INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

PREVALENCE OF METABOLIC SYNDROME AMONG TYPE 2 DIABETIC PATIENTS IN JEDDAH, SAUDI ARABIA

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ABSTRACT
The diabetes and related metabolic and cardiovascular disorders are highly prevalent in the Arabian Gulf countries. Type 2 diabetes mellitus (T2 DM) is a complex disorder and metabolic syndrome (MetS) in combination with diabetes leads to increased risk of microvascular and macrovascular complications due to associated dyslipidemia, hypertension and obesity. The present study aimed to assess the metabolic syndrome in type 2 diabetes and compare them with two used methods of diagnostic criteria in Jeddah, Saudi Arabia. Fasting blood samples of 135 diabetic patients (70 males and 65 females) attending King Abdulaziz University health clinic were collected with informed consent. The lipid profile, blood pressure and anthropometric parameters were assessed using standardized techniques. The metabolic syndrome was determined according to ATP III and IDF definitions. According to both criteria, the frequency of MetS was 74.81% and 75.55%, respectively. The prevalence of MetS was significantly higher in females as compared to males. Females were more affected, males with MetS were older, and females were significantly more obese. According to ATP III, the mean triglycerides, body mass index, systolic blood pressure and diastolic blood pressure were significantly higher in subjects with MetS than subjects without MetS. According to IDF, the mean triglycerides, body mass index, males' waist circumference were significantly higher in subjects with MetS than subjects without MetS. According to ATP III, the prevalence of MetS was more in females (84.61%) than in males (65.71%). According to IDF, the prevalence of MetS in females was 89.23%, whereas in males the prevalence was 62.86%. In both males and females, central obesity (80.00% female, 64.28% male) and high density lipoprotein (78.46% female, 62.85% male) followed by hypertriglyceridemia (TG) (58.57% female, 53.85% male) were the driving forces for metabolic syndrome. The most significant predictor of MetS in type 2 diabetic patients in Jeddah is central obesity. Metabolic syndrome is significantly high among Saudi diabetic patients with female preponderance. It is very important to diagnose it early to halt the burden of cardiovascular complications in type 2 diabetic patients. This health problem is to be tackled with proven strategies.

KEYWORDS: Type 2 diabetes mellitus, Metabolic syndrome, Obesity, Prevalence, Saudi Arabia.

INTRODUCTION

Obesity, T2 DM and related metabolic and cardiovascular diseases are highly prevalent in the Gulf Cooperative Council (GCC) countries. The socio-economic development which followed the discovery of oil resources brought about considerable changes in the food habits and lifestyle of the Saudi population. Excessive caloric intake and decrease energy expenditure due to sedentary lifestyle have led to a rapid increase in obesity, diabetes and other non-communicable chronic diseases in the population. Obesity is fast turning out to be a major cause of concern for the Kingdom with seven out of 10 Saudis suffering from obesity, and 37 percent of Saudi women facing problems related to overweight. Overweight and obesity affect more than 75% of the total population in Saudi Arabia. Almost all age groups are affected in general and adults particularly [1]. Individuals with overall and/or abdominal obesity have an increased risk of developing metabolic disorders such as metabolic syndrome (MetS). Studies from around the world, the Arabian Gulf and Saudi Arabia in particular, where the nutrition transition has been particularly rapid and dramatic show that obesity is increasing both in prevalence and also severity [1- 4]. Worldwide, obesity has been shown to pose a major risk for a variety of debilitating and life-threatening chronic conditions, including cardiovascular disease (CVD), type 2 diabetes mellitus (T2 DM), hypertension and stroke, gall bladder disease, osteoarthritis and certain cancers [5]. Already in Saudi Arabia, T2 DM is reported to be a growing public health concern. The prevalence of DM among adults in Saudi Arabia is 30% and that figure is expected to be more than double by 2030. Half of the people over 30 years of age are prone to diabetes. Saudi Arabia ranks seventh worldwide and the first in the Gulf in terms of diabetes rates. The emergence of T2 DM in Saudi Arabia, coinciding with the country's rapid financial growth in the past several decades, is often considered as a modern epidemic resulting from westernization [6-8].

"Obesity epidemic" is considered by the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) as mainly responsible for the increasing

prevalence of MetS. Obesity has been strongly associated with insulin resistance, T2 DM, and the MetS and higher CVD risk. Since there is a strong connection between abdominal obesity and metabolic risk factors, ATP III defined the MetS as a clustering of metabolic complications of obesity [5, 9-11].

Metabolic syndrome (MetS) is an important public health problem worldwide, and its prevalence is increasing. The major risk factors for developing MetS are physical inactivity and a diet high in fats and carbohydrates, contributing to the two central clinical features, *i.e*. central obesity and insulin resistance. Obesity is fundamental to MetS as it appears to precede the emergence of the other MetS risk factors[12]. Metabolic syndrome is a concept rather than a disease in itself. MetS is a constellation of metabolic abnormalities that confer an increased risk of cardiovascular diseases and type 2 diabetes mellitus (T2 DM). The major features of this syndrome are insulin resistance, central obesity, hypertension, and dyslipidemia[13]. It is estimated that approximately 20-25% of the world's adult population have MetS and they have 2-3 times higher risk of heart attack or stroke, 5-fold greater risk of developing T2 DM, 3-4 fold likelihood of myocardial infraction in their lifetime and collection of metabolic abnormalities in diabetic patients is associated with development of additional cardiovascular disease risk factors[14-18]. In fact, cardiovascular complications are the most common cause of morbidity and mortality in patients with T2 DM. The presence of MetS in T2 DM has been shown to decrease the survival rate at least by 10 years [19].

Type 2 diabetes and metabolic syndrome are both heterogeneous and complex conditions due to the interaction between environmental and genetical factors and in the population with T2 DM, nearly 70-80% are diagnosed with MetS[20,21]. This is much higher prevalence than in comparable general populations[13,22-25]. The relationship between MetS and diabetes and cardiovascular disease is well established and consistent and has been examined in many different populations. T2 DM and cardiovascular disease have many risk factors in common, and many of these risk factors are highly correlated with one another. The higher prevalence of MetS in patients with T2 DM may be explained by medication-, disease-, and lifestyle-related factors. Individuals with obesity have an increased risk of having components of MetS. Most of the studies have looked into the metabolic syndrome prevalence in general population. Limited information is available about the prevalence of MetS in patients with T2DM [21, 26-29] but there is complete paucity of such studies in the population of Jeddah. Therefore, the present study aimed to assess the metabolic syndrome in type 2 diabetic patients and compare them using two of the most widely used methods of diagnostic criteria (ATP III and IDF) in Jeddah, Saudi Arabia.

MATERIALS & METHODS

This cross-sectional study involved 135 adult patients with T2 DM attending King Abdulaziz University health clinic, Jeddah in Saudi Arabia. There were 70 males and 65 females. Informed consent was obtained from the participants after explaining the procedure and the objectives of the study and complete confidentiality of the collected data was ensured to them. The study protocol was reviewed and approved by the Institutional Ethical Committee. Data were collected by trained interviewers. The exclusion criterion was the coexistence of any other serious illness. T2 DM was defined as non-ketosis diabetes by medical history and current treatment with oral agent. None of the patients had microvascular complications (nephropathy or retinopathy). Administration of insulin for glycemic control was considered an exclusion criterion. Anthropometric measurements including weight, height and waist circumference were obtained using standardized techniques. BMI ≥30 kg/m^2 were defined as obese according to WHO criteria[30]. The blood pressure (BP) was recorded, in the sitting position, in the right arm to the nearest 2 mmHg using the mercury sphygmomanometer (Riester, Germany). Two readings were taken, five minutes apart, and their mean was taken as the blood pressure. Hypertension was defined as blood pressure ≥ 140/80 mmHg. A venous blood samples was collected from all subjects who came to the health service center after an overnight fasting of 8-12 hours. Serum was separated by centrifugation at 3000 rpm for15 minutes. The sera were analyzed for fasting blood sugar, triglycerides (TG) and high density lipoprotein cholesterol (HDL-c) using an auto-analyzer (Roche Modular P-800, Germany) in those who had type 2 diabetes.

Type 2 diabetic subjects were considered to have metabolic symbol if they had any two of the following four criteria, according to the modified ATP III (Adult treatment Panel III) [31]:

Abdominal Obesity: waist circumference (WC) ≥ 102 cm in males and ≥ 88 cm in females.

Hypertriglyceridemia: serum triglycerides level ≥ 150 mg/dl or on treatment.

Low HDL-cholesterol (HDL-c): < 40 mg/dl in males and < 50 mg/dl in females or treatment.

High Blood Pressure (BP**):** SBP ≥ 130 mmHg and/or DBP ≥ 85 mmHg or on treatment for hypertension.

According to other criteria (IDF) (International Diabetes Federation [32], metabolic syndrome was diagnosed if type 2 diabetic subjects had waist circumference (WC) ≥ 94 cm in males and ≥ 80 cm in females and at least one of the following three criteria was present:

Hypertriglyceridemia: Serum triglycerides level ≥ 150 mg/dl.

Low HDL-cholesterol (HDL-c): < 40 mg/dl in males and < 50 mg/dl in females.

High Blood Pressure (BP**):** SBP ≥ 130 mmHg and/or DBP ≥ 85 mmHg or on treatment for hypertension.

Values above the cut-off points for each parameter were regarded as abnormal. The results were expressed as mean ± standard deviation (SD). The statistical analyses were performed using SPSS-11.5 version software. Differences between groups were tested statistically using the Chi-squared test and the independent-sample 't' test. Data were considered statistically significant when the p-value was < 0.05.

RESULTS

In this study, a total of 135 type 2 diabetes patients were studied. Table 1 shows the baseline data of the total, male and female subjects. The mean age of patients was 54.32

±11.43 years, consisting of 70 (51.85%) males and 65 (48.15%) females. The mean duration of diabetes was 9.92 ±5.78 years. Of all patients, 57.77% were obese and obesity was significantly more frequent among females (p <0.05). Mean BMI was 31.25 ±5.89 kg/m^2. The mean waist circumference was 98.15 ±9.67 cm and 99.87 ±10.52 cm in male and female subjects, respectively.

TABLE 1. Clinical characteristics of subjects with type 2 diabetes (Total, Male and Female subjects)

Variables	Total number of subjects	Males	Females	p-value between genders
Number of patients (%)	135 (100%)	70 (51.85%)	65 (48.15%)	
Age (years)	54.32±11.43	56.45±12.51	52.99±10.89	>0.05
Duration of diabetes (years)	9.92±5.78	10.32±6.62	10.06±6.01	>0.05
Obesity	57.77%	47.14%	69.23%	<0.05
BMI (kg/m^2)	31.21±5.89	29.22±5.35	33.05±6.53	<0.05
Waist Circumference, WC (cm)	98.86±10.07	98.15±9.67	99.87±10.52	>0.05
Abnormal WC (cm)	71.85%	64.28%	80.00%	<0.05
HDL-c (mg/dl)	40.61±10.32	39.43±9.26	42.12±11.12	<0.05
Abnormal HDL-c (mg/dl)	70.37%	62.85%	78.46%	<0.05
Triglyceride, TG (mg/dl)	180.43±83.16	179.04±81.08	182.29±86.52	>0.05
Abnormal TG (mg/dl)	56.29%	53.85%	58.57%	>0.05
Systolic blood pressure (mmHg)	131.07±17.32	133.58±16.82	129.27±17.18	<0.05
Diastolic blood pressure (mmHg)	81.87±8.98	82.61±9.11	81.30±8.76	>0.05
Abnormal blood pressure (mmHg)	47.78%	53.57%	41.54%	>0.05
Hypertension (mmHg)	42.22%	47.14%	36.92%	>0.05
Metabolic syndrome according to ATP III criteria: n/n (%)	101/135 (74.81%)	46/70 (65.71%)	55/65 (84.61%)	<0.05
Metabolic syndrome according to IDF criteria: n/n (%)	102/135 (75.55%)	44/70 (62.86%)	58/65 (89.23%)	<0.05

64.28% and 80.00% subjects had abnormal waist circumference for males and females, respectively. There was no significant difference between males and females regarding WC and TG, but HDL-c was higher in females (p <0.05) and Systolic blood pressure (p <0.05) and Diastolic blood pressure were higher in males. The prevalence of hypertension (HTN) among the study group was 42.22%. In all patients, the frequency of MetS was 74.81% according to ATP III and 75.55% according to IDF criteria, and females were significantly more affected according to two criteria. Table 2 shows comparison of clinical data among type 2 diabetic patients with and without metabolic syndrome according to ATP III and IDF diagnostic criteria. According to ATP III, the mean HDL-c was lower in males (39.23 ±8.98 mg/dl) and females (40.53±10.31 mg/dl) with metabolic syndrome than subjects without metabolic syndrome (males: 40.33 ±10.08 mg/dl and females: 51.09 ±10.56 mg/dl, (p <0.05), respectively). According to ATP III, the mean TG, BMI, systolic blood pressure and diastolic blood pressure were significantly higher in subjects with metabolic syndrome (199.89 ±87.76 mg/dl, 32.87 ±6.23 kg/m^2, 133.26 ±20.06 mmHg (p<0.05) and 83.67±9.47 mmHg) than subjects without metabolic syndrome (122.64 ±30.06 mg/dl, 29.46 ±5.11kg/m^2, 126.07±17.16 mmHg, and 80.56 ±10.16 mmHg, respectively). According to IDF, the mean TG, BMI and males WC were significantly higher in subjects with metabolic syndrome (191.48±85.41 mg/dl, 31.91 ±6.10 km/m^2 and 104.92 ±8.03 cm (p<0.05) than subjects without metabolic syndrome (146.38 ±68.76 mg/dl, 29.51 ±5.61 kg/m^2 and 90.11 ±8.53 cm, respectively).

TABLE 2. Comparison of clinical data among type 2 diabetic patients with and without metabolic syndrome according to ATP III and IDF criteria

Parameters	Metabolic syndrome according to ATP III criteria		Metabolic syndrome according to IDF criteria	
	With MetS	Without MetS	With MetS	Without MetS
Males Waist Circumference (cm)	99.98 ± 9.06	94.06 ± 8.67	104.92 ± 8.03	90.11 ± 8.53*
Females Waist Circumference (cm)	101.72 ± 10.23	93.47 ± 9.88	100.42 ± 10.06	93.16 ± 10.98
Triglycerides, TG (mg/dl)	199.89 ± 87.76	122.64 ± 30.16*	191.48 ± 85.41	146.38 ± 68.76*
Males HDL-c (mg/dl)	39.23 ± 8.98	40.33 ± 10.08	40.12 ± 9.91	39.83 ± 8.91
Females HDL-c (mg/dl)	40.53 ± 10.31	51.09 ± 10.56*	40.08 ± 11.12	42.26 ± 10.96*
BMI (kg/m^2)	32.87 ± 6.23	29.46 ± 5.11*	31.91 ± 6.10	29.51 ± 5.61*
Systolic blood pressure (mmHg)	133.26 ± 20.06	126.07 ± 17.16*	132.76 ± 18.42	126.94 ± 17.68
Diastolic blood pressure (mmHg)	83.67 ± 9.47	80.56 ± 10.16*	82.41 ± 9.38	79.53 ± 8.78

*p value less than 0.05 was considered significant

Table 3 shows comparison of clinical data among males and females type 2 diabetic patients with metabolic syndrome according to ATP III and IDF criteria. According to ATP III and IDF diagnostic criteria, there were significant differences in type 2 diabetic patient's BMI, obesity and systolic blood pressure among males and females with metabolic syndrome.

TABLE 3.Comparison of clinical data among males and females type 2 diabetic patients with metabolic syndrome according to ATP III and IDF criteria

Parameters	Metabolic syndrome according to ATP III criteria		Metabolic syndrome according to IDF criteria	
	Males	Females	Males	Females
Number	46	55	44	58
Age (years)	54.63 ± 10.92	53.21 ± 9.74	54.89 ± 10.45	52.97 ± 9.78
Duration	10.67 ± 6.74	10.21 ± 6.19	10.52 ± 6.63	10.33 ± 5.98
Waist circumference (cm)	99.47 ± 10.28	100.86 ± 11.76	98.97 ± 10.09	100.49 ± 11.01
BMI (kg/m^2)	29.68 ± 5.62	33.31 ± 6.72*	29.96 ± 5.74	33.74 ± 6.87*
Obesity	48.36%	70.52%*	48.78%	70.94%*
Triglycerides, TG (mg/dl)	183.20 ± 86.76	185.97 ± 94.21	190.47 ± 90.72	184.92 ± 93.70
HDL-c (mg/dl)	39.24 ± 9.37	42.61 ± 10.94*	39.01 ± 9.76	42.69 ± 10.89
Systolic blood pressure (mmHg)	133.99 ± 17.20	128.14 ± 18.52*	132.81 ± 18.14	129.01 ± 20.06*
Diastolic blood pressure (mmHg)	83.66 ± 9.56	82.02 ± 10.10	82.51 ± 9.70	82.03 ± 10.21

* p value less than 0.05 was considered significant

Table 4 shows a comparison of the prevalence of metabolic syndrome among type 2 diabetics in different countries of the world. In this region of Saudi Arabia, the prevalence of MetS in patients with T2 DM is among the highest in the world.

TABLE 4. Comparison of prevalence of metabolic syndrome among type 2 diabetes in different countries

Study (ref)	Country	MetS according to ATP III criteria	MetS according to IDF criteria
Present Study	Saudi Arabia	74.8%	75.5%
Tan, M.C. et al. (38)	Malaysia	96.1%	84.8%
Alshkri, M.M. et al. (27)	Libya	92.0%	80.8%
Imam, S.K. et al. (39)	Pakistan	79.7%	68.1%
Marjani, A. et al. (26)	Iran	75.4%	76.8%
Pokharel, D.R. (33)	Nepal	73.9%	66.8%
Nahar, S. et al. (34)	Bangladesh	73.5%	61.0%
Lin, S.X. et al. (37)	USA	70.0%	/
Monami, M. et al. (35)	Italy	68.4%	73.7%
Biadgo, B. et al. (41)	Ethiopia	66.7%	53.5%
Lu, B. et al. (42)	China	55.7%	50.0%

DISCUSSION

Metabolic syndrome has been on the rise, contributing to the increasing prevalence of non-communicable disorders such as cardiovascular diseases and type 2 diabetes mellitus, as well as increased mortality from CVD. But there are few studies that have reported the prevalence of metabolic syndrome in diabetes population. In this study, attempt has been made to study the prevalence of metabolic syndrome risk factors in diabetes population of Jeddah, Saudi Arabia. It may be essential for healthcare service to establish the prevalence of MetS in all cities of Saudi Arabia. MetS is a cluster of the most dangerous heart attack risk factors: diabetes, and raised fasting plasma glucose, abdominal obesity, elevated TG, low HDL-c and high blood pressure. The overall prevalence of MetS in this study was 74.8% in ATP III whereas 75.5% in the IDF criteria. Previous studies also pointed out similar prevalence among T2 DM population in Nepal, Bangladesh, Iran and Italy [26,33-35]. Conversely, higher rate of MetS than the finding of this study was reported among DM patients 70-80% [20], 76% in Abbottabad (Pakistan) [36] and 70% in USA [37] according to ATP III. Other previous studies also reported higher prevalence of MetS in Malaysia (96.1%, (84.8%) [38], Libya (92%), (80.8%) [27] and Karachi (Pakistan) (79.7%), (68.1%) [39] among T2 DM patients according to ATP III and IDF definitions, respectively. Lower prevalence of MetS was reported in T2 DM patients in Bosnia and Herzegovina (47.91%) using NCEP ATP III [40], in Ethiopia (66.7%), (53.5%) [41] and in China (55.7%), (50%) [42] using ATP III and IDF criteria respectively. These differences in the prevalence of MetS can be explained by the interaction of genetic and environmental factors, rapid urbanization and the adoption of unhealthy lifestyle which predispose individuals to different risk factors of MetS [43].

The important findings of this study according to ATP III and IDF criteria, were the higher prevalence of metabolic syndrome among females (84.61% and 89.23%, respectively) when compared with males (65.71% and 62.86%, respectively) and the prevalence of metabolic syndrome in Jeddah is appreciably higher compared with that in some other countries. Our results are in agreement with the other studies [21,26-28,33,34,44-46] that the prevalence of MetS in females type 2 diabetic patients is higher than males. The high prevalence of the MetS found among women in the present study could be due to the fact that a significant proportion of women had abdominal obesity which is one of the components of the MetS according to ATP III and IDF criteria used in the study. In this study, the most difference seen between two genders was the prevalence of abnormal waist circumference (64.28% in males versus 80.00% in females). The prevalence of abnormal low HDL-c was also significantly higher in females (78.46%) than that of males (62.85%). These two parameters have mainly contributed to overall higher prevalence of MetS seen in females. Similar findings have also noted in some other studies carried out in this group of patients [26,27,34,47,48]. In our study, WC and low HDL

cholesterol were the most prevalent risk factors in males and females. The most significant predictor of MetS in type 2 diabetic patients in Jeddah is central obesity. The epidemic of MetS did not happen suddenly and it cannot be controlled quickly, but if there is a societal will, it can be done. As in the control of other epidemics, education of the population about the health hazard of the MetS will be very important. Since MetS is a complex medical diagnosis requiring blood tests, simple anthropometric definition that can be easily used and accepted by populace is necessary. While exact measure to be taken can be debated, promoting the danger of increase in abdominal girth or waist/hip ratio can be a starting point. A slogan like, if your belt size increases by a notch, danger is lurking inside the belly can be promoted. Or "sweets are for weak-lings, hot peppers are for machos". But knowledge of special diet and use of different herbs/functional foods can only go so far. To really stop and control the epidemic of MetS, a societal/ governmental/ global approach is urgently needed. The features of MetS continue to be present in many subjects with diabetes despite treatment for elevated glucose levels and other cardiovascular risk factors. This emphasizes the need for an aggressive multifactorial intervention in the management of cardiovascular risk in subjects with T2 DM [49].

There are several studies reporting prevalence of the MetS in the T2 DM population more than double the prevalence in the general population[50-54]. In a cross-sectional community- based study consisting of a total of 2,850 Saudi adults aged 18-55 years, it was reported by Al-Daghri *et al*.[55] that the over-all prevalence of MetS was 35.3% (CI 33.5-37.01), while an age adjusted prevalence was almost 37.0%. The present study revealed that the prevalence of MetS was almost the same (75%) among Saudi type 2 diabetic patients according to ATP III and IDF diagnostic criteria.

The results of this study revealed that the prevalence of MetS in this area of Saudi Arabia is among the highest in the world (Table 4). In view of the small sample size, larger studies would be needed to confirm this finding. This high frequency could be due to both genetic predisposition and environmental factors, such as high caloric diet and lack of exercise.

Females were more affected than males. This may be due to the specific characteristics in the lifestyle changes between females and males diabetic patients among Jeddah inhabitants. Females type 2 diabetic patients are less educated in comparison with the male diabetic patients. The majority of females with MetS were householders. It seems that they do less physical activity (PA) at home. In Saudi Arabia, females in general do less physical activity and overweight and obesity were more perceived between them. It appears that the female type 2 diabetic patients need to change their lifestyle in this area to halt the burden of cardiovascular complications in type 2 diabetic patients.

Due to westernization of the Saudi Arabian diet, the increased intake of high levels of fat, free sugars, sodium and cholesterol have become much more common in the daily dietary pattern [56,57]. In addition to the consumption of high-calorie traditional food (*e.g*. dates), excessive consumption of high calorie and fat based diets (*e.g*. fast food) is very common in Saudi Arabia[58]. Some clinical studies from Saudi Arabia, it is reported that not only the Saudi patients have poor knowledge of diabetes, but the physicians at primary care centers also have suboptimal awareness of proper diabetes management[59,60]. 66% of Saudi adult men and 71% of adult women are either overweight or obese in Saudi Arabia[2]. The prevalence of physical inactivity at less than the levels recommended for enhancing health is high in both developing (from 17 to 91%) and developed countries (from 4 to 84%)[61]. In Saudi Arabia, inactivity prevalence was very high (96.1%) and women were more inactive than men (98.1% vs. 93.9%)[62]. It reveals that the majority of men and women in Saudi Arabia did not reach the recommended physical activity (PA) levels necessary for promoting health and preventing disease [62]. Al-Nozha *et al*. [62] reported a lower level of leisure time PA among Saudis (6.1% in men and 1.9% in women).

The high prevalence physical inactivity in Saudi Arabia is a growing challenge to public health. The study by Al-Hazzaa[63] showed a prevalence of physical inactivity levels that ranged between 43% and 99% among Saudi children and adults alike. Another study conducted by Khalaf *et al*. [64] consisting of 663 female university students (mean age, 20.4 ±1.5 years) showed a high prevalence of students not meeting the WHO recommendations [65] for PA at a vigorous intensity level (85%). It is important to establish good health knowledge and attitudes toward overweight and obesity because it is associated with and considered to be an important risk factor for several chronic conditions, including MetS, diabetes, heart disease, and joint pain. It is also considered one of the important preventable causes of death worldwide[66,67]. A very recent cross-sectional study performed among 528 intermediate and high schools students (mean age, 15.58 ±1.80 years, 82.6% male and 17.4% female) in Taif, Saudi Arabia revealed that only 25.4% of students were considered to be aware of obesity. Those who are aware were more likely to be older male high school students [68]. As public health authorities in Saudi Arabia continue their efforts to educate people on the importance of PA and healthy lifestyle, the focus should be placed on providing support for community health centers. Efforts to improve the educational system, including the implementation of physical education classes for females should be made, and a larger number of public facilities for sports and exercise should be established specially for women and adolescent girls. Governments can also ensure creation of more parks and pedestrian walkways during urban development plan. One Latin American city once banned its citizens from using any automobile one Sunday a month. The result was astonishing. Suddenly, there were swarms of kids and adults in the street playing football or other games and no one was driving. It was magical.

Metabolic syndrome (MetS) and its associated chronic disorders including CVD and T2 DM are public concerns worldwide. "Good health is an investment in economic growth," and nutrition is one of the recommended preventive measures to manage these chronic diseases. Prevention and early management of MetS may help

manage these disease burdens and the associated health care cost worldwide. Similar to other chronic diseases, the metabolic syndrome is a complex, lifestyle-dependent illness. Its solution is not difficult to achieve: eat less, exercise more. These solutions must become part of everyday life and be woven into our social life to be effective. Thus, there is a need to increase awareness of the benefits of healthy food and physical activity and to develop strategies to increase physical activity levels and fitness capacity of persons with or at risk for diabetes or the metabolic syndrome. Health care professionals need to help people to understand the potential benefits that may result from the introduction of dietary patterns and exercise, and support them in adopting and adhering to these behavioral patterns. Actually, society as a whole needs to acquire a profound consciousness of the relevance for health of lifestyle factors such as nutrition and activity.

The metabolic syndrome diet is generally low in saturated fats, trans fat, cholesterol, and salt. The study by Lutsey and his colleagues [69] implicated meat, fried food, and diet soda in the development MetS. Trans fats raise cholesterol and may also negatively affect insulin sensitivity. The consumption of unsaturated fats, derived mostly from vegetable oils such as safflower, corn, olive and soybean oil, may be able to prevent serious disorders, such as atherogenesis, hypertension and consequently the metabolic syndrome. The required foods on a metabolic syndrome diet plan are usually lean protein, vegetables, healthy fats, whole grains, legumes, low-fat dairy products, and fruits. Extensive studies have suggested that whole grains (which are rich in fibers) help to prevent chronic diseases and MetS [70]. Observational data indicate an inverse relationship between dietary fiber intake (from cereals and whole grain) and body weight/diabetes/CVD [71]. A large body of evidence has revealed balanced dietary patterns, such as the Mediterranean, to lower mortality rates, decreased prevalence of some metabolic disorders (obesity, high blood pressure), as well as lower incidence of coronary heart disease and various types of cancers. The Mediterranean dietary pattern is characterized by the use of olive oil, the consumption of large quantities of vegetables in the form of salads and equally large quantities of legumes in the form of cooked foods. Other essential components of the Mediterranean diet are wheat, olives and grapes, and their various derivative products [72].

Carbohydrate consumption has been a critical factor blamed for weight gain, obesity, diabetes, and a number of diseases. It has been observed that a ketogenic diet (KD) which is low on carbohydrates effectively reduces damaging consequences of diabetes [73]. Fiber rich diets have been shown unequivocally to be associated with a reduced risk of obesity, and diabetes in many observational studies. Studies revealed that higher intake of sugar-sweetened beverages was found to be associated with greater risk of T2 DM, while substitution of these beverages with water, coffee, or tea was associated with a lower risk [73-75] . There is no doubt that there is strong supportive evidence that the use of ketogenic diets in weight loss therapy is effective, however the mechanisms underlying the effects of KDs on weight loss is still a subject of debate. Ketogenic diet can improve many aspects of the MetS, a major risk factor for obesity, T2 DM and heart disease [76].

The literature strongly supports the benefits of exercise and PA in the prevention of MetS and T2 DM. Increased PA promotes weight loss, improves insulin sensitivity, increases HDL-c levels, lowers TGs levels and prevents HTN [77-79], which are considered the main components of MetS. Different studies have consistently found an inverse association between PA levels and prevalence of MetS among T2 DM patients [77,80-83]. A very recent study [84] consisting of 1200 patients with T2 DM revealed that about 94% inactive patients , 64.4% of active patients and 32.5% of very active patients had metabolic syndrome. The results of the same study also showed a significant inverse association between PA levels and anthropometric measurements such as BMI and WC for both sexes. Moreover, the authors found a significant association between PA levels and TGs, HDL-c and BP in both sexes.

Exercise, either alone or in combination with comprehensive lifestyle intervention (physical activity and diet), is considered a cornerstone in the prevention and management of diabetes, CVD, and metabolic syndrome. A substantial body of evidence from observational and intervention studies, including randomized control trials, supports the role of regular physical activity and/or exercise as cornerstones in the prevention and treatment of T2 DM, CVD, and MetS [85,86]. The cross-sectional data support that obtaining at least 150 minutes per week of moderate-intensity physical activity (PA) is associated with a lower prevalence of MetS [87-89]. This level of activity: minimum of 150 min/wk of at least moderate-intensity physical activity (*i.e*., 30 min/d, most days of the week) is associated with significant reduction in risk of CVD, T2 DM, and MetS. Initially, sedentary individuals should be encouraged to reach this goal. The duration of physical activity need not be continuous; several 10-minute walks, for example, could be used to achieve the desired duration of $\geq$30 min/d. Emphasis should be placed first on enjoyment of physical activity, with subsequent efforts to increase intensity and duration. The increase in the level of physical activity (150 to 200 min/wk of more vigorous exercise) may provide greater reductions in the risk of CVD, T2 DM, MetS and associated risk markers [90,91].

Data from the DPP (Diabetes Prevention Program) demonstrated that lifestyle intervention was nearly twice as effective as metformin in reducing diabetes incidence (58% reduction *vs* 31% reduction compared with placebo) while the lifestyle intervention was more effective than metformin for reducing the incidence of metabolic syndrome (41% reduction vs 17% reduction compared with placebo)[92,93]. Understanding the concepts underlying the lifestyle changes, and then successfully enacting and recording them in logs, requires literacy and numeracy skills that are developed through formal education. Therefore, those with more formal education may have a relative advantage in preventing or delaying diabetes over those with lower levels of education. Evidence presented in different studies suggests that intensive lifestyle interventions and metformin have higher efficacy among more educated individuals. Interventions to enhance

patients' understanding of diabetes risk and its treatment options should be considered as a strategy to improve global diabetes/MetS prevention efforts [94].

Sustainable lifestyle modifications in diet and physical activity are the initial, and often the primary, component in the management of diabetes and the MetS. Results from studies on diet and exercise interventions provide promising data for the effective management of the MetS and type 2 diabetes, although much more remains to be learned. An energy-prudent diet coupled with at least moderate levels of physical activity may favorably affect parameters of the MetS, reduce the risk for developing type 2 diabetes, and minimize or delay the occurrence of diabetic complications. Finally, what appears to be of paramount importance and thus should be the focus of future investigations is the means by which patients can not only effect desirable changes, i.e., the adoption of a healthy, balanced diet and a physically active lifestyle, but also adhere to and maintain them in the long term[95].

In Saudi Arabia, the burden of MetS and T2 DM may likely to increase to disastrous levels, unless an approved comprehensive epidemic control program is implemented, which could rigorously promote healthy diet, exercise and active lifestyles, and curbing obesity. Creating awareness about the disease among patients and training primary care physician will contribute in lowering the risk of this malady. Such a long term strategy would be beneficial not only in controlling the disease but also lead to an overall increase in the health and quality of life of the Saudi population [59,60,96,97].

The main limitation of our study was the small size of the sample, which may have limited the power of the results. This study took place in one particular region and may limit the extrapolation to other regions of Saudi Arabia. Strengths of this study include being the first study to report MetS in T2 DM patients in Jeddah and its prospective nature. In general, the findings of the present study taken together showed that MetS is a major burden among T2 DM in Jeddah. Early identification of MetS among T2 DM patients is of great importance since MetS imply increased risk of morbidities such as CDV, decreased quality of life, increased health care cost, as well as mortality. Therefore, health authorities have to strengthen appropriate and targeted prevention strategies such as encouraging people to adopt dietary modification and physical activity which are reported to reduce occurrence and progression of MetS. In addition, there should be a more frequent screening of patients for MetS components prior to full-blown development of MetS.

CONCLUSION

The prevalence of MetS and its components among T2 DM patients were high. The prevalence of MetS was significantly higher in female patients with diabetes compared to males, suggesting that diabetic patients are at increased risk of CVD and other complications. Efforts should be geared towards addressing these abnormalities through lifestyle modification, health awareness and medications in order to reduce these complications.

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