ORIGINAL ARTICLE

The Association between Physical Activity and the Metabolic Syndrome among Type 2 Diabetes Patients in Gaza Strip, Palestine

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Competing Interests: The authors declare that this manuscript was approved by all authors in its form and that no competing interest exists.
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ABSTRACT

BACKGROUND: Metabolic syndrome is a major health problem worldwide. Globally, the World Health Organization identified physical inactivity as the fourth leading risk factor for mortality. This study was conducted to evaluate the association between physical activities and metabolic syndrome and diabetes complications among type 2 diabetes patients in Gaza Strip, Palestine.

METETHODS: This cross-sectional study was conducted among 1200 previously diagnosed type 2 diabetes mellitus patients (from both genders, aged 20 to 64 years) receiving care in the primary health care centers. Metabolic syndrome was defined based on the International Diabetes Federation criteria. The International Physical Activity Questionnaire was used to measure physical activity. Statistical analysis was performed using SPSS version 20.

RESULTS: A significant inverse association was found between inactive patients and metabolic syndrome. In our study, 93.7% of inactive patients, 66.4% of active patients and 23.5% of very active patients had metabolic syndrome (OR .048 CI 95% (.03-.072)), (OR .787 CI 95% (.59-1.03)) and (OR 15.9 CI 95% (11.8-21.3)) respectively. Our results showed a significant inverse association between physical activity levels and anthropometric measurements in both gender. Moreover, a significant association was found between physical activity levels and triglycerides, HDL-cholesterol and blood pressure in both sexes (P value < 0.05 for all) and diabetes complications (P value < 0.05 for all).

CONCLUSION: We conclude that low levels of physical activity are associated with increased prevalence of metabolic syndrome. Furthermore, inactive patients had a high percentage of diabetes complications among type 2 diabetes patients in Gaza Strip, Palestine.

KEYWORDS: Physical activity, metabolic syndrome, type 2 diabetes mellitus, Gaza, Palestine

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of the most dangerous heart attack risk factors: diabetes and raised fasting plasma glucose (FPG), abdominal obesity, high cholesterol and high blood pressure (BP) (1,2,3). MetS is a major health problem worldwide; it is estimated that around 20 to 25 percent of the world's adult population have MetS, and mortality rate in these people is twice as likely from heart attack, and three times as likely from stroke compared with people without MetS (4). The underlying causes of the MetS have been suggested as central obesity and insulin resistance (5,6). In addition, genetics, physical inactivity, ageing, proinflammatory state and hormonal changes may also have causal effects, but the role of these may vary depending on ethnic groups (7,8). Physical inactivity is an independent risk factor for chronic diseases which is estimated to cause 1.9 million deaths, globally (9,10,11). Moreover, physical inactivity is considered as the fourth leading risk factor for global mortality causing an estimated 3.2 million annual deaths (6% of global deaths) (12). Physical activity (PA) decreases the risk for premature death, coronary artery disease, obesity, diabetes, hypertension (HTN), cancer and depression thereby lowering medical and medication costs and improving quality of life (13). The fact that the lack of PA and MetS is cardiovascular risk factors that increase overall morbidity makes the study of their interrelationships extremely important. Moreover, low levels of PA are strongly associated with the development of MetS and chronic diseases. To the best of our knowledge, this is the first study, which examined this association among type 2 diabetes mellitus (T2DM) patients in Gaza Strip, Palestine. the study was conducted to evaluate the association between PA and the MetS among T2DM patients in Gaza Strip, Palestine, and to examine the association between PA and diabetes complications.

MATERIALS AND METHODS

Study design and sampling technique: This cross-sectional study was conducted in the years 2015 and 2016 among a representative sample of Palestinian T2DM patients, selected through cluster random sampling method. A total of 1200 patients (from both gender, aged 20 to 64 years) receiving care in the primary health care centers (PHCs) in Gaza Strip, Palestine, were included in the study. Gaza Strip is divided into five smaller governorates, which include North Gaza, Gaza City, Mid Zone, Khan Younis and Rafah. The total number of PHCs in Gaza Strip is fifty-four (14). The PHCs were distributed in each governorate as follows (eight, fourteen, sixteen, eleven and five respectively). The study sample was distributed according to the number of PHCs in each governorate as follows (178, 311, 356, 244 and 111 patients respectively). Pregnant women, lactating women and patients with other types of serious illness such as cancer, acute myocardial infarction or end stage kidney disease were excluded from the study.

Assessment of blood pressure and anthropometric measures: BP was measured from the left arm (mmHg), by mercury sphygmomanometer, three readings on different days. While the patient was seated after relaxing for at least 15 minutes in a quiet environment, empty bladder. The average of three measurements was recorded. Weight was measured with the use of a Seca scale and recorded to the nearest 0.1 kg. Height was measured with a Seca studiometer while subjects were standing with their shoulders positioned normally. The body mass index (BMI) was calculated as the weight in kilograms divided by the height in meters square. Waist circumference (WC) was measured at the narrowest level between the lowest rib and the iliac crest with the use of an outstretched tape measure. Measurements were recorded to the nearest 0.5 cm. After calculating BMI, individuals were categorized into underweight, healthy weight, overweight and obese using WHO cut-off point (15).

Assessment of biomarkers: After 12 hours fasting, a venous blood samples was collected from all patients in the primary health care centers (in the second meeting with the patients), by well-

trained and experienced nurses. Venous blood (4.0 ml) was drawn into vacationer tubes and was used for blood chemistry analysis. Serum was separated immediately and the extracted serum was investigated for (FPG mg/dl, High Density Lipoprotein cholesterol (HDL-c) mg/dl and triglycerides (TGs) mg/dl). Mindray BS-300 chemistry analyzer instrument was used for blood chemistry analysis. The laboratory tests were analyzed in private licensed laboratory.

Assessment of other variables: Data on PA were obtained using the International Physical Activity Questionnaire (IPAQ short version) (16). The internationally accepted protocol was used to estimate the weekly calorie expenditure expressed as metabolic equivalents per week (MET/wk) or converted to kcal/wk using the formula kcal = MET × weight ÷ 60. The IPAQ scoring protocol assigns the following MET values to walking, moderate and vigorous intensity activity: 3.3 METs, 4.0 METs, and 8.0 METs, respectively. According to the IPAQ scoring protocol, the patients were classified based on their weekly energy expenditure as follows: Insufficiently Active (IA) ≤600 MET/wk; Sufficiently Active (SA) 601 to 1500 MET/wk; and Very Active (VA) ≥1500 MET/wk (17). Additional covariate information regarding age, medical history and diabetes complications was obtained with an interview-based questionnaire. Before the data collection, pilot study was carried out on thirty patients to enable the researcher to examine the tools of the study. The questionnaire and the data collection process were modified according to the result of the pilot study. The data was collected by ten qualified data collectors who were given explanation and training by the researcher about the study, its purpose, objectives, procedures and ways of distributing and collecting the questionnaire with respect to confidentiality.

Definition of MetS: MetS was defined according to the International Diabetes Federation (IDF) definition (2).

Statistical analysis: All statistical analyses were performed using Statistical Package for Social Science (SPSS) version 20. The descriptive statistics of mean, standard deviation and percentages were calculated for the entire sample. Chi-square test was used to examine differences in the prevalence of different categorical variables. The differences between means were tested by independent samples t-test and one-way ANOVA. The odds ratio (OR) and the confidence interval (CI) for the presence of MetSat, different PA levels were calculated. P value less than 0.05 was considered as statistically significant.

Ethical issues: The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences (Code: IR.TUMS.REC.1394.58) and by the Palestinian Health Research Council (Helsinki Ethical Committee of Research PHRC/HC/60/15). Furthermore, written informed consent was obtained from the study participants and concerned bodies.

RESULTS

A total of 1200 patients with T2DM aged 20 to 64 years old (59.8% females, 40.2% males) were included in this study. Table 1 shows the characteristics of the study population by sex in relation to the presence of MetS and its absence (According to IDF definition). Our findings demonstrate that the mean age for males with MetS was 55.3±6.9 vs. 42.6±10.1 in the non-MetS group; the mean age for females with MetS is 55.5±6.9 and 38.0±9.6 in the non-MetS group. In addition, Table 1 shows that for the following risk factors (Age, BMI, central obesity, high BP, high TGs and low HDL-c), the difference was statistically significant in both sexes (P value < 0.05). Then, we examined the relationship between MetS and medical history factors (Table 2). A significant inverse association was found between diabetes duration, BMI and the MetS (P value < 0.05). In addition, our findings showed that 48.4% of the patients with MetS received diabetes care instructions, all patients (100%) used diabetes medications, 91.4% of the patients with MetS used pills and nsulin injections, 54.9% were smokers, no patients consumed alcohol and most of female patients with MetS (89.5%) were post-menopause. For these risk factors, the difference was statistically significant between T2DM patients with and without MetS (P value < 0.05).

In addition, we concluded in Table 3 that the mean weekly metabolic energy expenditure expressed as MET/wk for males with MetS was 905.2±9 vs. 2729.8±1 in males without MetS. The mean for females with MetS was 710.6±1 MET/wk and 2293.2±1 MET/wk in females without MetS. And the difference was statistically significant between the MetS and non-MetS groups in both sexes (P value < 0.05, T value = 5.903). The obtained results showed that the mean energy expenditure, which includes the body weight in its formula and is expressed in kcal/wk for males with MetS, was 1413.7±1 vs. 3465.3±2 in males without MetS. The mean for females with MetS is 1028.1±1 kcal/wk and 2564.3±1 kcal/wk in females without MetS and the difference was statistically significant between the MetS and non-MetS groups in both sexes (P value < 0.05, T value = 7.041). Also, we found a significant inverse association between PA levels (IA, SA and VA) and the incidence of MetS in both sexes (P value < 0.05). Furthermore, our findings demonstrated that there was a significant inverse association between PA levels and anthropometric measurements such as BMI and WC for males and females (P value < 0.05) as shown in Table 4. In addition, we found a significant association between PA levels and TGs (P value < 0.01), HDL-c (P value < 0.01) and BP (P value < 0.01) in males and females. With respect to FPG, we found a significant association between PA levels and FPG in males (P value < 0.05), but in females, the difference did not reach a statistical significant level (P value = 0.360). Also, we computed the OR and the CI of the MetS atdifference PA levels (IA, SA & VA) (Table 5). Our findings demonstrated that 93.7% of IA patients had MetS OR .048 CI 95% (.03-.072), 66.4% of SA patients had MetS OR .787 CI 95% (.59-1.03) and 23.5% of VA patients had MetS OR 15.9 CI 95% (11.8-21.3). Finally, we examined the relationship between PA levels (IA, SA and VA) and diabetes complications (Eye problems, kidney problems, protein in urine, heart problems, extremities problems and neurological problems). Table 6 shows that there was a significant association between PA levels and diabetes complications (P value < 0.05). Finally, a significant association was found between diabetes complications (Eye problems, kidney problems, protein in urine, heart problems, extremities problems and neurological problems) and the prevalence of MetS in our study population (P value < 0.05).

Table 1: Characteristics of the study population by sex in relation to the presence of MetS or its absence (According to IDF definition).

Parameters	Total No. of Subjects (n=1200)	Males		P	Females		P
		MetS (n=258)	Non-MetS (n=224)		MetS (n=490)	Non-MetS (n=228)	
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Age (years)	49.74±11.07	55.3±6.9	42.6±10.1	.001	55.5±6.9	38.0±9.6	.001
BMI (kg/m²)	30.22±6.28	31.1±4.5	25.0±3.6	.001	34.2±5.9	25.4±3.4	.001
Central obesity	985 (82.08%)	258 (100%)	57 (25.4%)	.001	490 (100%)	180 (78.9%)	.001
High BP	771 (64.25%)	250 (96.8%)	39 (17.4%)	.001	481 (98.1%)	1 (0.4%)	.001
High triglycerides	504 (42%)	154 (59.6%)	8 (3.5%)	.001	341 (69.5%)	1 (0.4%)	.001
Low HDL-c	487 (40.58%)	138 (53.4%)	8 (3.5%)	.001	340 (69.3%)	1 (0.4%)	.001
In our study, all participants previously diagnosed T2DM							

Central obesity was defined as waist circumference ≥ 94 cm in men and ≥ 80 cm in women. High blood pressure was ≥ 130/85 mmHg or treatment of previously diagnosed hypertension. High triglyceride was ≥150 mg/dl or specific treatment for this lipid abnormality. Low high-density lipoprotein cholesterol was <40 mg/dl in males and <50 mg/dl in females or specific treatment for this lipid abnormality.

The differences between means were tested by using independent sample t test. Descriptive statistics, Crosstabs, the chi-square test were used to examine difference in the prevalence of different categorical variables. P value less than 0.05 was considered as statistically significant.

Table 2: Distribution of the study population by medical history variables in relation to the presence of MetS or its absence.

Medical history		Metabolic syndrome				Total		P
		Presence		Absence				
		No.	%	No.	%	No.	%	
Diabetic duration	Less than five	72	22.8	244	77.2	316	100	
	Five to ten	274	63.1	160	36.9	434	100	.001
	More than ten	402	89.3	48	10.7	450	100	
BMI category	Under weight	0	0.0	7	100.0	7	100	
	Healthy weight	36	13.8	225	86.2	261	100	
	Over weight	186	50.8	180	49.2	366	100	.001
	Obesity	526	92.9	40	7.1	566	100	
Family history of diabetes	Yes	640	62.7	380	37.3	1020	100	
	No	108	60.0	72	40.0	180	100	.483
Received DM care instructions	Yes	278	48.4	296	51.6	574	100	
	No	470	75.1	156	24.9	626	100	.001
Use DM medications	Yes	748	62.3	452	37.7	1200	100	-
Type of diabetes medications used	Diabetes pills	243	49.5	248	50.5	491	100	
	Insulin injections	431	68.6	197	31.4	628	100	.001
	Pills & injections	74	91.4	7	8.6	81	100	
Smoking	Yes	89	54.9	73	45.1	162	100	
	No	659	63.5	379	36.5	1038	100	.001
Consume alcohol	No	748	62.3	452	37.7	1200	100	-
Females menopausal status	Premenopausal	40	18.6	175	81.4	215	100	
	Postmenopausal	450	89.5	53	10.5	503	100	.001
	Male	258	53.5	224	46.5	482	100	

Descriptive statistics, Crosstabs, the chi-square test was used to examine difference in the prevalence of different categorical variable. P value less than 0.05 was considered as statistically significant.

Table 3: Distribution of weekly energy expenditure, PA levels and weekly PA duration by sex in relation to the presence of MetS or its absence.

Parameters	Total No. of Subjects (n=1200)	Males		P	Females		P
		MetS (n=258)	Non-MetS (n=224)		MetS (n=490)	Non-MetS (n=228)	
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Weekly energy expenditure							
MET/wk	1430.1±1519.2	905.2±965	2729.8±1762	.001	710.6±1054	2293.2±1357	.001
Kcal/wk	1857.8±1965.7	1413.7±1766	3465.3±2352	.001	1028.1±1483	2564.3±1393	.001
Physical activity levels (MET/wk)							
IA (≤ 600)	476 (39.6%)	128 (86.5%)	20 (13.5%)		318 (97.0%)	10 (3.0%)	
SA (601 to 1500)	307 (25.5%)	88 (67.7%)	42 (32.3%)	.001	116 (65.5%)	61 (34.5%)	.001
VA (≥1500)	417 (34.75%)	42 (20.6%)	162 (79.4%)		56 (26.3%)	157 (73.7%)	

MET/wk: Weekly energy expenditure in metabolic equivalents per wk.
Kcal/wk: Weekly energy expenditure in kilocalories = MET * weight (kg) / 60.
IA= Insufficiently Active; SA= Sufficiently Active; VA= Very Active.
The differences between mean were tested by using independent sample T test and one-way ANOVA. P value less than 0.05 was considered as statistically significant.

Table 4: Risk factors for MetS at different PA levels for males and females.

Parameters	Males			P	Females			P
	Activity level category				Activity level category			
	IA (n=148)	SA (n=130)	VA (n=204)		IA (n=328)	SA (n=177)	VA (n=213)	
	Mean ± SD	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	Mean ± SD	
BMI (kg/m²)	31.0±4.6	28.8±4.7	25.9±4.6	.001	35.1±6.0	30.5±5.2	26.7±5.1	.001
WC (cm)	110.4±12.3	104.1±13.2	92.6±12.1	.001	117.2±13.7	105.3±15.0	93.1±16.2	.001
FPG (mg/dl)	171.4±29.1	171.3±29.1	164.7±24.9	.031	169.9±33.4	173.0±27.9	168.7±26.4	.360
TGs (mg/dl)	188.2±57.5	157.9±48.9	127.1±20.7	.001	193.7±50.6	150.4±43.8	131.4±43.2	.001
HDL-c(mg/dl)	37.9±6.1	41.8±5.6	46.1±4.2	.001	41.1±7.2	49.5±7.6	53.5±6.2	.001
SBP (mmHg)	138.9±9.6	134.3±10.2	122.3±8.2	.001	141.2±9.0	130.7±11.0	121.7±9.9	.001
DBP (mmHg)	87.4±6.0	86.0±5.5	79.2±5.6	.001	89.3±5.7	83.2±7.2	78.3±6.9	.001

Activity level category measured in metabolic equivalents per week (MET/wk): IA= insufficiently active (≤600 MET/wk); SA= sufficiently active (601 to 1500 MET/wk); and VA= very active (≥1500 MET/wk).
BMI= body mass index; WC= waist circumference; FPG= fasting plasma glucose; TGs= triglycerides; HDL-c= high-density lipoprotein-cholesterol; SBP= systolic blood pressure; DBP= diastolic blood pressure.
The differences between mean were tested by using independent sample T test and one-way ANOVA. P value less than 0.05 was considered as statistically significant.

Table 5: Odds ratios of having MetS at different PA levels (According to IDF definition).

Parameters		MetS		Total		P	OR (95%CI)
		Presence	Absence	No	%		
Insufficiently active (≤ 600 MET/wk)	Yes	446 (93.7%)	30 (6.3%)	476	100		
	No	302 (41.7%)	422 (58.3%)	724	100	.001	.048 (.03-.072)
Sufficiently active (601 to 1500 MET/wk)	Yes	204 (66.4%)	103 (33.6%)	307	100		
	No	544 (60.9%)	349 (39.1%)	893	100	.084	.787 (.59-1.03)
Very active (≥ 1500 MET/wk)	Yes	98 (23.5%)	319 (76.5%)	417	100		
	No	650 (83.0%)	133 (17.0%)	783	100	.001	15.9 (11.8-21.3)

MET/wk: metabolic equivalents per week
The presence of MetS at different PA levels was calculated, using odds ratio and confidence interval of each risk factor. P value less than 0.05 was considered as statistically significant.

Table 6: Distribution of the study population by diabetes complications variables in relation to the presence of MetS or its absence and at different PA levels.

Diabetes complications		Activity level category						*P*	Metabolic syndrome				Total		*P*
		IA (n=476)		SA (n=307)		VA (n=417)			Presence		Absence				
		No.	%	No.	%	No.	%		No.	%	No.	%	No.	%	
Eye problems	Yes	348	73.1	161	52.4	185	44.4		518	74.6	176	25.4	694	100	
	No	128	26.9	146	47.6	232	55.6	.001	230	45.5	276	54.5	506	100	.001
Kidney problems	Yes	89	18.7	23	7.5	18	4.3		122	93.8	8	6.2	130	100	
	No	387	81.3	284	92.5	399	95.7	.001	626	58.5	444	41.5	1070	100	.001
Protein in urine	Yes	361	75.8	159	51.8	118	28.3		512	80.3	126	19.7	638	100	
	No	115	24.2	148	48.2	299	71.7	.001	236	42.0	326	58.0	562	100	.001
Heart problems	Yes	59	12.4	14	4.6	14	3.4		84	96.6	3	3.4	87	100	
	No	417	87.6	293	95.4	403	96.6	.001	664	59.7	449	40.3	1113	100	.001
Extremities problems	Yes	187	39.3	54	17.6	23	5.5		235	89.0	29	11.0	264	100	
	No	289	60.7	253	82.4	394	94.5	.001	513	54.8	423	45.2	936	100	.001
Neurological problems	Yes	467	98.1	286	93.2	353	84.7		721	65.2	385	34.8	1106	100	
	No	9	1.9	21	6.8	64	15.3	.001	27	28.7	67	71.3	94	100	.001

Activity level category measured in metabolic equivalents per week (MET/wk): IA= insufficiently active (≤600 MET/wk); SA= sufficiently active (601 to 1500 MET/wk); and VA= very active (≥1500 MET/wk).
Descriptive statistics, Crosstabs, the chi-square test was used to examine difference in the prevalence of different categorical variable. P value less than 0.05 was considered as statistically significant.

DISCUSSION

To the best of our knowledge, this is the first report, which describes the relationship between PA and MetS among T2DM patients in Gaza Strip, Palestine. The main findings of this study indicate that low levels of PA are associated with increased prevalence of MetS. Many previous studies suggest that we should expect a higher number of IA individuals in the MetS patients (18,19). Katzmarzyk et al. (20) found that PA reduced the risk for MetS among black and white women and men in Canada. Other studies have consistently found an inverse association between PA and the lack of MetS among middle-aged white men in the United States (21), middle-aged and older men and women in China (22) and adult men and women in Australia (23). Moreover, Panagiotakos et al. (24) evaluated the association between PA and the prevalence of MetS among Greek adults. The author showed that even light to moderate leisure time PA was associated with a considerable reduction in the prevalence of MetS in 3042 men and women from the general population. The results of this study support these

findings. In addition, according to the IPAQ scoring protocol, the patients were classified based on their weekly energy expenditure as follows: IA, SA and VA (17). Roberta et al. (25) used the same method to investigate the levels of PA in patients with and without MetS. The author concluded that patients with MetS presented the same levels of PA as the individuals who did not have MetS. Our study also showed a significant inverse association between PA levels and anthropometric measurements such as BMI and WC for both sexes. Ohkawara et al. (26) in a systematic review found a dose-response effect between an increase in PA and decrease in visceral fat. Rennie et al. (27) similarly found an inverse relationship between PA and BMI and WC. Panagiotakos et al. (24) found that MetS subjects who were sedentary, both males and females, were having high WC compared to them with moderate PA. According to BMI classification results, obesity was more prevalent in subjects having sedentary PA compared to moderate physically active MetS subjects. Moreover, we found a significant association between PA levels and TGs, HDL-c and BP in both sexes (P value < 0.05). The

literature strongly supports the benefits of exercise and PA in the prevention of MetS and T2DM. Increased PA promotes weight loss, improves insulin sensitivity, increases HDL-c levels, lowers TGs levels and prevents hypertension (28,29,30,31), which are considered the main components of MetS. Finally, according to the results of this study, there were significant inverse associations between PA and diabetes complications including eye problems, kidney problems, protein in urine, heart problems, extremities problems and neurological problems among T2DM patients. Many previous studies show that a regular PA may prevent or delay diabetes and its complications (32,33,34). Moreover, the available data show that a higher degree of diabetes complication is associated with lower PA levels (35,36). The main limitations of our study include its cross-sectional design, the fact that the causal relationship could not be fully determined and the possibility of recall bias by using questionnaire-based assessment of PA. The main strength of this study was being the first study, which describes the relationship between PA and MetS among T2DM patients in Gaza Strip, Palestine, and its large sample size.

We conclude that low levels of PA are associated with increased prevalence of MetS. In addition, insufficiently active patients had a high percentage of diabetes complications among T2DM patients in Gaza Strip, Palestine.

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