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Prevalence and correlates of metabolic syndrome in an adult Lebanese population

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Summary
Aim: To assess the prevalence and correlates of metabolic syndrome in an adult population attending health centers in Lebanon.
Methods and results: A sample of 499 men and women aged 18—65 years was drawn randomly from 23 health centers, selected proportionate to their distribution in the six administrative districts across Lebanon. Using standardized techniques, anthropometric measurements were taken and biochemical analyses were conducted. Based on the International Diabetes Federation classification criteria, the overall prevalence of the metabolic syndrome ($\geqslant$2 factors additional to abdominal obesity) was 31.2% in the total sample and was significantly higher in men than women (OR = 2.31, 95% CI = 1.41—3.79). Abdominal obesity and low HDL-C were the factors that contributed most to the overall prevalence of metabolic syndrome. Lack of physical exercise was associated significantly with higher odds of metabolic syndrome, even after adjusting for baseline characteristics, energy consumption and fat intake (OR = 2.40, 95% CI = 1.02—4.51).
Conclusion: While larger population-based studies are needed, the relatively high prevalence of abdominal obesity and the negative association observed between metabolic syndrome and physical activity should trigger public health policies to institute multi-component interventions promoting physical activity and weight control nationwide.
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Introduction

Worldwide, metabolic syndrome is a major health problem associated with increased morbidity and mortality [1]. It started as a characteristic of westernized societies, but is now emerging as well in developing countries and countries of the Eastern Mediterranean Region [2]. Metabolic syndrome represents a constellation of cardiovascular risk factors, including central obesity, elevated blood pressure, hyperglycaemia, elevated triglycerides and decreased high-density lipoprotein (HDL) cholesterol [1,3]. Studies have shown consistently that it is associated with the development of diabetes and cardiovascular diseases [4—6] and with increased all-cause mortality risk [7,8]. Several definitions of the metabolic syndrome have been adopted in the literature, including that of the World Health Organization (WHO) (1999), the European Group for the Study of Insulin Resistance (EGIR) (1999) and the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) (2001), each using a different set of criteria. More recently, the International Diabetes Federation (IDF) proposed a definition, convenient for use in clinical practice and applicable to diverse populations, so that data from different studies and in various localities can be compared [1,9]. According to IDF, the metabolic syndrome is defined as central obesity, along with any two or more of the following components: raised blood pressure, triglycerides, fasting plasma glucose and low HDL cholesterol. Distinct from other definitions, the IDF definition recognizes central obesity as a necessary component and proposes a range of cut-offs for waist circumference for people from different ethnic groups.

Among its neighboring countries, Lebanon — a small middle-income country in the Eastern Mediterranean Region — has unique characteristics that render the health of its population a complex challenge: a high urbanization rate (87%), fast decline in fertility and mortality rates and a growing trend towards survival in later life, coupled with westernization and changes in lifestyle. Consequently, cardiovascular diseases, diabetes, and chronic disease risk factors, including obesity, have already emerged as the leading causes of morbidity and mortality [10—12]. Using IDF criteria, we assessed the prevalence of the metabolic syndrome and examined its correlates in an adult population in Lebanon. We also compared our results with data from the United States and Europe and with findings from selected countries in the region.

Methods

Subjects and study design

The sample was selected randomly from an adult population aged 18—65 years attending health care centers in Lebanon. Such centers, set by the government and nongovernmental organizations across all districts in Lebanon, serve primarily an underprivileged population and provide primary health care service for a minimal fee. The list of health centers ($n = 305$) was provided by the Ministry of Social Affairs, and a random sample of 23 centers was drawn proportionate to their distribution in the six administrative districts (*Muhafazats*) across the country. A total of 25 subjects were then drawn randomly from each center and were selected according to the age and sex distribution of the baseline population in the respective districts, as estimated by the Central Administration for Statistics Department [13]. Allowing for a 20% error with 95% confidence intervals and a power of 80%, the sample size for the study was determined for a one-sample comparison of proportions to a hypothesized value of 25% for the prevalence of metabolic syndrome based on a review of the literature. Pregnant and lactating women were excluded from the study sample. All selected subjects signed an informed consent before enrollment in the study, and were invited for individual testing. Refusals for blood measurements did not exceed 13%. The Institutional Review Board of the American University of Beirut approved the study protocol and field work was conducted between September 2003 and April 2004.

Baseline characteristics and dietary intake

The interview schedule covered information on socio-demographic characteristics, lifestyle and health complaints. In addition, the short version of the International Physical Activity Questionnaire (IPAQ) was used to assess patterns of habitual physical activity, where all types of activities (leisure, occupation, housework and transportation) were considered [14]. Subjects were classified into three categories: inactive, minimally active and health-enhancing physical activity (HEPA active) according to the guidelines set by the IPAQ Research Committee, 2004.

Dietary intake was assessed using 24-h dietary recall. Dietary consumption of macro- and micronutrients was analyzed using the Nutritionist Pro software (First Databank). The Middle East Food

Composition Tables were used to analyze local dishes [15].

Anthropometric and blood pressure measurements

Anthropometric measurements were taken using standardized techniques and calibrated equipment [16]. Subjects were weighed to the nearest 0.1 kg in light indoor clothing and with bare feet or stockings. Using a stadiometer, height was measured without shoes and recorded to the nearest 0.5 cm. Body mass index (BMI) was calculated as the ratio of weight (kg) to square of height (m). Overweight and obesity were defined as BMI $\geqslant$25 kg/m^2 and $\geqslant$30 kg/m^2, respectively (WHO, 1997). Using a plastic measuring tape, waist circumference was measured, to the nearest 0.5 cm, at the midpoint between the bottom of the rib cage and above the top of the iliac crest during minimal respiration. Blood pressure was measured using a mercury sphygmomanometer with subjects in a seated position, after a 5 min resting period.

Blood and laboratory measurements

A 10-ml overnight fasting blood sample was collected from each subject into a sterile serum separator tube with clot activator, by a registered nurse, for the measurement of serum lipids and glucose. Blood samples were immediately placed in an icebox, for a period not exceeding three hours. Blood samples were centrifuged and analyzed immediately after separation. Analyses for fasting blood lipids, including triglycerides (TG), HDL-C and total cholesterol (TC), and glucose were carried out using a Kodak Ektachem DT II analyzer (Johnson & Johnson Clinical Diagnostics, Inc., NY, USA). Low-Density Lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula ((TC—HDL-C—TG)/5) [17].

Statistical analyses

Means and frequencies for socio-demographic characteristics, anthropometric measurements and biochemical indices were computed for categorical and continuous variables, respectively. The metabolic syndrome was defined, based on IDF criteria [1], as subjects having abdominal obesity, defined as a waist circumference $\geqslant$94 cm in men or $\geqslant$80 cm in women, and 2 or more of the following risk factors: (1) hypertension, defined as a blood pressure value $\geqslant$130/85 mm Hg, (2) hyperglycemia, defined as a fasting glucose value $\geqslant$100 mg/dl, (3) hypertriglyceridemia, defined as a triglyceride value $\geqslant$150 mg/dl, and, (4) low HDL-C, defined as a fasting HDL-C value <40 mg/dl in men or <50 mg/dl in women. Multivariate logistic regression analysis was carried out with metabolic syndrome as the dependent variable and baseline characteristics as covariates. These included age (<29 years, 30—39, 40—49, and 50 years and over), gender, education, marital status, smoking, physical exercise, crowding index and dietary intake. Education was considered in two categories, high for attainment of secondary level education and above, and low for the remainder. Crowding index was calculated as number of persons within the household divided by the number of rooms, excluding kitchen and bathrooms. Total energy consumption and proportion of energy consumption from fat were divided into tertiles and included in the model as dummy variables with three categories [18]. Prevalence odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. Using weighted data, the Statistical Package for Social Sciences for Windows (version 14.0) was used for all computations and a *p*-value <0.05 was considered significant.

Results

The final study sample consisted of 215 men and 284 women between the ages of 18 and 65 years, with a mean age of 35.61 years (SE = 0.59). Baseline socio-demographic characteristics, levels of physical activity, anthropometric measurements and energy consumption of the study subjects are shown in Table 1, separately for men and women. More than half of the subjects were physically inactive (54.0% of men and 52.1% of women), and approximately 16% of men and women were defined as being engaged in health-enhancing physical activity (HEPA). Sixty-four percent of the study sample was overweight and around one in four subjects was obese. Mean energy intake amounted to 2087 kcal of which 38% was derived from fat consumption.

The results for biochemical analysis with the criteria used to define at risk subjects are presented in Table 2. The prevalence of all individual risk factors was higher among men than women. Differentials were most pronounced (over two-fold) for hypertriglyceridmia and high blood pressure. Approximately 59% of the participants had one or more of the abnormalities of the metabolic syndrome (Table 3). Based on the IDF criteria, the overall prevalence of the metabolic syndrome ($\geqslant$2 factors additional to abdominal obesity)

Table 1 Characteristics of the study subjects by gender

Factor	Men, *n* = 215	Women, *n* = 284	Total, *n* = 499
Socio-demographic characteristics			
Age (y), mean ± SE	35.33 ± 0.94	35.82 ± 0.76	35.61 ± 0.59
Marital status (%)			
Married	47.7	61.7	55.5
Unmarried	52.3	38.3	44.5
Academic level (%)			
⩽Elementary	11.2	16.7	14.3
Intermediate	52.6	62.4	58.1
University	36.3	20.9	27.6
Occupation (%)			
Student	19.3	12.3	15.4
Working	64.2	33.0	46.5
Retired/unemployment	16.5	8.7	12.1
Housewife	—	46.0	26.0
Levels of physical activity (%)			
Inactive	54.0	52.1	52.9
Minimally active	30.2	32.4	31.5
HEPA active[a]	15.8	15.5	15.6
Anthropometric measurements			
Body weight (kg), mean ± SE	83.33 ± 1.03	67.26 ± 0.85	74.18 ± 0.74
Height (cm), mean ± SE	173.08 ± 0.50	159.29 ± 0.42	165.24 ± 0.44
Body mass index (kg/m^2), mean ± SE	27.79 ± 0.30	26.62 ± 0.35	27.12 ± 0.24
Overweight ⩾25 (%)	72.6	57.4	64.0
Obesity ⩾30 (%)	25.6	24.7	25.1
% body fat, mean ± SE	26.56 ± 0.57	36.84 ± 0.46	32.40 ± 0.43
Waist-hip-ratio, mean ± SE	0.94 ± 0.01	0.86 ± 0.00	0.90 ± 0.00
Waist circumference (cm), mean ± SE	95.74 ± 0.89	85.46 ± 0.87	89.87 ± 0.67
M ⩾ 94 cm; F ⩾ 80 cm (%)	55.7	61.8	59.2
Energy and macronutrients			
Energy (kcal), mean ± SE	2569.44 ± 84.03	1720.80 ± 38.90	2087.18 ± 46.43
Protein (% of energy), mean ± SE	14.58 ± 0.38	13.44 ± 0.28	13.93 ± 0.23
Carbohydrate (% of energy), mean ± SE	49.17 ± 0.87	47.73 ± 0.74	48.35 ± 0.56
Total fat, (% of energy), mean ± SE	36.40 ± 0.71	39.57 ± 0.73	38.20 ± 0.52
Fiber (g), mean ± SE	25.34 ± 1.27	17.32 ± 0.57	20.78 ± 0.66

[a] HEPA active: health-enhancing physical activity.

was 31.2% in the total sample, 38.6% and 25.8% among men and women, respectively. Increased abdominal obesity (59.2%) and reduced HDL-C (49.3%) were the factors that contributed most to the prevalence of the metabolic syndrome (Tables 1, 2).

Findings of the logistic regression analysis (Table 4) show that men were significantly more likely to present with metabolic syndrome than women (OR = 2.31, 95% CI = 1.41—3.79). The prevalence of the metabolic syndrome increased consistently with increasing age. Subjects who were inactive or minimally active were significantly more likely to have metabolic syndrome than those who were HEPA active (OR = 2.40, 95% CI = 1.02—4.51; and OR = 2.33, 95% CI = 1.13—4.79).

Discussion

Using the IDF definition, the prevalence of the metabolic syndrome among adults attending health centers, aged 18—65 years old, was shown to be 31.2% with men presenting with a significantly higher rate than women. Abdominal obesity and to a lesser extent reduced HDL-C levels appeared to be the main factors that contributed to the syndrome. Lack of physical exercise was associated significantly with metabolic syndrome even after controlling for baseline characteristics, dietary intake and energy consumption.

Various definitions of the metabolic syndrome have been used in the literature with different sets

Table 2 Biochemical indices of the study subjects by gender (mean ± SE; % at risk)

	Men Mean ± SE	Women	Total
Total cholesterol (mg/dl)	191.96 ± 3.17	189.84 ± 2.50	190.75 ± 1.97
HDL-C (mg/dl)[b]	40.14 ± 0.77[a]	51.67 ± 0.77	46.74 ± 0.61
LDL-C (mg/dl)[b]	117.48 ± 2.69	115.81 ± 2.28	116.51 ± 1.74
Triglycerides (mg/dl)	195.51 ± 11.23[a]	111.76 ± 4.32	147.85 ± 5.73
Fasting blood glucose (mg/dl)	96.92 ± 1.85[a]	91.08 ± 1.48	93.60 ± 1.16
Systolic blood pressure (mm Hg)	125.61 ± 1.05[a]	114.28 ± 0.94	119.15 ± 0.75
Diastolic blood pressure (mm Hg)	74.99 ± 0.57[a]	71.84 ± 0.55	73.19 ± 0.40
	% At risk		
Total cholesterol, ⩾200 mg/dl	42.3[a]	32.7	36.9
HDL-C: M < 40 mg/dl; F < 50 mg/dl	51.9	47.3	49.3
LDL-C ⩾130 mg/dl	39.4[a]	26.9	32.1
Triglycerides ⩾150 mg/dl	52.4[a]	22.6	35.3
Fasting blood glucose ⩾100 mg/dl	25.7[a]	17.0	20.7
Hypertension ⩾130/85 mm Hg	46.2[a]	20.1	31.2

[a] Significant differences between men and women, $p < 0.05$.
[b] HDL-C: high-density-lipoprotein cholesterol; LDL-C: low-density-lipoprotein cholesterol.

Table 3 Prevalence of metabolic syndrome as defined by IDF criteria

Number of risk factors	Men		Women		Total	
	n	%	*n*	%	*n*	%
None	93	44.3	108	38.2	201	40.8
One	11	5.2	44	15.5	55	11.2
Two	25	11.9	58	20.5	83	16.8
Three	38	18.1	46	16.3	84	17.0
Four	31	14.8	19	6.7	50	10.1
All five	12	5.7	8	2.8	20	4.1
Metabolic syndrome	81	38.6	73	25.8	154	31.2

of criteria and different thresholds for each risk factor; hence, variation in prevalence rates across studies is difficult to appraise. For comparison, we recalculated the prevalence of metabolic syndrome in our study sample using the ATP III criteria [19] and compared our results with those obtained in the region and elsewhere (Table 5). Findings indicate that the prevalence of metabolic syndrome among men in Lebanon is notably high, exceeding those in the US, Europe and most neighboring countries. While the prevalence of metabolic syndrome was comparable between the two genders in the US, Europe and the West Bank, it was higher among women than men in Turkey, Oman and Tehran [20–25]. This is likely to be attributed to sex differentials in the prevalence rates of abdominal obesity in these countries. For example, while women in the US and European studies [20,21] were two times more likely to show abdominal obesity compared to men, in Tehran [25] and Oman [24], women were around 4–10 times more likely (46.0% vs. 10.0%; and 44.3% vs. 4.7%; respectively).

Abdominal obesity was notably high in our study sample reaching around 56% and 62% in men and women, respectively, and this contributed the greatest share to the prevalence of metabolic syndrome. Similarly, our study findings revealed that over 64% are overweight and about 1 in 4 is obese. These estimates, derived from a population attending health centers in Lebanon, are to some extent higher than those established from an earlier national population-based study (53% and 17%, respectively) [12] suggesting that obesity is not a characteristic solely of affluent societies. Recent evidence indicates that, as elsewhere in the developed world, the prevalence of obesity in countries of the Middle Eastern region including Lebanon is likely to rise in the years ahead [12]. In fact, current prevalence rates of obesity in such countries as

Table 4 Associations of metabolic syndrome with baseline co-variates: prevalence, odds ratios (ORs) and their 95% confidence intervals (CIs)

Variable (reference category)	OR (95% CI)
Gender	
Female	1
Male	2.31* (1.41–3.79)
Age (years)	
<30	1
30–39	2.72* (1.36–5.45)
40–49	3.93* (2.00–7.70)
⩾50+	9.54* (4.12–22.10)
Marital status	
Married	1
Unmarried	0.81 (0.44–1.50)
Education	
High	1
Low	1.26 (0.78–2.05)
Crowding index	
<1 person	1
⩾1 person	0.82 (0.51–1.34)
Smoking	
No	1
Yes	0.77 (0.47–1.27)
Physical activity	
HEPA active	1
Minimally active	2.33* (1.13–4.79)
Inactive	2.40* (1.02–4.51)
Energy consumption (kcal)	
⩽1545	1
1545–2259	1.09 (0.58–2.05)
⩾2259	0.89 (0.50–1.58)
Energy consumption from fat (%)	
<20	1
20–35	1.11 (0.66–1.86)
>35	1.10 (0.38–3.21)
Fiber intake (g) per 1000 kcal	
⩽14	1
>14	1.25 (0.73–2.14)

*$p < 0.05$.

Kuwait and Jordan are alarmingly high, particularly among females (40.6% and 59.8%, respectively), placing them among the highest rates in the world [26,27].

Consistent with results from other studies [20,28–30], metabolic syndrome was inversely associated with participation in physical activity. This association remained robust after adjustment for baseline sociodemographic variables and dietary intake. Numerous mechanisms have been suggested in the literature as contributing to a protective effect of physical activity on the metabolic syndrome. Physical activity directly improves insulin sensitivity [31,32] and higher levels of physical activity have favorable effects on individual risk factors of the metabolic syndrome [31–34]. Baseline data from this study revealed elevated levels of physical inactivity among adults (52.9%). These rates are higher than those reported in several member states of the EU (range 8–40%, average 32%) [35], as well as, in a recent study conducted in Brazil (41%) using the same measurement tool (IPAQ) as in the present study [36]. Whereas it is now well established that regular physical exercise, a modifiable risk factor, is key in weight loss and weight maintenance [37,38], physical activity as a method to lose weight was least common among overweight subjects and those of lower socioeconomic status in a recent study conducted among adolescents in Lebanon [39].

The findings of this study should be considered in light of the following limitations. Because this was a cross-sectional study, the directionality of the associations cannot be established with confidence. It is possible that subjects who reported low levels of physical activity may have reduced their activity as a result of having metabolic syndrome, or alternatively, the association between physical activity and metabolic syndrome may be the result of a natural selection process, whereby lean individuals with less risk factors are more likely to engage in regular physical activity. Also, social desirability bias with a tendency for respondents to underreport dietary intake and overreport physical activity may have biased our effect measures. Nevertheless, there is no reason to believe that respondents misclassified their exposure differentially by outcome status, particularly since metabolic syndrome represents a constellation of syndromes. Finally, although this study offers the advantage of being demographically representative of the adult population in Lebanon, it does focus mainly on subjects of low to medium socio-economic status; hence, findings cannot be generalized to the total population of Lebanon. Higher socio-economic strata should be considered in future studies.

In spite of the above, this is the first study, that we are aware of, to asses the prevalence of metabolic syndrome and to examine its association with physical activity in a segment of the Lebanese population. Moreover, using the IPAQ, the interview schedule measured not only vigorous activities such as sports but also low to moderate activity undertaken in leisure pursuits, housework, and transportation. Previous methods of assessing physical

Table 5 Prevalence of the metabolic syndrome in adults by gender in selected countries[a] compared with the Lebanese data

	Men (%)	Women (%)	Total (%)
United States [20]	24.0	23.4	23.7
Europe [21]	12.4	10.7	11.5
Turkey [23]	23.7	39.1	33.4
Saudi Arabia [29]	20.8	—	—
Oman [24]	19.5	23.0	21.0
Tehran [25]	24.0	42.0	33.7
West Bank [22]	17.0	17.0	17.0
Lebanon	33.0	19.8	25.4

[a] Except for the West Bank estimate which is based on the WHO criteria, all other data are estimated according to the ATP III criteria.

activity relied either on occupational or leisure-time activity, thus ignoring physical activity undertaken by housewives, for example, who constituted a large proportion of the study sample. The ability to quantify benefit from even household chores and routine daily pursuits in this study is essential to promote public health recommendations that are attainable and affordable for the majority of the population.

In conclusion, acknowledging study limitations, findings from our study indicate elevated levels of metabolic syndrome and abdominal obesity among underprivileged adults and show that preventive lifestyle changes such as physical activity may be beneficial to the metabolic syndrome cluster of cardiovascular risk factors. In the interest of further defining the relationship of physical activity with metabolic syndrome, studies that seek to examine the underlying social and psychological factors that promote active lifestyles among the Lebanese population are warranted.

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