMI > 30 kg/m ² and/or waist/hip ratio > 0.90 cm in men and > 0.85 cm in women	Central obesity (waist circumference > 40 inches (102 cm) in men and > 35 inches (88 cm) in women)	Central obesity (waist circumference ≥ 94 cm for European men and ≥ 80 cm for European women, with ethnicity specific values for other groups)
Glucose	Diagnosis of type 2 diabetes	Fasting blood glucose > 110 mg/dL	Fasting blood glucose ≥ 100 mg/dL (5.6 mmol/L), or diagnosis of type 2 diabetes
Requirements for Diagnosis	Diagnosis of type 2 diabetes plus any 2 other risk factors	Any 3 of the above disorders	Central obesity plus any 2 other risk factors

Some for the major risk factors for metabolic syndrome are age, genetic influences, Environmental influences-deficiency of certain nutrients, excessive caloric intake, low physical activity, hormone changes, central obesity, insulin resistance, dietary pattern.⁷ The metabolic syndrome also called Syndrome-X is a cluster of most dangerous heart attack risk factors. It is estimated that around 20–25% of world's adult population have metabolic syndrome. Moreover, the prevalence is also high among south Asians and Indians and about one third of the urban population in large cities has varying degrees of Metabolic Syndrome.⁵ The ICMR task force collaborative study reported the prevalence of metabolic syndrome to be 30% in urban areas of Delhi and 11% in rural Haryana using ATP-3 criteria. They also reported that prevalence was higher in women than men (46.5 vs 36.4%) and in older people.¹² A very high prevalence rate of 43.2% (n = 509) of metabolic syndrome was reported in Asian in a community study from urban Eastern Indian community. In this study, metabolic syndrome rates are significantly higher among females with 52.2% (n = 307) than in males at 34.2% (n = 202) (DS Prasad1, 2012). In a cross-sectional study involving 700 type 2 diabetic subjects from the urban areas of Gwalior Chambal region (Central India). The Prevalence of metabolic syndrome was found to be 45.8%, 57.7% and 28% following NCEP-ATPIII Criteria, IDF and WHO definitions, respectively. Using all the three definitions the prevalence was higher in women in all age groups.³

2. Aims and objectives

Metabolic syndrome (MS) is becoming a serious global public health problem. The aim of the present study is to assess the risk of Metabolic Syndrome in and around Udupi district population using the WHO, ATPIII and IDF definitions. The main objective of the study is to assess the risk of metabolic syndrome among adults; to study the association between socio-demographic factors and risks of metabolic syndrome; to compare the risk of metabolic syndrome based on biochemical parameters and life style addiction based on age and gender; to study association between anthropometric characteristics and the risk of metabolic syndrome; to study impact of physical activity level on the risk of metabolic syndrome; to study the association between co-morbid condition and family diseases history and the risk of metabolic syndrome and to study the association between food group and nutrient adequacy and the risk of metabolic syndrome.

According to a national health survey, more than one in five

of genetic and lifestyle factors. Lifestyle factors include diet, activity and perhaps interrupted sleep patterns.

Generally all the components of the metabolic syndrome, from all the existing definitions, can be discovered in the picture of obesity. Therefore, we can postulate that obesity represents the background of the problem or “the roots of evil”; central obesity is a complex and aggressive form of disease with a huge potential for cardiovascular and metabolic disorders. The metabolic syndrome is, in fact, a complication of this type of obesity. Diet is recognized as a key factor in the cause and management of the metabolic syndrome.² Various aspects of diet have been linked to metabolic syndrome in many studies, but the type of diet's which plays a role in developing the syndrome isn't well understood. Studies on Comparison of purely vegetarian diet and non-vegetarian diet and their risk in developing metabolic syndrome have not been done.

3. Methods and materials used

This is a cross-sectional study. The sample size was 420 individuals, using a simple random sampling method. Inclusion criteria: Individuals of age group ≥ 20 years including both male and female of all socio-economic status. Data collection was conducted for 3 months between August to November in which various visits were made to the selected households for data collection.

Tools used were interview schedule, Kuppuswamy scale (2007) and SPSS Package Version 16.0. WHO/ATP III criteria for assessing the risk. Diet software to calculate the different nutrients consumed by the individual.

4. Results and discussion

In the study the risk assessment of metabolic syndrome was conducted for 420 individuals including both genders. The risk assessment of metabolic syndrome was developed based on the score's given from biochemical parameter from the existing data which was laboratory tested by professionals in the health care domain, clinical laboratory in and around Udupi and Kasturba Hospitals. Parameters like normal BP, FBG, HDL, LDL, TG, Triglyceride, Anthropometric measurements like (WC, WHR, BMI) PAL, family history, personal history of diseases, total saturated fat and total dietary total fiber consumption.

Fig. 1. risk assessment of metabolic syndrome

4.1. Risk assessment of metabolic syndrome based on biochemical parameters

In the study the maximum number of samples falls under that moderate/at risk category that is 50% of the samples. While 46.4% of the samples had no/low risk of metabolic syndrome. And the study showed a prevalence of metabolic syndrome 3.6% as shown in Fig. 1. It is also noteworthy that, in a study which states that overall metabolic syndrome as per ATP-III criteria was observed in 5.0% adult rural population.¹³

The demographic distribution of study population is shown in Table 1. There was a statistical significant association in both gender with the risk of metabolic syndrome ($p < 0.001$). This explains that females are having higher prevalence of metabolic syndrome and have higher risk of metabolic syndrome when compared to males. This observation was also found in a study which states that Age-standardized prevalence rates of metabolic syndrome were 33.5% overall, 24.9% in males and 42.3% in females. Older age, female gender, general obesity, inadequate fruit intake, hypercholesterolemia, and middle-to-high socioeconomic status significantly contributed to increased risk of metabolic syndrome.⁶ On correlation analysis of the samples age group with the risk of metabolic syndrome there was found to have positive correlation and high degree of significance. ($r = .270^{**}$), in a retrospective

Table 2

Anthropometric characteristics with the risk of metabolic syndrome.

Risk assessment of metabolic syndrome		
Correlation analysis		
	r-value	p-value
BMI	0.340**	< 0.001
WC	0.573**	< 0.001
WHR	0.423**	< 0.001
PAL	−0.299**	< 0.001

** = significant at 1% level.

analysis of data there was gender-wise prevalence of metabolic syndrome across different age groups.¹⁶ However it showed significantly higher rates of metabolic syndrome in older age groups. This table depicts there is no statistical significant association between the place of residence of the samples with the risk of metabolic syndrome ($p = .089$), whereas there is statistical significant association between the risk of metabolic syndrome and Literacy level of the sample ($p = .011$). Lower the literacy level higher the risk as well as prevalence of metabolic syndrome.

Table 2 summarizes the individual components of anthropometric measurement which had significant association between the risk of metabolic syndrome and BMI of the samples ($p < 0.001$). On correlation analysis it was there was between the BMI of the samples with the risk of metabolic syndrome. ($r = .340^{**}$), increased BMI can increase the risk of metabolic syndrome ($p < 0.001$). In a cross-sectional study which states that Overall prevalence of metabolic syndrome was 31%. Body mass index and waist circumference had a positive correlation with a number of metabolic syndrome factors ($p < 0.001$).⁹

The study describes that there is a statistical significant association between the waist circumference, waist hip ratio and risk of metabolic syndrome ($p < 0.001$) and ($p < 0.001$) respectively. there was a significant correlation between the waist circumference, the waist-to-

Table 1

Impact of Socio-demographic factors on the risk of metabolic syndrome.

Risk assessment of metabolic syndrome									
Parame ters	Frequency	Low risk	At risk	Metabolic syndrome	Chi- Square	p- Value			
Gender	Male	107(59.4%)	66(36.7%)	7 (3.9%)	22.783**	< 0.001			
	Female	88 (36.7%)	144 (60%)	8 (3.3%)					
Place of residence	Rural	67 (39.9%)	94 (56%)	7 (4.2%)	4.847NS	0.089			
	Semi- urban	128 (50.8%)	116 (46%)	8 (3.2%)					
Literacy	Illiterate	14 (31.8%)	25(56.8%)	5 (11.4%)	25.948*	0.011			
	Primary School certificate	12 (37.5%)	19(59.4%)	1 (3.1%)					
	Middle school certificate	14 (37.8%)	23(62.2%)	0 (0%)					
	High school certificate	28 (42.2%)	34(51.5%)	4 (6.1%)					
	Intermediate or Post high school diploma	30 (44.1%)	36(52.9%)	2 (2.9%)					
	Graduate or Postgraduate	79 (53.4%)	66(44.6%)	3 (2%)					
	Profession or Honors	18 (72%)	7 (28%)	0 (0%)					
	Occupat ion	Unemployed	87(39.7%)	123(56.2%)			9(4.1%)	18.578 ^{NS}	0.099
Unskilled worker		4 (80.0%)	1 (20.0%)	0(.0%)					
Semi-skilled worker		7(46.7%)	8(53.3%)	0(.0%)					
Skilled worker		36 (59.0%)	21(34.4%)	4(6.6%)					
Clerical, shop-owner, farmer		11 (36.7%)	18(60.0%)	30 (3.3%)					
Semi-Profession		4 (57.1%)	3(42.9%)	0(.0%)					
Profession		46 (55.4%)	36 (43.4%)	1(1.2%)					
Correlation analysis									
		r-value		p-value					
Age		0.270**		< 0.001					
SES score		− 0.129**		< 0.001					

^{NS} = not significant.

** = significant at 1% level.

* = significant at 5% level.

Table 3
Anthropometric characteristics with the risk of metabolic syndrome with Genders.

Risk assessment of metabolic syndrome				
	Correlation analysis			
	Male		Female	
	r-value	p-value	r-value	p-value
BMI	0.235**	< 0.001	0.615**	< 0.001
WC	0.657**	< 0.001	0.708**	< 0.001
WHR	0.467**	< 0.001	0.566**	< 0.001
PAL	−0.273**	< 0.001	−0.402**	< 0.001

** = significant at 1% level.

hip ratio and the risk of metabolic syndrome ($r = .573^{**}$) and ($r = .423^{**}$) respectively, which describes greater waist circumference as well as the hip-to-waist ratio is a risk of developing metabolic syndrome. Similarly there was statistical significant association between the physical activity level (PAL) of the samples with the risk of metabolic syndrome ($p < 0.001$). On correlation analysis between the PAL and risk of metabolic syndrome it can be observed that there is strong negative correlation between the two and is statistical significance ($r = -.299$) explaining an increased physical activity level decreases the risk of metabolic syndrome. Prevalence of MS in the different physical activity categories of the IPAQ were; 'inactive'–38.8% (95% CI 34.5–43.2), 'moderately active'–33.5% (95% CI 30.9–36.1) and 'active'–21.1% (95% CI 19.6–22.7)¹⁴

In table 3, correlation analysis showed that the risk of metabolic syndrome increased for both the gender groups with increased anthropometric measurement ($p < 0.000$). while decreased the risk for both the genders with increase in physical activity level ($p < 0.00$).

The number of respondents with co-morbid condition and family history with risk of metabolic syndrome is shown in Table 4. Samples with the family history of high blood pressure, type 2 diabetes, Dyslipidemia and CVD had higher risk of metabolic syndrome 2.9% of the sample are showing the prevalence of metabolic syndrome with the family history of blood pressure, while 2.15% with the family history of

type diabetes, 1.5% with family history of Dyslipidemia and 1% of samples with the family history of CVD ($p < 0.001$).

Studies on metabolic syndrome which states that Individuals with a history of both parents affected from diabetes had significantly higher ($P < 0.001$) body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and fasting blood glucose (FBG; $P = 0.035$) than individuals having no family history of T2DM. Significant difference was also noticed between individuals with and without MS according to the family history of diabetes ($P < 0.001$)⁸

Overall there is a statistical association between the lifestyle habits of alcohol and tobacco with the risk of metabolic syndrome ($p = .030$) and ($p = .013$) respectively shown in Table 5. While there was no statistical significant association between the smoking and drugs and risk of metabolic syndrome ($p = .186$) and ($p = .561$) respectively. In the recent study smoking had a strong risk factor for atherosclerosis and CVD, with a dose dependent relationship. Thus, based on these findings, smoking may be considered as an important modifiable risk factor for metabolic syndrome.¹⁵

However there is no statistical association between the dietary pattern and risk of metabolic syndrome ($p = .524$). Since in the study the samples with non-vegetarian dietary pattern were higher than vegetarian pattern there prevalence of metabolic syndrome is resulting higher in the non-vegetarians. However it was not found to be significant. Similar findings in a study which stated that a vegetarian dietary pattern was associated with significantly lower means for all MRFs except HDL and a lower risk of having MetS when compared with a non-vegetarian dietary pattern.¹¹ The table depicts that there is a statistical significant association between the daily consumption and risk of metabolic syndrome ($p = 0.032$). This explains that daily consumption of non-vegetarian pattern in higher metabolic syndrome than the daily consumption of vegetarian pattern. However it was found to be significant. There was no statistical significant association between the total liters of oil consumption ($p = 0.893$) with the risk of metabolic syndrome while there was statistical significant association between the type of oil consumption with the risk of metabolic syndrome ($p = 0.024$).

Table 6 depicts that there is statistical significant correlation between the cereal ($r = -0.341^{**}$) and fats/oil ($r = 0.112^{*}$) intake of the

Table 4
Co-morbid condition/Family history of diseases with the risk of metabolic syndrome.

Risk assessment of metabolic syndrome						
Parameters	Frequency	Low risk	At risk	Metabolic syndrome	Chi-Square	p-Value
High blood pressure	No	185(56.2%)	139(42.4%)	5(1.5%)	67.567**	< 0.001
	Yes	10(11%)	71(78%)	10(11%)		
Type 2 diabetes	No	186(51.1%)	174(47.8%)	4(1.1%)	62.194**	< 0.001
	Yes	9(16.1%)	36(64.3%)	11(19.6%)		
Dyslipidemia	No	189(48.6%)	191(49.1%)	9(2.3%)	29.484**	< 0.001
	Yes	6(19.4%)	19(61.3%)	6(19.4%)		
Cardio vascular diseases	No	193(47%)	203(49.4%)	15(3.6%)	2.908NS	0.234
	Yes	2(22.2%)	7(77.8%)	0(0%)		
Fathers history of BP	No	173(50.1%)	161(46.7%)	11(3.2%)	10.834**	0.004
	Yes	22(29.4%)	49(65.3%)	4(5.3%)		
Mothers history of BP	No	169(51.5%)	152(46.3%)	7(2.1%)	21.045**	< 0.001
	Yes	26(28.3%)	58(63%)	8(8.7%)		
Fathers history of DM	No	176(49.6%)	167(47%)	12(3.4%)	9.147*	0.010
	Yes	19(29.2%)	43(66.2%)	3(4.6%)		
Mothers history of DM	No	169(51.4%)	151(45.9%)	9(2.7%)	16.063**	< 0.001
	Yes	26(28.6%)	59(64.8%)	6(6.6%)		
Fathers history of CVD	No	186(47.9%)	188(48.5%)	14(3.6%)	5.360NS	0.525
	Yes	9(29%)	21(67.7%)	1(3.2%)		
Mothers history of CVD	No	193(48%)	197(49%)	12(3%)	15.940**	< 0.001
	Yes	2(11.1%)	13(72.2%)	3(16.7%)		

NS = not significant.

** = significant at 1% level.

* = significant at 5% level.

Table 5
Lifestyle addiction/Dietary pattern with the risk of metabolic syndrome.

Risk assessment of metabolic syndrome						
Parameters	Frequency	Low risk	At risk	Metabolic syndrome	Chi- Square	p- Value
Smoking	No	182(45.5%)	204(51%)	14(3.5%)	3.360NS	0.186
	Yes	13(65%)	6(30%)	1(5%)		
Alcohol	No	170(45.3%)	194(51.7%)	11(2.9%)	6.998*	0.030
	Yes	25(55.6%)	16(35.6%)	4(8.9%)		
Tobacco	No	173(45.4%)	197(51.7%)	11(2.9%)	8.691*	0.013
	Yes	22(56.4%)	13(33.3%)	4(10.3%)		
Drugs	No	194(46.3%)	210(50.1%)	15(3.6%)	1.157NS	0.561
	Yes	1(100%)	0(0%)	0(0%)		
Dietary pattern	Vegetarian	66(46.8%)	72(51.1%)	3(2.1%)	1.293NS	0.524
	Non-veg	129(46.2%)	138(49.5%)	12(4.3%)		
Daily consumption	Vegetarian	149(50.2%)	140(47.1%)	8(2.7%)	6.904*	0.032
	Non- veg	46(37.4%)	70(56.9%)	7(5.7%)		
Total liters of oil per month	1 L	37(46.2%)	40(50%)	3(3.8%)	3.583 ^{NS}	0.893
	2 L	66(47.1%)	70(50%)	4(2.9%)		
	3 L	43(51.2%)	39(46.4%)	2(2.4%)		
	> 3 L	44(41.5%)	56(52.8%)	6(5.7%)		
	< 1 L	5(50%)	5(50%)	0(0%)		
Type of oil consumption	Olive oil	1(33.3%)	2(66.7%)	0(0%)	42.112*	0.024
	Coconut oil	97(49.2%)	97(49.2%)	3(1.5%)		
	Sunflower oil	59(52.2%)	52(46%)	2(1.8%)		
	Groundnut oil	2(50%)	2(50%)	0(0%)		
	Palm oil	11(44%)	11(44%)	3(12%)		
	Coconut + sunfloweroil	14(28.6%)	30(61.2%)	5(10.2%)		
	Coconut + groundnutoil	3(60%)	2(40%)	0(0%)		
	Sunflower + palmoil	2(66.7%)	1(33.3%)	0(0%)		
	Coconut + sunflower + olive oil	0(0%)	1(100%)	0(0%)		
	Coconut + Palm/Mustard oil	3 (30%)	6(60%)	1 (10%)		
	Coconut + sunflower + groundnut oil	1(100%)	0(0%)	0(0%)		
	Sunflower + groundnutoil	1(20%)	4(80%)	0(0%)		
	Coconut + Sunflower + olive oil	0(0%)	1(100%)	0(0%)		
	Sunflower + olive oil	0(0%)	1(50%)	1(50%)		

^{NS} = not significant.

** = significant at 1% level.

* = significant at 5% level.

Table 6
Correlation of Food group intake with risk of metabolic syndrome.

Food group	Risk Group of metabolic syndrome	
	r value	p value
Cereals	−0.341**	< 0.001
Pulses/meat	0.069	0.160
Milk & its product	−0.057	0.241
Roots & tubers	0.010	0.836
Green Leafy Vegetables	−0.031	0.530
Other veg	−0.032	0.518
Fruits	−0.014	0.778
Sugar	0.018	0.717
Fats/oils	0.112*	0.022

^{NS} = not significant.

** = significant at 1% level.

* = significant at 5% level.

samples with the risk of metabolic syndrome. This explains that there is strong negative correlation of intake of cereal with significant decrease risk of metabolic syndrome, while strong positive correlation of increase intake of total fat with significant increase risk of metabolic syndrome.

This **Table 7** describes the correlation between the nutrient intake and Risk of metabolic syndrome based on biochemical parameters and lifestyle addiction. It can be observed that there is no statistical significant correlation between both the macronutrient as well as micro-nutrient like Energy ($r = .63$), Carbohydrates ($r = -0.025$), MUFA ($r = 0.008$), PUFA ($r = 0.039$), calcium ($r = -0.042$), zinc ($r = -0.062$), total B-carotene ($r = -0.05$), Vitamin C ($r = -0.308$)

Table 7
Correlation of nutrient intake with Risk of metabolic syndrome.

Nutrients	Risk Group of metabolic syndrome	
	r value	p value
Energy	0.63NS	0.197
Carbohydrates	-.025NS	0.607
Protein	0.104*	0.032
Total fats	0.115*	0.018
Poly Unsaturated Fatty Acid	0.008NS	0.866
Mono Unsaturated Fatty Acid	0.039NS	0.427
Saturated Fatty Acids	0.097*	0.047
Total Dietary Fiber	−0.166**	< 0.001
Total soluble fiber	−0.174**	< 0.001
Iron	0.164**	< 0.001
Calcium	-.042NS	0.392
Zinc	-.062NS	0.156
Total B-carotene	−0.050 ^{NS}	-.302
Vitamin C	−0.308 ^{NS}	0.440
Vitamin B-12	-.069NS	0.161

^{NS} = not significant.

** = significant at 1% level.

* = significant at 5% level.

and Vitamin B12 ($r = 0.069$) with Risk group (1). While there was statistical significant correlation of protein ($r = .053^*$), Total fats ($r = .013^*$) Saturated fat ($r = .058^*$), total dietary fiber ($r = -0.166^{**}$), soluble fiber ($r = 0.174^{**}$) and iron ($r = 0.164^{**}$). This explains us that there is a strong positive correlation of the risk of metabolic syndrome with increasing intake of the protein, total fat, saturated fat and iron of the samples.

Table 8
Correlation of nutrient intake with anthropometric measurements.

Nutrients	BMI		WC		WHR	
	r value	p value	r value	p value	r value	p value
Energy	0.130**	0.007	0.323**	< 0.001	0.177**	< 0.001
Carbohydrates	0.101*	0.039	0.244**	< 0.001	0.159**	< 0.001
Protein	0.118*	0.102	0.259**	< 0.001	0.163**	< 0.001
Total fats	0.102*	0.102	0.259**	< 0.001	0.069NS	0.156
PUFA	0.034NS	0.484	0.051NS	.298	−0.090 ^{NS}	0.065
MUFA	0.035NS	0.471	0.105*	.031	−0.056 ^{NS}	0.252
SAT	0.058NS	0.235	0.191**	< 0.001	0.173**	< 0.001
Total Dietary Fiber	0.034 NS	0.493	0.107*	.028	0.047NS	0.023
Total soluble fiber	0.047 NS	0.339	0.160*	< 0.001	0.106NS	0.030
Iron	0.086NS	0.078	0.161**	< 0.001	0.102*	0.038
Calcium	0.072NS	0.139	0.156**	< 0.001	0.098*	0.045
Zinc	0.059NS	0.231	0.160**	< 0.001	0.136**	0.005
Total B-carotene	0.012 NS	0.810	0.099*	.042	0.001NS	0.984
Vitamin C	−0.001 ^{NS}	0.982	0.094NS	.053	0.055NS	0.265
Vitamin B-12	−0.008 ^{NS}	0.874	0.021NS	.669	−0.114 ^{NS}	0.020

NS = not significant.

** = significant at 1% level.

* = significant at 5% level.

The Table 8 shows correlation between the Nutrient intake of the samples with their BMI, Waist circumference (WC), Waist-hip ratio (WHR), Age of the samples and socio-demographic status (SES). This explains that as there is a strong positive correlation between energy, protein, carbohydrate and total fat intake with their BMI of the samples. In the other macronutrients like PUFA, MUFA and saturated fat was found to have no statistical significant association with their BMI ($r = .034$) ($r = .035$) ($.058$) respectively. This explains that there is a positive correlation between the macronutrients and BMI. However it was found to have no significance. In total dietary and soluble fiber there was found no statistical significant association with their BMI ($r = .034$) ($r = .047$) respectively. In micronutrient likes iron, calcium, zinc and total B-carotene there was found no statistical significant association with their.

BMI. This explains that there is a positive correlation, however it is not significance. In other micronutrients like Vitamin C and Vitamin B-12 is no statistical significant association. It explains that there is no negative correlation and in not significant. It can also observed that there is a strong positive correlation between energy, protein, carbohydrate, total fat, and saturated fat, dietary and soluble fiber with their BMI of the samples.

The Table 9 represents the correlation of age with nutrient intake of the samples. It shows that there is statistical significant association between the age so the samples and their Energy ($r = -.117^*$) Protein ($r = -.105^*$), Carbohydrates($r = -.113^*$), Total Fat ($r = -.115^*$), MUFA ($r = -.214^{**}$), and PUFA ($-.236^{**}$). It explain there is a negative correlation between the nutrient intake of the samples and their age and has a strong significance.

Other macronutrients like Saturated fat, Total fiber and Soluble fiber was found to have no statistical significant association with their age ($r = 0.013$) ($r = -.014$) ($r = -.071$) respectively. It explains that there is positive correlation between the saturated fat and age of the sample while there is negative correlation for total dietary fiber and soluble fiber and is not found to have significance. In the micronutrients zinc, B-carotene and Vitamin b12 there was found statistical significant association with their WC ($r = -.131^{**}$) ($r = -.105^{**}$) and ($r = -.152^{**}$) respectively. This explains that there is a strong negative correlation and is highly significant. Other micronutrients like iron, calcium and Vitamin C there was found no statistical significant association with the WC. It explain there is negative correlation and is not significant.

Table 9
Correlation of nutrient intake with Age and SES.

Nutrients	AGE		SES	
	r value	p value	r value	p value
Energy	-.117*	.016	.242**	< 0.001
Carbohydrates	-.113*	.020	.209**	< 0.001
Protein	-.105*	.031	.144**	.003
Total fats	-.115*	.019	.228**	< 0.001
PUFA	-.214**	< 0.001	.250**	< 0.001
MUFA	-.236**	< 0.001	.185**	< 0.001
SAT	.013 NS	.792	-.054NS	.268
Total Dietary Fiber	-.014 ^{NS}	.779	.198**	< 0.001
Total soluble fiber	-.071 ^{NS}	.149	.301**	< 0.001
Iron	-.049 ^{NS}	.317	.006 NS	.901
Calcium	-.068 ^{NS}	.166	.254**	< 0.001
Zinc	-.131**	.007	.266**	< 0.001
Total B-carotene	-.105*	.032	.324**	< 0.001
Vitamin C	-.060 ^{NS}	.220	.272**	< 0.001
Vitamin B-12	-.152**	.002	.295**	< 0.001

NS = not significant.

** = significant at 1% level ($p = 0.01$).

* = significant at 5% level ($p = 0.05$).

The table also depicts the SES class of the samples with their nutrient intake. It was found that there was a statistical significant association between the high SES class and Energy ($r = .242^{**}$), Carbohydrates ($r = .209^{**}$), Protein ($r = .144^{**}$), total fat ($r = .228^{**}$), PUFA ($r = .250^{**}$), MUFA ($r = .185^{**}$) Total dietary fiber ($r = .198^{**}$) and soluble fiber ($r = .301^{**}$). It explains that there is a positive correlation between nutrients and the SES class and is highly significant. While in the case of saturated fat there was no statistical significant association with the SES class ($r = -.054$). This explain there is negative correlation and is not significant. In the micronutrients calcium, zinc, B-carotene and Vitamin C, vitamin b12 there was found statistical significant association with their high WC ($r = .254^{**}$) ($r = .266^{**}$) and ($r = .324^{**}$) ($r = .272^{**}$) and ($r = .295^{**}$) respectively. This explains that there is a strong positive correlation and is highly significant. While iron has no statistical significant association with the SES class ($r = .006$) it explain there is positive correlation but is not significant.

5. Conclusion

On the basis of metabolic syndrome risk assessment score of biochemical parameters, 50% of the samples are at moderate/at risk category, while 46.4% of the samples are at low/no risk and 3.6% of the samples should the prevalence of metabolic syndrome. This explains that more than 50% of the samples are at moderate risk group. The statistically significant risk factor for metabolic syndrome were females ($p = 0.000$), advancing age ($p < 0.001$, $r = 0.270^{**}$), low SES class ($p < 0.001$, $r = -0.129^{**}$), high Body mass index (BMI) waist hip ratio (WHR) waist circumference(WC) ($p < 0.001$, $r = 0.340^{**}$), ($p < 0.001$, $r = 0.423^{**}$), ($p < 0.001$, $r = 0.573^{**}$), Daily non-vegetarian pattern ($p = 0.004$) and coconut oil consumed ($p < 0.001$). With urbanization and economic development, a nutritional transition characterized by improved dietary habits, improvements in socio-economic status and increasingly sedentary lifestyles have been observed which has contributed to the increasing prevalence of risk of metabolic syndrome among the population of Udupi, Karnataka. Further preventive strategies will require addressing modifiable risk behaviors, including lack of physical activity, and dietary intake. Continued investigation of other environmental and biological factors, will be needed to better understand the risk profile in this population and potential means of prevention.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cegh.2019.06.003>.

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