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Original Research Article

Prevalence of metabolic syndrome and its risk factors among medical undergraduates at Northern Border University, Arar, Saudi Arabia

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Abstract

Purpose: *To determine the prevalence of metabolic syndrome (MetS) and its associated factors among medical undergraduates of Northern Border University.*

Methods: *This cross-sectional study was performed on 200 medical undergraduates of Northern Border University, Arar, Saudi Arabia from August 2023 to October 2023. Data on demographic details and anthropometric measurements were collected. Complete lipid profile and blood glucose levels were measured after at least 8-h fast. The International Diabetes Federation (IDF) recommendations were utilized for diagnosing MetS. The data obtained were analyzed using Statistical Package for Social Sciences (SPSS), version 20.0. Group differences were analyzed using Chi-square test and Post hoc analysis.*

Results: *The estimated overall prevalence of MetS was 21.5 %. Metabolic syndrome (MetS) was more prevalent among older students (37.36 %) and obese students (45.28 %) than among younger and non-obese students. Female students had a higher prevalence of MetS (29 %) than their male counterparts (14 %). The most frequent risk factors for MetS were elevated waist circumference (36 %) and low HDL levels (33 %). The majority of students (76.7 %) with high waist circumference had 2 or more risk factors for MetS. Students with a positive family history of hypertension and obesity showed greater prevalence of MetS.*

Conclusion: *The study has demonstrated a high prevalence of MetS among young adults in Arar, Saudi Arabia. High prevalence of obesity and elevated waist circumference suggests that early and targeted interventions are required to prevent the development of MetS and cardiovascular risk in later life.*

Keywords: *Metabolic syndrome, Lipid profiles, Body mass index, Cardiovascular risk factor, Anthropometrics*

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INTRODUCTION

Metabolic syndrome (MetS) is characterized by simultaneous presence of metabolic derangements and cardiac risk factors such as hypertension, central obesity, elevated plasma glucose, high levels of triglyceride, and low HDL levels [1]. It is considered one of the major public health issues because it predisposes all age groups to type 2 diabetes and cardiovascular diseases. An increase in incidence of early deaths has been reported in MetS [2]. It has

been observed that persons with MetS are three times more prone to stroke or heart attack and two times more susceptible to death from these conditions than persons without MetS [3].

The prevalence of MetS is increasing steadily, with nearly 25 % of the global population affected. The incidence of MetS varies in different parts of the world due to factors such as age, gender, race and ethnicity [4]. It has been reported that MetS occurs at young ages, and its prevalence is rising worldwide due to increasing incidence of obesity [4]. It is characterized by the presence of activated macrophages and crown-like structures in adipose tissue, leading to adipose tissue damage [5]. The pathophysiology of MetS is complex and several mechanisms have been proposed. It involves complex interplay of genetic, environmental and lifestyle characteristics such as high caloric intake and low levels of physical activity [6]. These factors trigger insulin resistance, chronic inflammation and neurohormonal changes, all leading to progression and transition from MetS to cardiovascular disease and diabetes [7].

Metabolic syndrome (MetS) is considered important, not only because of its high prevalence but also because it is a strong predictor for the development of cardiac complications and Type 2 diabetes mellitus. It has been defined in various ways which comprise all the metabolic abnormalities such as deranged lipid profile reflected in high LDL, reduced HDL-cholesterol, high triglycerides levels, central obesity, and hypertension, all linked together by insulin resistance as the main pathogenic factor [8]. The high levels of triglyceride and cholesterol predispose individuals to development of gallstones, non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH) [9]. The Guidelines of the National Cholesterol Education Program (NCEP) expert panel suggest that the basic aim of diagnosing MetS is to focus on individuals who are prone to developing cardiovascular complications which are considered linked to obesity-related morbidity [10].

As obesity has become a worldwide epidemic, its prevalence is on the rise in Western as well as Asian countries. Therefore, there is a need for early preventive measures and changes in lifestyle in order to stop the development of metabolic abnormalities. Saudi Arabia has undergone tremendous socio-economic advancements due to changes in health, education and environment which have resulted in rural-urban migration and lifestyle modifications. As a result, there are increases in prevalence of chronic diseases such as diabetes, obesity and cardiovascular disease. The prevalence of MetS in Saudi Arabis has been put at 31.6 % (IDF criteria) and 39.9 % (ATP III criteria) [10]. However, the age group-specific prevalence of MetS has not been reported. As the presence of a single risk factor for MetS is related to heightened risk of cardiovascular diseases, it is worthwhile to investigate the prevalence of MetS and its components among young adults. Early detection of MetS and its risk factors will be helpful in designing public health strategies for timely intervention.

METHODS

Study design and participants

This cross-sectional study was done on medical undergraduates of Northern Border University, Arar, Saudi Arabia, between August 2023 and October 2023. The RAOSFT sample size calculator was used to estimate the sample size by assuming a 95 % confidence level, 5 % sampling error, and 50 % probability of occurrence. The estimated sample size was 200. The MBBS classes were selected randomly using Excel software for Windows. From each selected class, participants were chosen for the study using convenience sampling. The study was conducted on 200 male and female students. Informed written consent was obtained from the students prior to data collection. Ethical approval for the study was obtained from the ethical review committee of Northern Border University (approval no. HAP-09-A-043), and the guidelines of Helsinki Declaration were followed.

Inclusion criteria

Medical students aged 21 - 30 years who were willing to participate in study and fast for 8 h prior to sample collection, were included in the study.

Exclusion criteria

Students who had illnesses requiring hospital admissions at the time of the study, as well as students with known inflammatory diseases, and those who were unwilling to give blood samples, were excluded from the study.

Data collection procedure

Data were collected using the WHO step-wise method recommended for identification of risk factors for chronic diseases. The STEPS method consists of three levels of evaluation of risk factors *viz* using a questionnaire, making

physical measurements and biochemical investigations. The questionnaire was designed to get information about students' demographic data such as age, year of study, and family history of any chronic diseases, e.g., diabetes and hypertension. In the measurement aspect, students' anthropometric data, blood pressure and waist circumference were recorded using standard procedures. All measurements were performed by trained physicians. Blood pressure was estimated using an automated blood pressure device (Omron BP M6 comfort, Omron Healthcare Ltd., Kyoto, Japan). The blood pressure of each student was measured three times, and the average value was calculated. An appropriate cuff size was used for each student. Using a stadiometer, height was recorded for each student standing on bare feet, with relaxed shoulders. Weight was recorded on a digital scale while the student was without shoes. The BMI was calculated for each student, based on which they were categorized as normal, overweight or obese. Waist circumference was measured in standing position using a non-elastic tape at the midpoint between the iliac crest and the lower rib margin. Then, blood samples were collected after at least 8 h of fasting. The blood samples were used for measuring fasting blood glucose and lipid profiles; triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein-cholesterol, using the CardioChek PA Analyzer (Polymer Technology Systems, Inc. CardioChek, Zionsville Rd, IN, USA) [11].

The International Diabetes Federation (IDF) recommendations were adopted for identification of students with MetS. These criteria require simultaneous presence of abdominal obesity or elevated waist circumference (≥ 80 cm for females and ≥ 94 cm for males) and two or more factors such as raised triglycerides level (≥ 150 mg/dL of blood), reduced HDL cholesterol (<40 mg/dL for males and < 50 mg/dL for females), systolic blood pressure (SBP) of ≥ 130 mmHg), diastolic blood pressure (DBP) of ≥ 85 mmHg, or fasting plasma glucose (FPG) of ≥ 100 mg/dL [12].

Statistical analysis

Data analysis was done using Statistical Package for Social Sciences (SPSS), version 20.0 (IBM Corp, Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are presented as frequencies and percentages. Groups were compared using Chi-squared test and ANOVA. When group differences were identified, a post-hoc test was done. Values of $p < 0.05$ were considered indicative of statistically significant differences.

RESULTS

Out of 200 students who participated in the study, 53 (26.5 %) were obese, while 62 (31 %) students were overweight. Relative to the normal weight group, the obese students had significantly higher blood pressure (143.22 ± 5.29 mmHg vs. 131.51± 8.11 mmHg), waist circumference (96.88 ± 6.43 cm vs. 89.94 ± 6.84), triglyceride levels (172.05 ± 15.59 mg/dL vs. 142.78 ± 13.24 mg/dL) and low HDL level (42.83 ± 3.97 mg/dL vs. 47.23 ± 4.98 mg/dL). Similarly, when compared with students within the age group of 21 - 25 years, students within the age group of 26 - 30 years had greater increases in blood pressure (137.40 ± 10.54 mmHg vs. 135.29 ± 5.11 mmHg), triglycerides (160.48 ± 20.55 mg/dL vs. 145.97 ± 13.51 mg/dL), and fasting plasma glucose (108.16 ± 10.33 mg/dL vs. 96.72 ± 4.69 mg/dL). However, students within the age group of 26 - 30 years had lower HDL cholesterol than those within the age group of 21 - 25 years (44.68 ± 5.75 mg/dL vs. 45.96 ± 4.84 mg/dL). The levels of the various variables associated with MetS are presented in Table 1.

There were 36 and 33 % incidence of elevated waist circumference and low HDL, respectively, among the students. Students aged 26 - 31 years showed higher prevalence of elevated fasting plasma glucose (61.5 %), higher blood pressure (47.25 %), and lower HDL (45.05 %) than students who were 21 - 25 years old. Waist circumference was significantly higher among female students (43 %), as shown in Table 2. Obese students had significantly higher prevalence of all risk factors for MetS (73.58 % higher waist circumference, p <0.001; 66.03 % higher blood pressure, $p < 0.001$), 75.47 % higher elevated fasting plasma glucose, $p > 0.001$), 83.01 % higher elevated triglycerides, $p < 0.001$, and 45.28 % lower HDL, $p < 0.015$) than non-obese and normal weight students. These data are shown in Table 2.

The estimated prevalence of metabolic syndrome among students aged 21-30 years was 21.5 %. Metabolic syndrome (MetS) was observed more frequently among students with high BMI and older students. A higher prevalence of MetS was observed among students having parental history of hypertension and obesity. These results are shown in Table 3.

Table 1: Physical characteristics and MetS components classified according to age, gender and BMI

Variable	Age range (years)		*P*-value	Gender		*P*-value	BMI			*P*-value
Basic properties	21-25 (n=109)	26-30 (n=91)		Male n=100	Female n=100		Normal (n=85)	Over-weight (n=62)	Obese (n=53)	
Waist circumference (cm)	91.33 (8.06)	93.54 (6.11)	<0.001	88.89 (5.53)	95.80 (7.26)	<0.001	89.94 (6.84)	91.75 (6.94)	96.88 (6.43)	<0.001*
Weight (kg)	56.61 (5.93)	51.45 (11.25)	<0.001	51.80 (9.95)	56.73 (7.45)	<0.001	55.42 (3.68)	52.38 (12.17)	54.60 (10.75	0.130
Height (cm)	147.45 (9.81)	137.39 (13.48)	<0.001	140.14 (15.14)	145.62 (8.75)	<0.001	151.74 (6.49)	141.16 (11.89)	130.67 (9.68)	<0.001*
BMI (kg/m^2)	25.43 (2.73)	28.33 (4.60)	<0.001	26.88 (4.20)	26.62 (3.73)	<0.001	23.29 (1.26)	26.61 (1.73)	32.46 (1.14)	<0.001*
Systolic blood pressure (mm of Hg)	135.29 (5.11)	137.40 (10.54)	<0.001	136.17 (9.12)	136.34 (6.95)	<0.001	131.51 (8.11)	136.79 (5.05)	143.22 (5.29)	<0.001*
Diastolic blood pressure (mm of Hg)	84.97 (3.54)	85.47 (5.69)	<0.001	84.94 (5.47)	85.46 (3.64)	<0.001	83.52 (3.60)	83.79 (3.24)	89.52 (4.79)	<0.001*
Fasting Plasma glucose (mg/dL)	96.72 (4.69)	108.16 (10.33)	<0.001	103.5 (10.86)	100.36 (7.98)	<0.001	97.57 (5.07)	101.58 (9.37)	109.32 (11.13)	<0.001*
Triglyceride levels (mg/dL)	145.97 (13.51)	160.48 (20.55)	<0.001	153.71 (20.31)	151.44 (16.53)	0.0061	142.78 (13.24)	149.33 (13.96)	172.05 (15.59)	<0.001*
High-density lipoprotein (mg/dL)	45.96 (4.84)	44.68 (5.75)	<0.001	43.47 (5.32)	47.29 (4.570	<0.001	47.23 (4.98)	45.01 (5.78)	42.83 (3.97)	<0.001*
Low-density lipoprotein (mg/dL)	119.64 (16.90)	118.36 (20.19)	0.001	117 (18.20)	121.12 (18.53)	0.05	110.20 (17.59)	119.41 (17.01)	132.84 (11.80)	<0.001*

Note: All values are shown as mean ±SD. *Post hoc analysis was significant among BMI groups. (BMI = body mass index)

Table 2: Prevalence of risk factors for metabolic syndrome among medical undergraduates

Variable	High WC; n (%)	*P*-value	High BP; n (%)	*P*-value	Elevated FPG; n (%)	*P*-value	Elevated TG; n (%)	*P*-value	Low HDL; n (%)	*P*-value

Total (200)	72 (36)		64 (32)		64 (32)		63 (31.5)		66 (33)	
Age range in years (n)										
21-25 (109)	24(22.01)	<0.001	21 (19.26)	<0.001	8 (7.33)	<0.001	19 (17.43)	<0.001	25 (22.93)	<0.001
26-30 (91)	48(52.74)		43 (47.25)		56 (61.5)		44 (48.35)		41 (45.05)	
Gender										
Male (n) 100	29 (29)	0.039	37 (37)	0.130	34 (34)	0.544	33 (33)	0.648	42 (42)	0.007
Females (n) 100	43 (43)		27 (27)		30 (30)		30 (30)		24 (24)	
BMI (kg/m^2)										
Normal (n) 85	17 (20)*	<0.001	11 (12.94*)	<0.001	9 (10.58)*	<0.001	5 (5.88)*	<0.001	19 (22.35)*	0.015
Over-weight (n) 62	16(25.8)		18 (29.03)		15 (24.19)		14 (22.58)		23 (37.09)	
Obese (n) 53	39 (73.58)*		35 (66.03)*		40 (75.47)*		44 (83.01)*		24 (45.28)*	

Note: All values are shown as frequency and percentage. *Post hoc tests between groups were significant (post hoc comparisons for BMI were Bonferroni-adjusted). (WC = waist circumference, BP =blood pressure, FPG =fasting plasma glucose, TG =triglycerides, HDL = high-density lipoprotein, BMI =body mass index)

Table 3: Prevalence of MetS among medical undergraduates

Parameter	n (%)	Number of students with MetS; *n* (%)	*P*-value
Total	200	43(21.5)	
Age range (years)			
21-25	109(54.5)	9(8.25)	<0.001
26-30	91(45.5)	34(37.36)	
Gender			
Male	100	14(14)	0.010
Female	100	29(29)	
BMI (kg/m^2)			
Normal	85 (42.5)	5 (5.88)*	<0.001
Overweight	62 (31)	14 (22.58)	
Obese	53 (26.5)	24 (45.28)*	
Parental history of diabetes			
Yes	56 (28)	9 (16.07)	0.244
No	144 (72)	34 (23.61)	
Parental history of hypertension			
Yes	64 (32)	25(39.06)	<0.001
No	136 (68)	18 (13.23)	
Parental history of obesity			
Yes	84 (42)	28 (33.33)	0.001
No	116 (58)	15 (12.93)	

Note: *Post hoc test among BMI groups was significant (Bonferroni-adjusted). BMI body mass index

Table 4: Prevalence of MetS risk factors based on age, waist circumference, and BMI categories

Parameter	0 risk factor	1 risk factor	2 risk factors	3 risk factors	4 risk factors	5 risk factors	*P*-value
Total n=200	87 (43.5%)	70 (35%)	15 (7.5%)	19 (9.5%)	6 (3%)	3 (1.5%)	
Age (years)							
21-25(n=109)	60 (55.04%)	47 (43.11%)*	1 (0.91%)	1 (0.91%)	0 (0%)	0 (0%)	<0.001
26-30(n=91)	27 (29.6%)	23 (25.27%)*	14 (15.38%)*	18 (19.78%)*	6 (6.59%)	3 (3.29%)	
Gender							
Male (n=81)	37 (45.67)	20 (24.69)	9 (11.11)	9 (11.11)	3 (3.70)	3 (3.70)	0.040
Female (n=119)	50 (42.01%)	50 (42.01%)*	6 (5.04%)	10 (8.40%)	3 (2.52%)	0 (0%)	
Waist circumference (cm)							
Normal (n=144)	87 (60.41%)	57 (39.5%)*	0 (0)	0 (0)	0 (0)	0 (0)	<0.001
Elevated (n=56)	0 (0)	13 (23.21%)	15 (26.78%)*	19 (33.92%)*	6 (10.71%)*	3 (5.35%)	
BMI (kg/m^2)							
Normal (n=85)	59 (69.41)	26 (30.58)	0 (0)	0 (0)	0 (0)	0 (0)	<0.001
Overweight (n=62)	23 (37.09)	38 (61.29)	1 (1.61)	0(0)	0(0)	0(0)	
Obese (n=53)	5 (9.43)	6 (11.32)	14 (26.41)	19 (35.84)	6 (11.32)*	3 (5.66)	

Note: *$P < 0.001$ vs. other group(s), $p < 0.001$ vs. BMI and waist circumference groups were Bonferroni-adjusted. (BMI = body mass index)

It was observed that 43.5 % of the 200 students did not have any risk factor for MetS, while 35 % of the students had at least one risk factor. In addition, 21.5 % of the students had 2 or more risk factors for MetS. Results from post hoc analysis indicated that students with high waist circumference had a significantly higher frequency of risk factors, i.e., ≥ 2 risk factors (76.79 %, $p < 0.001$). However, students with normal waist circumference had significantly higher frequency of one risk factor (39.5 %), while only 9.43 % of obese students showed

zero risk factor for MetS. In post hoc analysis, obese students had significantly higher frequency of 4 risk factors for MetS than students with normal BMI ($p < 0.001$; Table 4).

DISCUSSION

Metabolic syndrome (MetS) is an extensive global health issue and a significant predisposing factor for atherosclerosis and non-atherosclerotic cardiovascular diseases. It is characterized by complex interactions between genetic and environmental factors, leading to metabolic derangements. Inactive lifestyles are on the rise due to enormous economic growth and urbanization [13]. Consequently, diseases such as obesity, diabetes, hypertension and dyslipidemias are becoming more prevalent even in the younger population. Therefore, this study was intended to provide data on MetS prevalence among medical students in the age range of 21 - 30 years. The overall prevalence of MetS among the students was 21.5 %. Moreover, MetS was found to be more prevalent among the males than the females, and its prevalence increased with age. Regardless of gender, low HDL was the most frequently reported metabolic derangement.

A previous study reported a 31.6 % incidence of MetS in Saudi Arabia, but it was not age-specific [14]. However, few studies done on adolescents showed prevalence values of 17.1 % in Makkah and 2.0 - 18 % in Riyadh [15]. Another study done on female adolescents revealed MetS prevalence of 7.1 % [16]. The prevalence of MetS was high in the present study because the students studied were older. It has been previously observed that MetS prevalence was proportional to age, with values of 47.4 % in males and 61.8 % in females in the age group of 60 - 70 years [15]. In the present study, the prevalence of MetS was also higher among students aged 26 - 30 years, when compared to those aged 2 - 25 years. This may be due to increasing incidence of obesity with age. In this study, the prevalence of MetS was higher in females than in males. There are conflicting results in the literature regarding gender differences in prevalence of MetS. Consistent with the results obtained in this study, a study done in Algeria showed a higher prevalence of MetS among females than among males, due to higher waist circumference and obesity in females than in males [16]. In contrast, a study done in the past has reported a high prevalence of MetS among males [17]. These conflicting findings suggest that MetS involves a complex interaction among gender, age and ethnicity of the studied population.

Overweight and obesity were observed in 31 and 26.5 % of the students, respectively, which were very high when compared to previous reports. A study done in Makkah showed that 15.2 % of the studied population were overweight, while 15.3 % of the subjects were obese [15]. Another study [18] reported higher prevalence of obesity and overweight in northern region of Saudi Arabia (20.1 % overweight and 9 % obesity, respectively) than in the southwest zone (13.4 % overweight and 6.1 % obesity, respectively). It has been proposed that these variations are not only due to individual risk factors like race and ethnicity, but also due to accessibility to, and availability of physical and healthcare facilities [19]. Similar regional variations have been reported in studies done in Canada and UK [20]. It has been observed that the risk of being overweight and obese was independent of individual factors, thereby indicating the vital roles of regional factors such as environmental quality, provision of physical activity facilities, and awareness of healthy lifestyles.

In the current study, the most common risk factor for MetS was elevated waist circumference, followed by low HDL levels. This finding is consistent with data from studies done previously in Saudi Arabia, South Asia and the Middle East [21]. These findings may be due to association of low HDL levels with high waist circumference, as shown in previous studies [22]. Students with a family history of obesity and hypertension showed greater prevalence of MetS than those without positive family history of these diseases. These findings are consistent with previous reports. Studies have shown that positive family history of obesity increases the chances of developing obesity and other components of MetS later in life [23]. Similarly, a study done in Iraq suggests that individuals with positive family history of hypertension and obesity are more prone to developing these diseases and other components of MetS [24]. This may be because individuals living together have similar lifestyles and environments, which are further complicated by shared genetic factors, leading to onset of MetS and its components.

It was observed that 21.5 % of the students had 2 or more risk factors for MetS. This is lower than the 43.4 % of participants with more than 2 risk factors, as reported in a previous study [25]. This disparity may be due to differences in age groups of participants in both studies. It was observed that 79.2 % of obese students showed 2 or more risk factors for MetS. This is in agreement with the results obtained in a study done in Palestine which reported that increases in BMI and waist circumference make the affected person more

susceptible to developing other metabolic abnormalities such as low HDL and high triglycerides levels [26]. Therefore, there is need for early lifestyle modifications which include maintenance of healthy weight, regular exercise and cessation of smoking, in order to arrest the development and progression of this life-threatening syndrome. Lack of awareness is also a factor leading to weight gain. Thus, it is important to implement community health programs targeted at lowering obesity burden.

Limitations of the study

This study did not assess the causal relationship between MetS and its risk factors, due to its cross-sectional nature. Moreover, physical activity and dietary assessments were not determined. These may be important factors in pathogenesis of MetS.

CONCLUSION

The prevalence of MetS among medical undergraduates in Arar, Saudi Arabia, as reported in the current study, is 21.5 %. Metabolic syndrome (MetS) is more prevalent among obese and female students who have a positive family history of obesity and hypertension than in non-obese students.

DECLARATIONS

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Ethical approval

This study was approved by the ethical review committee of Northern Border University (approval no. HAP-09-A-043),

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

No conflict of interest associated with this work.

Contribution of Authors

We declare that this work was performed by the authors named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Dr Ehtisham designed the study, supervised the data collection, and analyzed the data. Dr Tehreem interpreted the data and prepared the manuscript for publication.

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