RESEARCH ARTICLE

Impact of metabolic syndrome on nutrients intakes among Saudi females

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Abstract

Objective: To estimate the adequacy of nutrients intake among females with metabolic syndrome.

Methods: The quantitative case-control study was conducted in November 2015 at King Fahd University Hospital, Al Khobar, Eastern Province, Saudi Arabia, and comprised patients who had three or more risk factors associated with metabolic syndrome. Group I had patients who met three of the six criteria components, Group II had those who met four components, and Group III had those who met more than four components. Healthy subjects were enrolled as controls. Socioeconomic data as well as weight, height, body mass index and waist circumference was collected. The 24-hour recall method was used for collecting data about food intake, and the nutrient intake was calculated by Saudi food composition tables. Data related to nutrient intake was compared with standard dietary requirements.

Results: Of the 216 subjects, 134(%) were patients and 82(%) were controls. Among the patients, 20(15%) were in Group I, 34(25%) in Group II and 89(60%) were in Group III. None of the cases in the three groups had normal weight compared to 20(24.4%) controls ($p<0.001$). Intake of calories, protein and carbohydrates in groups II and III were lower than the controls and those in group I ($p<0.05$). Percentage of energy yielded from protein, fat, and carbohydrates by the patients differed significantly from normal values ($p<0.05$).

Conclusion: Majority of the patients failed to fulfill their requirements from essential nutrients. The higher the number of metabolic syndrome risk factors, the higher was the insufficiency of nutrient intake.

Keywords: Diet, Female, Metabolic syndrome, Nutrients, Obesity, Saudi Arabia. (JPMA 69: 330; 2019)

Introduction

Dietetic evolution has increased the prevalence of obesity in most Gulf countries compared to the Western world.[1] Metabolic syndrome (MetS) is associated with various risk factors that include central obesity, insulin resistance, dyslipidaemia, and hypertension.[2] These patients are at greater risk of developing type 2 diabetes mellitus (T2DM) and cardiovascular diseases (CVDs).[3] MetSis considered a universal health issue which is associated with succeeding development of CVDs. Although data is limited regarding the prospective relationship between CVD and MetS in populations free of past cardiovascular history and diabetes.[3]

The mortality rate associated with CVD is higher amongst patients with MetS. The global prevalence of MetS in adults has been estimated to be 25% which increases with age, especially among females.[4] According to a study,[4] MetS is considered an epidemiological construct of several permutations of risk-related factors with treatment strategies and unique clinical implications. It is important to recognise the population with MetS because individuals have an adverse metabolic state particularly which permits aggressive intervention for particular traits.

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The prevalence of MetS is higher in Gulf countries compared to the United States (US) population from 21% to 37% in males and 32% to 43% in females.[5] The severity of MetS is dependent on the severity of its risk factors. The patients suffering from MetS usually experience atherogenic dyslipidaemia due to increased concentrations of low-density lipoprotein (LDL) and triglyceride (TG), and low concentration of high-density lipoprotein (HDL) cholesterol.[6] The management of MetS requires regular physical activity, healthy diet, reduction in body weight and abdominal obesity.[7] The development of obesity among population is influenced by various socioeconomic factors. Moreover, the body weights among all age groups are increasing in developed countries. An increase in prevalence rate of obesity and allied co-morbidities has been observed among patients suffering from T2DM, CVDs and hypertension.[8] The improvements in blood glucose levels, TGs LDL and HDL are associated with weight loss of approximately 5-10%.[9] The dietary pattern that encourages weight loss would improve MetS criteria.[10] Some dietary practices, like Mediterranean diet and dietary approaches to stop hypertension, are inversely associated with the prevalence of MetS and its co-morbidities.

Intake of some micronutrients has also been correlated with the risks of MetS. The risk factors associated with

type 1 diabetes and CVD, such as hypertension, hyperglycaemia and metabolic diseases, are increased in vitamin D deficiency. Patients with MetS had higher carbohydrate and lower fat intake compared to normal individuals.[11] However, a negative association was found between plant intake and risk of MetS.[12] A diet rich in unsaturated fats (Omega 3) and low in saturated fatty acids (SFAs) has been associated with a reduced risk of developing MetS. The intake of carbohydrates and proteins is observed to be lower than recommended among MetS patients, and these deficiencies explain the increased prevalence of MetS, especially among females.[13]

MetS is negatively associated with sufficient calcium intake, vitamin D status, high intake of fibre, and magnesium intake. Moreover, the patients with MetS have lower serum concentrations of antioxidants.[10,14] The patients with MetS mostly experience deficiency in micronutrient intake, especially vitamin A, C, E, K, calcium, zinc and magnesium.[13] However, the results indicated that majority of the MetS patients failed to meet the requirements of essential nutrients in their diet.

Diversified range of published literature, as cited above, has focussed on nutrient intake along with MetS to identify core reasons behind the syndrome. However, there is limited research on the health benefits related to dietary nutrient patterns; specifically in Saudi Arabia. At the same time, no study has investigated the relationship between MetS and nutrient intake among Saudi women within the Eastern Province of Saudi Arabia. The current study was planned to assess the intake of micro and macro nutrients among Saudi women suffering from MetS.

Patients and Methods

The quantitative case-control study was conducted in November 2015 at King Fahd University Hospital, Al Khobar, Eastern Province, Saudi Arabia, and comprised patients aged 25-65 years who had three or more risk factors associated with metabolic syndrome. Healthy subjects were enrolled as controls. The subjects were recruited from outpatient clinics, while the controls were selected from the healthy individuals accompanying the patients. Written informed consent was obtained from all the subjects. Those who did not volunteer to participate were excluded. Also excluded were patients who were non-Saudi nationals; suffering from disabilities or mental retardation; had medication of cancer, pregnancy, lactation; had ascites or oedema; suffering from end-stage liver or renal diseases; and those undergoing dialysis. Approval was obtained from the Department of Clinical Nutrition, College of Applied Medical Sciences, and University of Dammam, Saudi Arabia. Patients satisfying three or more of the International Diabetes Federation (IDF) criteria[14] were classified as MetS patients. The cut-off criteria includes obesity and waist circumference $\geq$ 80 cm; HDL <1.3 mmol/L (<50mg/dL); TG $\geq$ 1.7mmol/dL (>150 mg/dL) or treated; patients with T2DM; fasting blood glucose (FBS) $\geq$ 5.6 mmol/L (>100 mg/dL); and systolic blood pressure (SBP) $\geq$ 130 and diastolic blood pressure (DBP) $\geq$ 85 or treated for hypertension.

Group I had patients who met three of the six criteria components, Group II had those who met four components, and Group III had those who met more than four components.

Demographic data, including age, marital status, educational level, job status and family size, was collected through questionnaire. Data about medical history (such as cancer, hypertension and diabetes), use of medicines, supplements, and special regimen was also collected.

The ratio of body weight to the square of height (kg/m^2) was used to calculate body mass index (BMI). Waist circumference (WC) was obtained at a horizontal plane midway between the iliac crest and the lower rib margin to the nearest 0.1cm using a non-stretchable measuring tape. An automated sphygmomanometer was used for measuring blood pressure (BP) after enough resting time. Fasting blood samples were collected from each subject to determine FBS, TG, total cholesterol (TC), HDL, and LDL using automated analyzer (Architect c8000; Toshiba Inc., Tokyo, Japan).

The subjects were asked to recall, describe and quantify the foods and drinks consumed over the preceding 24 hours. The obtained data about nutrient intake was analysed by food composition tables for the Arab Gulf countries (Saudi Foods)[24] and compared with standard dietary requirements.

Daily energy requirements (kcal/kg/day) were calculated for each participant (protein as 1g/kg/day; dietary fat as 25% of total energy requirements, carbohydrates by differences (g/day), and fibre as 25 g/day). Moreover, the requirements from minerals and vitamins were calculated, using the dietary reference intakes (DRI)[25] — adequate intakes (AI). Percentages of nutrient intakes were calculated by dividing the actual intake from different nutrients by the nutrients requirements.

Data was statistically analysed and presented as mean± standard deviation (SD). One-way analysis of variance (ANOVA) test was carried out and followed by least

significant difference (LSD) to find out the significant difference among the groups. Chi-square test was used to compare categorical variables between the controls and the patients.

Results

Of the 216 subjects, 134(%) were patients and 82(%) were controls. Among the patients, 20(15%) were in Group I, 34(25%) in Group II and 89(60%) were in Group III. The overall mean age of the sample was 48.8±8.6 years. On all socioeconomic parameters, there was significant difference between the cases and the controls (Table-1).

Anthropometrics measurements, including body weight, BMI, WC, in addition to SBP and DBP of the MetS patients were significantly different from the controls ($p<0.05$ each). Blood glucose concentrations of controls were decreased than MetS patients, but there was a significant difference ($p<0.05$) compared to only groups I and II. Concentrations of lipids, TG and LDL of the controls and group I were significantly decreased compared to the other groups ($p<0.05$). There were no significant differences among the groups in relation to TC ranging from 165.2±30.9 to 185.0±42.2 mg/dL. HDL concentration in the control group was significantly ($p<0.05$) decreased compared to MetS patients ($p<0.05$). None of the patients in any of the three groups had normal body weight compared to 20(24.4%) controls. Morbid obesity (BMI >40kg/m2) was prevalent among 8(40%) patients of group I, 10(29.4%) of group II and 24(30%) of group III patients. Overweight and obesity were common among Saudi females population ($p<0.001$) (Table-2).

Nutrient intakes of the three patient groups were compared among themselves and with the corresponding values of the control group (Table-3).

Table-1: General characteristics of the subjects.

		Control		Case		Chi^2	
		No.	%	No.	%	Value	p-value
Education Level	Illiterate	7	8.5%	40	29.9%	33.3	0.000***
	Elementary	16	19.5%	24	17.9%		
	Preparatory	9	11.0%	24	17.9%		
	Secondary	8	9.8%	20	14.9%		
	Diploma	8	9.8%	10	7.5%		
	Bachelor	33	40.2%	16	11.9%		
	Postgraduate	1	1.2%	0	0.0%		
	Total	82	100.0%	134	100.0%		
Work Status	No work	48	58.5%	98	73.1%	16.4	0.000***
	Retired	2	2.4%	14	10.4%		
	Work	32	39.0%	22	16.4%		
	Total	82	100.0%	134	100.0%		
Marital Status	Single	10	12.2%	8	6.0%	35.2	0.000***
	Widowed	1	1.2%	26	19.4%		
	Divorced	0	0.0%	22	16.4%		
	Married	71	86.6%	78	58.2%		
	Total	82	100.0%	134	100.0%		
Family size	Less than 4 persons	5	6.1%	8	6.0%	8.5	0.037*
	4 to 6 persons	34	41.5%	36	26.9%		
	7 to 9 persons	33	40.2%	54	40.3%		
	More than 9 persons	10	12.2%	36	26.9%		
	Total	82	100.0%	134	100.0%		
Number of MetS criteria	None	82	100.0%	0	0.0%	216	0.000***
	Three MetS criteria	0	0.0%	20	14.9%		
	Four MetS criteria	0	0.0%	34	25.4%		
	+ four MetS criteria	0	0.0%	80	59.7%		
	Total	82	100.0%	134	100.0%		

MetS: Metabolic syndrome.

Table-2: Anthropometric measurements and biochemical indices of MetS patients and control subjects (mean±SD).

	Cases					
	Control (n=82)	Group I (n=18)	Group II (n=34)	Group III (n=80)	ANOVA	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	F	p-value
Weight (kg)	62.7±9.1 a	98.8±21.0 b	94.7±22.1 b	90.3±20.6 b	51.5	0.000***
Height (cm)	156.8±5.3 a	159.9±5.6 a	157.0±6.0 a	155.2±7.7 a	2.2	0.085
BMI (Kg/m^2)	25.4±3.0 a	38.4±6.7 b	38.2±7.1 b	37.4±7.7 b	68.8	0.000***
Waist circum. (cm)	83.2±5.4 a	120.8±13.5 b	119.8±14.5 b	120.0±13.5 b	179.4	0.000***
Systolic BP	116.0±9.3 a	145.1±18.6 b	134.8±16.5 c	142.9±13.8 b	61.8	0.000***
Diastolic BP	70.3±9.4 a	80.5±6.2 b	78.9±9.8 b	80.5±7.1 b	25.7	0.000***
Glucose (mg/dl)	99.8±18.9 a	151.0±69.3b	121.1±27.8 a	172.1±62.1c	8.5	0.000***
TG (mg/dl)	86.4±29.2 a	60.6±6.9 a	114.3±39.4 b	138.4±56.0 b	20.5	0.000***
TC (mg/dl)	183.6±28.0 a	165.2±30.9 a	185.0±42.2 a	172.5±34.4 a	2.1	0.099
HDLc (mg/dl)	70.7±14.2 a	56.0±15.8 b	53.1±13.3 b	49.3±12.6 b	29.5	0.000***
LDLc (mg/dl)	92.9±25.8 a	92.6±24.3 a	114.6±35.9 b	103.7±27.4 b	4.3	0.006**

BMI classification of MetS patients and control subjects (mean±SD)

	Control (n=82)	Group I (n=18)	Group II (n=34)	Group III (n=80)	Chi^2	
	No. (%)	No. (%)	No. (%)	No. (%)	Value	p-value
Normal (18.5 - 25 kg/m^2)	20 (24.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	104	0.000***
Overweight (25 - 30 kg/m^2)	33 (40.2%)	4 (20.0%)	4 (11.8%)	10 (12.5%)		
Obesity grade 2 (30 - 35 kg/m^2)	29 (35.4%)	2 (10.0%)	8 (23.5%)	26 (32.5%)		
Obesity grade 3 (35 - 40 kg/m^2)	0 (0.0%)	6 (30.0%)	12 (35.3%)	20 (25.0%)		
Morbid obesity (>40 kg/m^2)	0 (0.0%)	8 (40.0%)	10 (29.4%)	24 (30.0%)		
Total	82 (100.0%)	20 (100.0%)	34 (100.0%)	80 (100.0%)		

Group I = three MetS criteria, Group II = four MetS criteria, and Group III = + four MetS criteria.
*P<0.05, ** P<0.01, and *** P<0.001
Mean values subscripted with different letters in the same row showed significant differences at P<0.05 between these values as shown by ANOVA and LSD
MetS: Metabolic syndrome. ANOVA: Analysis of variance. SD: Standard deviation. BMI: Body mass index.
BP: Blood pressure. TG: Triclycerides. TC: HDLc: Total cholesterol. HDLc: High-density lipoprotein cholesterol
LDLc: Low-density lipoprotein cholesterol. LSD: Least significant difference.

Table-3: Nutrient intakes of MetS patients and control subjects (mean±SD).

	Control (n=82)	Cases			ANOVA	
Nutrients		Group I (n=18)	Group II (n=34)	Group III (n=80)	F-value	Sig
Energy (Kcal/day)	2053.8±532.4 (97.9%) a	2219.3±528.0 (99.5%) a	1561.3±465.2 (71.4%) b	1648.5±538.7 (79.2%) b	11.8	0.000***
Protein (g/day)	68.6±20.8 (111.4%) a	98.1±31.1 (94.2%) b	72.1±25.3 (71.3%) a	73.3±25.5 (73.5%) a	7.3	0.000***
Fat (g/day)	52.6±16.5 (99.2%) a	74.8±32.4 (131.6%) b	46.3±16.1 (81.5%) a	51.1±25.0 (107.0%) a	7.4	0.000***
Carbs. (g/day)	326.6±95.5 (96.0%) a	288.5±67.0 (91.6%) a	214.0±82.7 (67.6%) b	223.9±91.1 (73.0%) b	16.2	0.000***
Fiber (g/day)	9.4±3.9 (37.7%) a	14.1±8.0 (56.2%) b	12.2±7.7 (48.6%) ab	13.8±11.3 (55.2%) b	4.3	0.006**
Vitamin C (mg/day)	103.8±13.0 (152.1%) a	119.7±43.9 (159.6%)b	85.3±42.1 (113.8%) c	71.9±42.1 (95.8%) c	32.7	0.000***
Vitamin A (mcg/day)	240.7±135.6 (41.3%) a	300.8±101.4 (43.0%) a	194.1±95.9 (27.7%) c	200.6±132.9 (28.7%) c	4.2	0.006**
Iron (mg/day)	16.9±8.9 (167.4%) a	22.5±10.5 (170.0%) b	18.1±8.3 (165.8%) ab	16.3±9.9 (174.1%) a	2.3	0.082
Calcium (mg/day)	708.8±207.6 (79.2.%) a	715.7±197.7 (67.4%) b	571.6±185.8 (52.0%) a	565.4±203.4 (49.0%) a	3.4	0.018*
Phosphors (mg/day)	1078.3±294.3 (172.2%) a	1271.2±288.3 (181.6%) b	1007.6±345.2 (143.9%) a	1031.5±332.1 (147.4%) a	3.3	0.022*
%Kcal from protein	13.4±3.7 a	17.7±3.4 b	18.7±5.4 b	18.2±4.3 b	16.6	0.000***
%Kcal from fat	23.0±4.8 a	29.4±7.6 b	27.2±6.9 b	28.0±9.0 b	5.5	0.001***
%Kcal from carbs	63.6±6.1 a	52.9±10.2 b	54.1±9.7 b	53.8±10.4 b	14.2	0.000***

Group I = three MetS criteria, Group II = four MetS criteria, and Group III =+ four MetS criteria. *P<0.05, ** P<0.01, and *** P<0.001.
Mean values subscripted with different letters in the same row showed significant differences at P<0.05 between these values as shown by ANOVA and LSD.
MetS: Metabolic syndrome. ANOVA: Analysis of variance. SD: Standard deviation. Carbs: Carobohydrates. Kcal: Kilocalories. LSD: Least significant difference.

Table-4: Distribution of MetS patients and control subjects according to percentage of nutrients intakes.

Nutrient	Quartiles	Control group (n=82)	Cases			Chi^2	
			Group I (n=18)	Group II (n=34)	Group III (n=80)	Value	p-value
Energy	Q I			6 (17.6%)	12 (15.0%)	28.0	0.001***
	Q II	20 (24.4%)	4 (22.2%)	14 (41.2%)	26 (32.5%)		
	Q III	30 (36.6%)	6 (33.3%)	10 (29.4%)	24 (30.0%)		
	Q IV	32 (39.0%)	8 (44.4%)	4 (11.8%)	18 (22.5%)		
Protein	Q I		2 (11.1%)	10 (29.4%)	22 (27.5%)	61.5	0.000***
	Q II	16 (19.5%)	6 (33.3%)	12 (35.3%)	32 (40.0%)		
	Q III	28 (34.1%)		8 (23.5%)	6 (7.5%)		
	Q IV	38 (46.3%)	10 (55.6%)	4 (11.8%)	20 (25.0%)		
Fat	Q I			4 (11.8%)	4 (5.0%)	24.6	0.003**
	Q II	21 (25.6%)	2 (11.1%)	14 (41.2%)	32 (40.0%)		
	Q III	29 (35.4%)	6 (33.3%)	8 (23.5%)	14 (17.5%)		
	Q IV	32 (39.0%)	10 (55.6%)	8 (23.5%)	30 (37.5%)		
Carbohydrates	Q I			10 (29.4%)	22 (27.5%)	37.2	0.000***
	Q II	23 (28.1%)	6 (33.3%)	10 (29.4%)	28 (35.0%)		
	Q III	33 (40.2%)	4 (22.2%)	10 (29.4%)	14 (17.5%)		
	Q IV	26 (31.7%)	8 (44.4%)	4 (11.8%)	16 (20.0%)		
Fiber	Q I	66 (80.5%)	8 (44.4%)	22 (64.7%)	28 (65.0%)	28.7	0.001***
	Q II	16 (19.5%)	5 (27.8%)	6 (17.6%)	14 (17.5%)		
	Q III		2 (11.1%)		2 (2.5%)		
	Q IV		4 (22.2%)	6 (17.6%)	12 (15.0%)		
Vitamin C	Q I			6 (17.6%)	22 (27.5%)	66.9	0.000***
	Q II			6 (17.6%)	8 (10.0%)		
	Q III	56 (68.3%)	6 (33.3%)	4 (11.8%)	20 (25.0%)		
	Q IV	26 (31.8%)	12 (66.7%)	18 (52.9%)	30 (37.5%)		
Vitamin A	Q I	49 (59.8%)	12 (66.7%)	32 (94.1%)	62 (77.5%)	23.0	0.001***
	Q II	27 (32.9%)	6 (33.3%)		18 (22.5%)		
	Q III	6 (7.3%)		2 (5.9%)			
	Q IV						
Iron	Q I	10 (12.2%)		4 (11.8%)	2 (2.5%)	21.6	0.01**
	Q II	4 (4.9%)	2 (11.1%)		6 (7.5%)		
	Q III	13 (15.9%)	2 (11.1%)	2 (5.9%)	2 (2.5%)		
	Q IV	55 (67.1%)	14 (77.8%)	28 (82.4%)	70 (87.5%)		
Calcium	Q I	24 (29.3%)	5 (27.8%)	14 (41.2%)	52 (65.0%)	27.6	0.000***
	Q II	30 (36.6%)	6 (33.3%)	16 (47.1%)	16 (20.0%)		
	Q III	28 (34.1%)	7 (38.9%)	4 (11.8%)	12 (15.0%)		
	Q IV						
Phosphors	Q I					26.0	0.000***
	Q II						
	Q III			8 (23.5%)	18 (22.5%)		
	Q IV	82(100.0%)	18(100.0%)	26 (76.5%)	62 (77.5%)		

QI =Quartile I (less than 50% of standard requirements)
QII = Quartile II (50% to 75%of standard requirements)
QIII = Quartile III (75% to 100%of standard requirements)
QIV = Quartile IV (More than 100% of standard requirements)
*P<0.05, ** P<0.01, and *** P<0.001.

It was also calculated if the cases and the controls were able to satisfy their body requirements with the intake they reprited (Table-4).

Discussion

Different surveys from various countries have depicted that majority of MetS patients are illiterate or have low educational level.[15-18] Low socioeconomic status is one of the important factors that may help trigger occurrence of MetS among adult Saudi females.[18] About 60% of MetS patients in our study were having more than four MetS criteria, among which obesity was the most common. The findings showed that obesity, prevalent among MetS patients was very high; and none of the respondents had

normal body weight. More than 80% of the patients had grade II obesity or higher BMI (BMI >30kg/m^2) compared to 35.4% respondents in the control group. Moreover, MetS patients had increased blood concentrations of glucose, cholesterol, TGs, and LDL, and decreased HDL concentrations.

Obesity, more specifically abdominal obesity, is the main risk factor for MetS among females in Saudi Arabia.[15] Obesity was prevalent among approximately 44% of females, 26.4% of males, and one-fifth of Saudi children.[13,19,20] Such high prevalence of obesity and its correlation with MetS explained increased occurrence of MetS among Saudi population.[12] However, higher rate of obesity among children may increase the risk of developing MetS in the future, which could further increase the burden of the problem.

Recent studies carried out in Saudi Arabia on MetS patients and their dietary patterns revealed that both controls and MetS patients had an evident deficiency in intakes of vitamin A, fibre, and calcium.[13,18] Moreover, a few studies revealed that MetS patients had a marked deficiency in the intakes of calcium, which is consistent with results of the present study.[13,18,21] The consumption of adequate amounts of dietary calcium and dairy products reduced body weight and prevented obesity that can lead to the development of MetS.[21-23] Therefore, calcium deficiency has been considered a risk factor for MetS among Saudi females. In several regions of Saudi Arabia, calcium intakes were found at lower levels than required. The deficiency among the control group is related to low consumption of milk and dairy products during the preceding few years.[21] However, a study also revealed that dairy consumption in Asia is much lower compared to the Western countries.[21]

The overall intake of energy, protein and carbohydrates by the patients with four or more MetS criteria were decreased than 80% of the standard values. About 50% of MetS patients with four or more of MetS criteria failed to satisfy 75% of their needs from energy, protein, and carbohydrates. Moreover, the percentage of energy intakes, yielded from protein, fats, and carbohydrates by MetS patients, were not significant with normal ranges, especially for protein (range: 17.7-18.7%) and carbohydrates (range: 52.9-54.1%). Similar findings were reported by a study conducted on adult Saudi females from Qassim region.[18]

As MetS patients tried to lose excess body weight by following special dietary regimen (i.e. consumed low calorie diet), the intakes of energy-providing nutrients were significantly decreased than the required values. Some patients increased their intakes from protein as they believed that high consumption of protein can promote weight loss among MetS patients.

A study also revealed that the risk for MetS across quartiles of dietary nutrients, including vitamins A, C, E and K, calcium, zinc, and magnesium ($p<0.05$) were significantly decreased among Saudi females suffering from MetS.[13] The higher prevalence of obesity among Saudi females is associated with sedentary behaviour, physical inactivity, and unhealthy dietary habits. The higher rate of sedentary behaviours, unhealthy dietary, and physical inactivity among adolescents is a main public health issue. However, the existence of MetS with micro-nutrients deficiency suggested increased burden of the disease that is more prevalent among the less-developed countries.

The current study reviewed the current situation and exammed the nutrition-related development of MetS and risk factors associated with the disease in Saudi Arabia. The study suggests that there is an urgent need to promote healthy eating and physical activity practices, due to increased prevalence of obesity among Saudi females. An appropriate intake of vegetables, fruits and dairy products may help to decrease the risk of developing MetS. Moreover, the increased prevalence of MetS highlights the importance of regular screening and intervention programmes for reducing weight among Saudi women. National representative surveys at community level are also needed to be conducted for the determination of importance of various factors contributing to MetS.

There were some limitations of the study, especially in the estimation of nutrient intakes. As 24-hour recall relied on memory, some foods may have been missed out or not reported. Also, Saudi food composition tables were insufficient and not all consumed foods were available in the tables. Besides, the sample size may be not enough to draw a strong association. Finally, the major confounders, like age, gender, nationality and lifestyle, were adjusted but the socioeconomic confounders could not be adjusted. However, the findings are considered good enough to help in understanding the nutritional status of MetS patients.

Conclusion

The most common criterion among MetS patients was obesity, especially abdominal obesity. Both the controls and the patients experienced an evident deficiency in the intakes of vitamin A, fibre and calcium. The intakes of energy, total protein and carbohydrates by patients who had four or more MetS criteria were lower than 80% for

energy and lower than 75% for other nutrients. The percentage of energy yielded from protein, fats and carbohydrates by MetS patients were not significant with normal ranges of these nutrients.

Acknowledgement: We are grateful to everyone who contributed to the study in any manner.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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