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Adapting a Prediction Rule for Metabolic Syndrome Risk Assessment Suitable for Developing Countries

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Abstract

Background: Metabolic syndrome (MetS) is a cluster of cardiometabolic disturbances that increases the risk of cardiovascular diseases (CVD) and type 2 diabetes mellitus (DM). The early identification of high-risk individuals is the key for halting these conditions. The world is facing a growing epidemic MetS although the magnitude in Egypt is unknown. **Objectives:** To describe MetS and its determinants among apparently healthy individuals residing in urban and rural communities in Egypt and to establish a model for MetS prediction. **Methods:** A cross-sectional study was conducted with 270 adults from rural and urban districts in Alexandria, Egypt. Participants were clinically evaluated and interviewed for sociodemographic and lifestyle factors and dietary habits. MetS was defined according to the harmonized criteria set by the AHA/NHLBI. The risk of ischemic heart diseases (IHDs), DM and fatty liver were assessed using validated risk prediction charts. A multiple risk model for predicting MetS was developed, and its performance was compared. **Results:** In total, 57.8% of the study population met the criteria for MetS and were at high risk for developing IHD, DM, and fatty liver. Silent CVD risk factors were identified in 20.4% of the participants. In our proposed multivariate logistic regression model, the predictors of MetS were obesity [OR (95% CI) = 16.3 (6.03-44.0)], morbid obesity [OR (95% CI) = 21.7 (5.3-88.0)], not working [OR (95% CI) = 2.05 (1.1-3.8)], and having a family history of chronic diseases [OR (95% CI) = 4.38 (2.23-8.61)]. Consumption of caffeine once per week protected against MetS by 27.8-fold. The derived prediction rule was accurate in predicting MetS, fatty liver, high risk of DM, and, to a lesser extent, a 10-year lifetime risk of IHD. **Conclusion:** Central obesity and sedentary lifestyles are accountable for the rising rates of MetS in our society. Interventions are needed to minimize the potential predisposition of the Egyptian population to cardiometabolic diseases.

Keywords

metabolic syndrome, risk factors, prediction, fatty liver, diabetes, cardiovascular disease, risk assessment, Egypt

What Gap This Fills

What Is Already Known

- Metabolic syndrome is a cluster of the most dangerous heart attack risk factors.
- The world is facing a growing epidemic of metabolic syndrome and the magnitude in Egypt is unknown

What This Research Adds

- The magnitude of metabolic syndrome among apparently healthy Egyptians is alarmingly high
- Central obesity contributes a major role for metabolic syndrome regardless the age and gender
- Unemployment and sedentary occupations are robust predictors of metabolic syndrome
- Understanding the impact of caffeine consumption on metabolic syndrome needs to be elucidated

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Introduction

Metabolic syndrome (MetS) is a cluster of coexisting interrelated disorders that increase the likelihood of developing cardiovascular diseases (CVDs), stroke, and type 2 diabetes. MetS comprises dysglycemia; central obesity; elevated blood pressure (BP) and dyslipidemia, mainly characterized by elevated triglycerides (TGs) and decreased high-density lipoprotein cholesterol (HDL-C).[1] Cardiometabolic risk is strongly associated with the presence of visceral adiposity, which promotes insulin resistance, a prothrombotic state, dyslipidemia, hypertension, adipokine dysregulation, and proinflammation.[2,3] Early diagnosis and management of the condition will reduce health complications over the long term.[4]

MetS is a complex pathophysiological entity that originates primarily from an imbalance between calorie intake and energy expenditure. Its initiation is influenced by genetic and lifestyle factors, specifically, a sedentary lifestyle, decreased physical activity, consumption of calorie-dense foods, smoking, alcohol consumption, stress and the gut microbiome profile.[5,6]

The world is facing a growing epidemic of MetS. It is estimated that approximately one-quarter of the world's adult population (1 billion) is affected by MetS.[4] The American Heart Association (AHA) reports that 35% of US adults currently have MetS.[7] In Egypt, the burden was as high as 60.0% among the apparently healthy general adult population.[8]

To date in Egypt, limited data about the magnitude of MetS among the general population are available. The purpose of this study was to describe the frequency of MetS and silent CVD risk factors and to predict the risk of ischemic heart disease (IHD), diabetes mellitus (DM), and fatty liver among apparently healthy individuals residing in urban and rural communities in Egypt. We sought to identify which individual risk factors are strongly associated with MetS and to derive a clinical rule that best predicts risk factor clustering.

Methods

Study Design, Setting, and Population

A cross-sectional screening survey was conducted among adults older than 20 years to identify individuals with MetS among the apparently healthy population. The study was conducted in Alexandria, the second largest city in Egypt, which had an estimated population of ~5.2 million in 2018. The city comprises urban and rural districts and represents the demographics of the Egyptian population. One rural and one urban community were selected randomly. Community sensitization and announcement of the survey was performed by a community leader to facilitate the recruitment of the study participants. Banners and posters displaying information about the survey and short health promotion messages were distributed in the neighborhoods in each district.

The sample size was calculated by computer Epi-info software version 6.04. Using power of 80% to detect the prevalence of metabolic syndrome = 42%,[8] a desired degree of precision of 6% and confidence limits of 95%, the minimal required sample size was found to be 260 subjects.

Volunteering participants were consecutively enrolled in the study until the minimal required sample size was fulfilled. Participants were evaluated in a virtual clinical setting at health care centers in the selected districts.

Data Collection

A structured data collection interview questionnaire was designed and used to collect data from each participant regarding sociodemographic characteristics (age, sex, residence, marital status, occupation and level of education), personal habits and lifestyle factors (smoking, alcohol intake, substance abuse, physical exercise, and dietary habits), medical history (DM, hypertension, IHD, dyslipidemia, bronchial asthma, liver disease, renal disease), medications (antihypertensives, antidiabetics, lipid-lowering agents, corticosteroids, nonsteroidal anti-inflammatory drugs), and family history (DM, hypertension, IHD, dyslipidemia, stroke, sudden death; Supplemental Material 1, available online). All individuals involved in data collection attended a comprehensive training workshop regarding interview techniques, data collection tools, practical applications, and field guidelines.

Risk Assessment Charts and Tools

The risk of IHD, DM, and fatty liver were assessed using validated risk prediction charts. These included (*a*) the online ASCVD (atherosclerotic cardiovascular disease) algorithm for calculating the 10-year cumulative risk of heart disease or stroke,[9] (*b*) the Australian type 2 diabetes risk assessment tool (AUSDRISK),[10] and (*c*) the Non–Laboratory Screening Score for Non-Alcoholic Fatty Liver Disease (NAFLD) Risk Assessment.[11]

The original risk assessment charts were translated into Arabic (forward and backward) by an expert panel. The data collection tools were pretested in a pilot study comprising 10 adults who were not included in the final analysis. Necessary adjustments were made to the questionnaires in light of the pretest. Senior health experts verified and endorsed the face validity and content validity (kappa [κ] > 0.8), construct validity (evident concordance, confirmatory factor analysis [CFA] = 0.95) and concurrent validity (evident correlation, $r = 0.85$) of the questionnaires.

Clinical Assessment

All patients were clinically assessed for BP according to the standard procedures.[12] Anthropometric measurements were

performed. Body mass index (BMI) was calculated according to the Quetlet formula: BMI = weight (kg)/height (m^2). Waist circumference was measured to the nearest 0.5 cm using a nonstretchable tape placed horizontally midway between the inferior rib margin and the superior border of the iliac crest. Measurements were performed while the subject was standing after exhaling with the arms hanging freely.[8]

Laboratory Investigations

Five milliliters of blood was collected aseptically from each participant in vacutainer plastic tubes through vein puncture after 12 hours of fasting. Serum was prepared and stored according to the standard laboratory procedure.[13] Levels of blood lipids (total cholesterol [TC], HDL-C, and TGs) and fasting blood glucose (FBG) were analyzed by commercially available enzymatic colorimetric kits [QCA (Amposta, Spain)] using a spectrophotometer (Jenway, Keison International Ltd, Chelmsford, UK). LDL-C was calculated according to the Friedewald formula (LDL-C = TC − HDL − [TG/5]).

Case Definitions

MetS was defined according to the harmonized criteria set by the AHA/NHLBI, IDF (International Diabetes Federation), IAS (International Atherosclerosis Society), IASO (International Association for the Study of Obesity), and WHF (World Heart Federation).[1] High BP was defined as a systolic BP≥ 130 mmHg and/or a diastolic BP≥ 85 mmHg. Self-reported antihypertensive drug treatment in a patient with a history of hypertension was an alternate indicator. Diabetes was defined as FBG ≥ 126 mg/dL or use of antidiabetic medications. An FBG ≥ 100 mg/dL was an indicator of hyperglycemia. The cutoff for low HDL-C was <40 mg/dL for men and <50 mg/dL for women. LDL-C was considered high if it exceeded ≥100 mg/dL. Hypertriglyceridemia was defined as a serum TG level ≥150 mg/dL or self-reported use of antihypertriglyceridemia medications.[1]

Statistical Analysis

The collected data were reviewed for accuracy and integrity and input into computer software. Data were analyzed using a statistical software package (IBM SPSS Statistics Base 21.0). Continuous variables are presented as the mean ± standard deviation (SD). Categorical variables are expressed as numbers with proportions, n (%). Variables relevant to laboratory data were dichotomized according to prefixed cutoffs, taking into consideration the normal reference values.

Derivation of a Prediction Rule for MetS

We compared the baseline sociodemographic, clinical, and laboratory characteristics of individuals with MetS with those of non-MetS subjects. Continuous variables were compared using an independent-samples *t* test or Mann-Whitney *U* test, as appropriate. Categorical variables were compared by chi-square test or Fisher's exact test. The variables associated with MetS at the $P < .05$ significance level in univariate analyses and deemed potentially useful for clinical prediction were selected for multivariable analysis. In the analysis, we excluded the cluster variables used for the definition of MetS in the present cohort as well as the history of chronic disease. The selected variables were entered as covariates to develop a multivariable logistic regression equation by conditional (forward) stepwise elimination, with MetS being the outcome variable.

Scoring and Weighing Clinical Data

A weight equal to the β coefficients rounded to the first decimal was devised for each variable retained in the final equation. The aggregate of these weighted variables was expressed as a total score (diagnostic index) for each patient individually. This value of the total score constituted the prediction rule.

Testing the Validity and Accuracy of the Derived Clinical Prediction Rule

The total score was calculated for each participant individually using the prediction rule equation derived from the multivariate analysis. A receiver operating characteristic (ROC) curve was plotted with the total score as the test variable and MetS as the state variable. The cutoff point was identified by calculating the Youden index (Youden index = sensitivity + specificity − 1) of the total score from the ROC curve as the point corresponding to the best trade-off between sensitivity and specificity. The area under the ROC curve (AUC) was used to assess the overall predictive performance, sensitivity, specificity, positive and negative predictive values of the prediction rule. Cohen's kappa statistic was calculated as a measure of interrater reliability (interobserver agreement) between the derived prediction rule and the preset cluster diagnostic criteria of MetS.

Results

Characteristics of the Study Population

A total of 270 participants were enrolled in the study, with the majority being female (77.0%), living in rural regions (56.7%), having low literacy levels (63.3%), working (91.5%), being married (87.4%), and being nonsmokers (87.8%). The mean age (±SD) was 42.7 ± 12.7 years. Details about the sociodemographic characteristics of the study participants are shown in Table 1. High BMI was a predominate feature among the study population (25.9% overweight, 46.7% obese, and 11.5% morbidly obese;

Table1. Sociodemographics of the Study Population.[a]

		Total		Metabolic Syndrome				
				No (n = 114)		Yes (n = 156)		
		n	%	n	%	n	%	*P*
Age (years)	18 to <25	21	7.8	18	15.8	3	1.9	**<.001**
	25 to <40	92	34.1	39	34.2	53	34.0	
	40 to <55	107	39.6	39	34.2	68	**43.6**	
	55 to 83	50	18.5	18	15.8	32	**20.5**	
Mean ± SD		42.7 ± 12.7		40.1 ± 13.0		44.6 ± 12.2		**.004**
Gender	Male	62	23.0	35	30.7	27	17.3	**.010**
	Female	208	77.0	79	69.3	129	82.7	
Residence	Urban	117	43.3	46	40.4	71	45.5	.398
	Rural	153	56.7	68	59.6	85	54.5	
Education	Illiterate	101	37.4	39	34.2	62	39.7	.726
	Read and write	35	13.0	13	11.4	22	14.1	
	Primary	16	5.9	6	5.3	10	6.4	
	Preparatory	19	7.0	9	7.9	10	6.4	
	Secondary	54	20.0	24	21.1	30	19.2	
	University	45	16.7	23	20.2	22	14.1	
Occupation	Not working	23	8.5	5	4.4	18	**11.5**	**.001**
	Housewife	131	48.5	48	42.1	83	**53.2**	
	Professional	18	6.7	10	8.8	8	5.1	
	Clerical	60	22.2	24	21.1	36	23.1	
	Crafts	22	8.1	18	15.8	4	2.6	
	Farmer	12	4.4	7	6.1	5	3.2	
	Others	4	1.5	2	1.8	2	1.3	
Marital status	Married	236	87.4	98	86.0	138	88.5	.541
	Not married	34	12.6	16	14.0	18	11.5	
Smoking	Nonsmoker	237	87.8	99	86.8	138	88.5	.575
	Current smoker	19	7.0	10	8.8	9	5.8	
	Ex-smoker	14	5.2	5	4.4	9	5.8	

[a]Boldfaced values indicate significance. *P* is significant at <.05.

Table 2). BMI positively correlated with waist circumference ($r = 0.751$, $P < .001$).

Individual risk factors associated with MetS

In total, 156 (57.8%) of the study participants met the criteria for MetS. At least 1 MetS component was found in 86.7% of the participants (Figure 1). Central obesity was the most common metabolic abnormality (94.2%) [odds ratio OR (95% CI) = 12.2 (5.6-26.4)] (Figure 2). Apart from the likelihood of the cluster variables that we used to diagnose MetS (Table 2), those with MetS were more likely to be females [OR (95% CI) = 2.1 (1.2-3.8)], older than 40 years (64.1%) [OR (95% CI) = 1.8 (1.1-3.0)], of low literacy (66.7%) [OR (95% CI) = 1.4 (0.9-2.3)], and not working (66.7%) [OR (95% CI) = 2.1 (1.3-3.5)] (Table 1). High-risk waist circumference (94.2%), obesity (60.3%) and morbid obesity (17.3%) were common features among the MetS population ($P < .05$; Table 2). Participants who reported travelling to and from work on foot [OR (95% CI) = 0.32 (0.16-0.62)] or by public transportation [OR (95% CI) = 0.51 (0.29-0.91)] and those experiencing high work activity (25.4%) [OR (95% CI) = 0.19 (0.09-0.43)] were less likely to have MetS. The occurrence of MetS did not differ significantly with regard to practicing physical exercise or dietary habits, although a lack of physical exercise, regular snacks between meals, and daily consumption of trans fat, salty food, red meat, and caffeine were more frequently reported by individuals with MetS. Interestingly, the consumption of caffeine once per week was protective against MetS [OR 95% CI = 0.074 (0.01-0.64)] (Supplemental Table S1). Self-reported chronic diseases [OR (95% CI) = 3.1 (1.8-5.3)], particularly hypertension [OR (95% CI) = 8.5 (2.5-28.5)] and DM [OR (95% CI) = 3.3 (1.5-7.1)] or being on medications for these diseases [OR (95% CI) = 2.7 (1.6-4.5)] were strongly associated with MetS. Likewise, participants with MetS were more likely to have a family history of chronic diseases [OR

Table 2. Components of Metabolic Syndrome Among the Study Population.[a]

			Metabolic Syndrome					Sex				
	Total		No (n = 114)		Yes (n = 156)			Male (n = 62)		Female (n = 208)		
	n	%	n	%	n	%	*P*	n	%	n	%	*P*
High-risk waist circumference	207	76.7	60	52.6	147	**94.2**	**<.001**	27	43.5	180	86.5	**<.001**
Hypertension	88	32.6	24	21.1	64	**41.0**	**.001**	20	32.3	68	32.7	.949
Newly diagnosed hypertension	45	16.7	15	13.2	30	**19.2**	.186	14	22.6	31	14.9	.155
Glucose intolerance	47	17.4	4	3.5	43	**27.6**	**<.001**	7	11.3	40	19.2	.148
Newly diagnosed DM	15	5.6	1	0.9	14	**9.0**	**.004**	3	4.8	12	5.8	.779
Hypertriglyceredemia	66	24.4	5	4.4	61	**39.1**	**<.001**	16	25.8	50	24.0	.771
Low HDL	122	45.2	28	24.6	94	**60.3**	**<.001**	25	40.3	97	46.6	.381
Elevated LDL	210	77.8	79	69.3	131	**84.0**	**.004**	45	72.6	165	79.3	.262
BMI (kg/m^2)												
18.5-24.99 (normal weight)	36	31.6	7	4.5	36	31.6	**<.001**	22	35.5	21	10.1	**<.001**
25-29.99 (overweight)	42	36.8	28	17.9	42	36.8		19	30.6	51	24.5	
30-39.99 (obese)	32	28.1	94	60.3	32	28.1		18	29.0	108	51.9	
40+ (morbid obesity)	4	3.5	27	17.3	4	3.5		3	4.8	28	13.5	

Abbreviations: DM, diabetes mellitus; HDL, high-density lipoprotein; LDL, low-density lipoprotein; BMI, body mass index.
[a]Boldfaced values indicate statistical significance. *P* is significant at <.05.

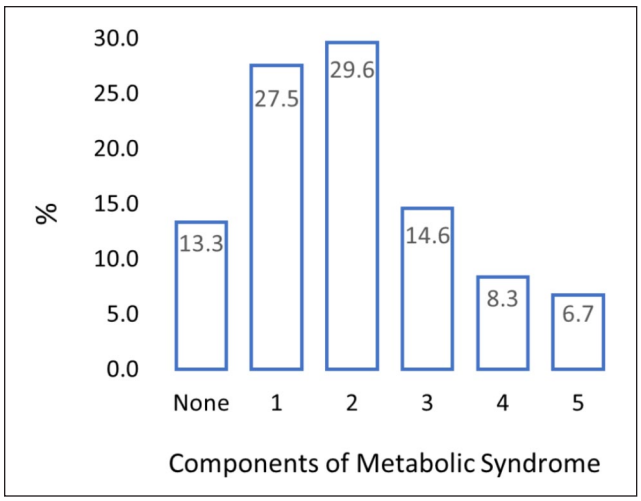


Figure 1. Clustering of metabolic syndrome risk factors in the study population.

(95% CI) = 3.8 (2.2-6.4)], particularly hypertension [OR (95% CI) = 7.5 (4.2-13.3)] and DM [OR (95% CI) =2.1 (1.2-3.4)] (Supplemental Table S2).

Risk Assessment of Coronary Heart Disease, Diabetes Mellitus, and Fatty Liver

Individuals in the MetS category had a 2.5-fold increased lifetime risk of developing coronary heart disease (CHD) [OR (95% CI) = 2.5 (1.2-5.1)]. Almost 83.7% of nondiabetic subjects with MetS had a 26.4% higher risk of developing DM [OR (95% CI) = 26.4 (3.3-209.1)]. Likewise, the risk of having fatty liver increased by 5.7-fold [OR (95% CI) = 5.7 (3.3-9.7)] (Table 3).

Silent Cardiovascular Risk Factors

We identified 55 (20.4%) subjects with silent hypertension [45 (16.7%)] or undiagnosed DM [15 (5.6%)] among the study population. The occurrence of silent CV risk factors did not differ significantly by sex, although these risk factors were more frequent among individuals who had MetS [OR (95% CI) = 2.04 (1.1-3.9)], were older than 40 years (72.7%) [OR (95% CI) = 2.2 (1.7-4.3)], were obese (50.9%) or morbidly obese (23.6%), and had hypertriglyceridemia (36.3%) ($P < .05$). Moderate and high risk of DM was predicted among 10.9% and 83.6% of the subjects with silent CV risk factors, respectively. Likewise, these participants were more likely to have a risk of fatty liver and a 10-year lifetime risk of developing CHD ($P < .05$; Supplemental Table S3).

Multivariate Model for the Prediction of MetS

In our proposed multivariate logistic regression model, the predictors of MetS were obesity [OR (95% CI) = 16.3 (6.03-44.0)], morbidly obesity [OR (95% CI) = 21.7 (5.3-88.0)], not working [OR (95% CI) = 2.05 (1.1-3.8)], and having a family history of chronic diseases [OR (95% CI) = 4.38 (2.23-8.61)]. Consumption of caffeine once per week protected against MetS by 27.8-fold [OR 95% CI = 0.036 (0.003-0.382)] (Table 4).

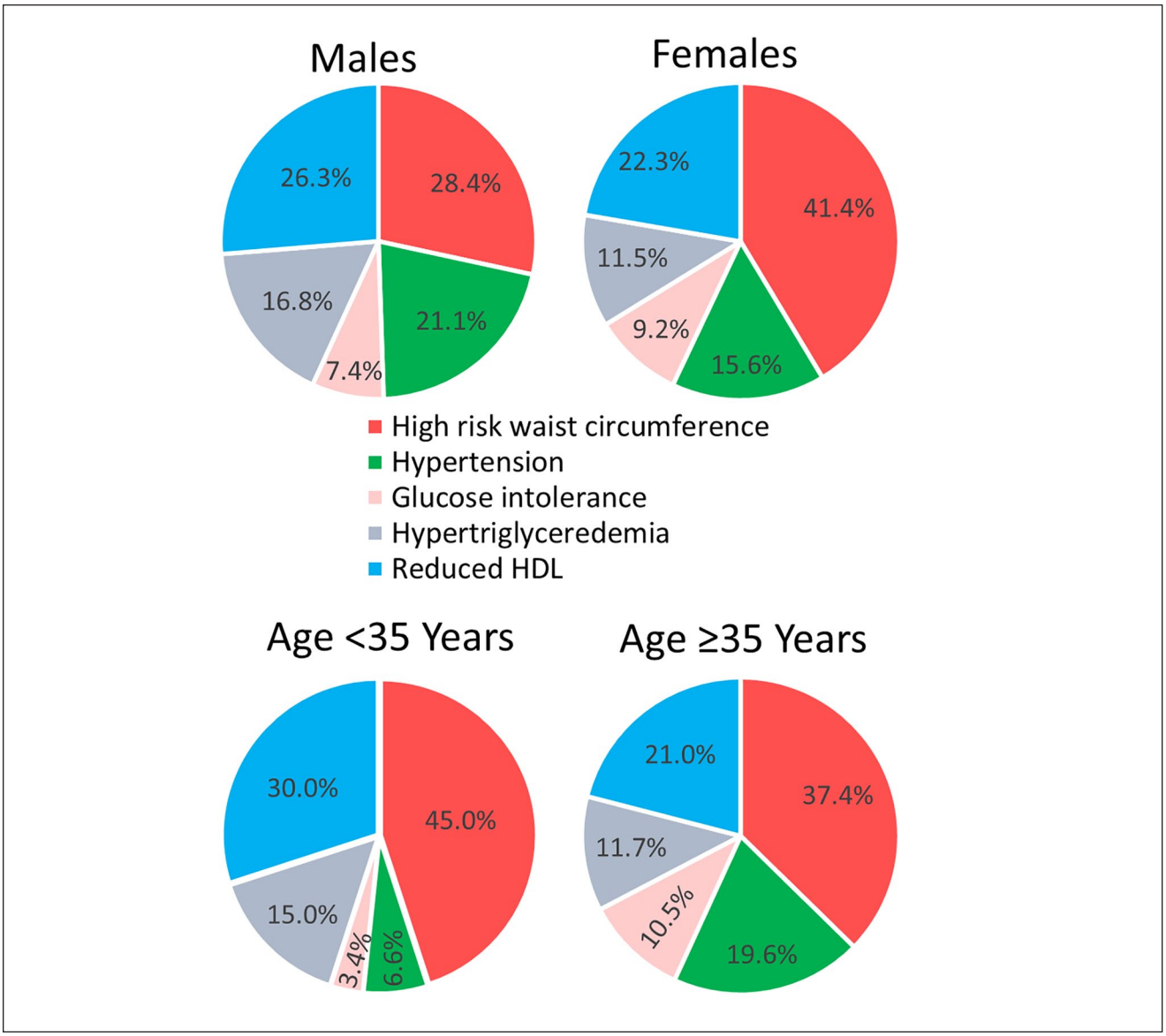


Figure 2. Relative contribution of cardiometabolic risk factors to metabolic syndrome by gender and age.

The performance of the derived prediction rule in the diagnosis of MetS is depicted in Figure 3. The prediction rule predicted MetS in 80.8% of the participants with positive and negative predictive values of 79.7% and 73.2%, respectively. The AUC for MetS probability was 0.834 (95% CI 0.795-0.890; $P < .001$). The agreement with the cluster variables used for diagnosing MetS was moderate ($\kappa = 0.528$, $P < .001$). Likewise, the model had a moderate agreement with the AUSDRISK for predicting participants with a high risk of DM ($\kappa = 0.425$, $P < .001$), although the performance was poor in detecting those with a moderate risk of diabetes ($\kappa = 0.11$, $P < .001$).

The interrater reliability between our derived model and the NAFLD screening score developed by Lee et al[11] in predicting the risk of fatty liver. was fair ($\kappa = 0.385$, $P < .001$). On the other hand, poor agreement was observed for the ASCVD algorithm ($\kappa = 0.120$, $P < .010$; Table 5).

Discussion

We identified MetS in more than half of the study population, which is comparable to the figures from other national, regional and international studies conducted in Egypt,[8,14] Saudi Arabia,[15-17] the United Arab Emirates,[18] Kuwait,[19] Oman,[20] and Turkey.[21] Lower rates were reported in Qatar

Table 3. Assessment of Cardiometabolic Risk.[a]

				Metabolic Syndrome					Sex				
		Total		No (n = 114)		Yes (n = 156)			Male (n = 62)		Female (n = 208)		
		n	%	n	%	n	%	*P*	n	%	n	%	*P*
Framingham risk score category	NA (age <30 years)	36	13.3	24	21.1	12	7.7	**.005**	7	11.3	29	13.9	**<.001**
	<10%	182	67.4	78	68.4	104	66.7		31	50.0	151	72.6	
	10% to <20%	29	10.7	7	6.1	22	**14.1**		10	16.1	19	9.1	
	20% to <30%	15	5.6	3	2.6	12	**7.7**		6	9.7	9	4.3	
	30% to <40%	4	1.5	1	0.9	3	**1.9**		4	6.5	0	0.0	
	≥40%	4	1.5	1	0.9	3	**1.9**		4	6.5	0	0.0	
DM risk	NA (diabetic)	30	11.1	3	2.6	27	**17.3**	**<.001**	4	6.5	26	12.5	.533
	Low risk (≤5)	12	4.4	12	10.5	0	0.0		2	3.2	10	4.8	
	Moderate risk (6-11)	71	26.3	50	43.9	21	13.5		17	27.4	54	26.0	
	High risk (≥12-25)	157	58.1	49	43.0	108	**69.2**		39	62.9	118	56.7	
Fatty liver risk	No	106	39.3	71	62.3	35	22.4	**<.001**	12	19.4	30	14.4	**<.001**
	Yes	164	60.7	43	37.7	121	77.6		5	8.1	50	24.0	
	<10%	42	15.6	35	30.7	7	4.5		11	17.7	72	34.6	
	10% to <25%	55	20.4	28	24.6	27	17.3		18	29.0	35	16.8	
	25% to <50%	83	30.7	30	26.3	53	**34.0**		16	25.8	21	10.1	
	50% to <80%	53	19.6	16	14.0	37	**23.7**		27	43.5	79	38.0	
	80% to 100%	37	13.7	5	4.4	32	**20.5**		35	56.5	129	62.0	

Abbreviations: NA, Not applicable; DM, diabetes mellitus.
[a]Boldfaced values indicate statistical significance. *P* is significant at <.05.

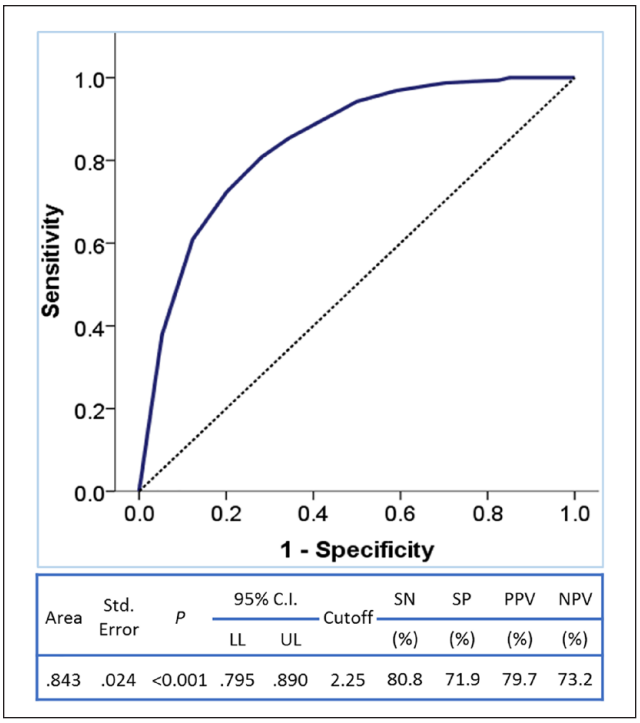
Table 4. Multivariate Logistic Regression Model for Prediction of Metabolic Syndrome.

	Multivariate					
			95% CI			
	β	OR	LL	UL	*P*[a]	Score
BMI (kg/m^2)						
18.5-24.99 (normal weight)					<0.001	
25-29.99 (overweight)	1.001	2.72	0.99	7.45	.051	1
30-39.99 (obese)	2.790	16.3	6.03	44.0	<0.001	3
40+ (morbid obesity)	3.078	21.7	5.35	88.0	<0.001	3
Occupation (not working)	0.716	2.05	1.10	3.81	.024	1
Family history of chronic diseases	1.477	4.38	2.23	8.61	<0.001	1.5
Consumption of caffeine						
Never					.039	
Once per week	−3.50	.036	.003	.382	.006	−3.5
2-4 times per week	−.084	.920	.232	3.65	.905	
Daily	−.090	.914	.348	2.40	.854	

Abbreviations: OR, odds ratio; CI, confidence interval; LL, lower limit; UL, upper limit; BMI, body mass index.
[a]*P* is significant at <.05.

(28.0%),[22] Italy (33.0% in the general population vs 70% in the obese population),[23,24] Greece (23.6%),[25] China (24.2%),[26] Mexico (41.0%),[27] India (20.0%),[28] the United States (24%-32%),[29,30] and across Europe (24.3%).[31] The growing burden of abdominal obesity and MetS and consequently the accelerated development of DM and CVD are explained by transitions toward unhealthy patterns in regard to socioeconomic characteristics, lifestyle factors, and nutritional status that are ongoing in these communities.

Because of the growing epidemic of obesity, proper identification of individuals with MetS is imperative to avert multiple predictors linked to cardiovascular



Area	Std. Error	P	95% C.I. LL	95% C.I. UL	Cutoff	SN (%)	SP (%)	PPV (%)	NPV (%)
.843	.024	<0.001	.795	.890	2.25	80.8	71.9	79.7	73.2

Figure 3. Performance of a multivariate model for the prediction of metabolic syndrome.
Abbreviations: SN, Sensitivity; SP, Specificity; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval; LL, lower limit; UL, upper limit; *P* is significant at < 0.05.

morbidity and mortality and the related healthcare costs.[32,33] Despite the attempts to harmonize the classification criteria for MetS, there remains a lack of consensus regarding the predictive variables or cutoff points.[1,34] In fact, these risk assessment models have restricted use and limited usefulness in low resource settings because they rely on pricy biochemical predictors and a limited set of variables. Moreover, the current MetS diagnostic algorithms do not factor in established CVD risk factors such as patient demographics, BMI, smoking, physical activity, dietary habits, family history, and medical events. Updating these models to incorporate emerging risk factors for IHD may improve their accuracy in risk prediction. The creation of a clinical rule for the prediction of MetS that does not require any laboratory tests would be more convenient and would provide physicians with the tools to instantly identify those at risk and compare the impact across nations and ethnic groups. In this context, we developed a tool with a high level of accuracy that requires only simple examination and a few questions. The proposed clinical rule can be widely used as a 2-stage screening method to screen apparently healthy subjects. Those found to be at high risk could benefit from further investigation to tailor a proper intervention plan. However, further community-based research is required to examine the performance of this model in different populations.

Consistent with previous studies, BMI was found to be significantly correlated with waist circumference in individuals with MetS.[35] BMI showed robust performance in estimating visceral fat measured using computed tomography compared with waist circumference.[36] A credible body of evidence supports waist circumference as a better predictor of MetS. In fact, BMI cannot account for body fat distribution.[37-40] Moreover, MetS frequently occurs in normal weight individuals.[41-43] However, a number of studies have shown that BMI is as effective as waist circumference in predicting cardiometabolic disturbances.[35,44-51] In the proposed model, obesity and morbid obesity predicted MetS by 16- to 21-fold. Accordingly, incorporating this criterion in the routine clinical assessment of MetS should not be abandoned.

Unemployment and sedentary occupations were robust predictors of MetS in the present study. The frequency of MetS among unemployed individuals, housekeepers, and clerical employees was higher than that among professionals, craftsmen, and farmers. This finding is in agreement with other studies, although there was no consistency with the category of occupational activity. A higher risk was reported among blue-collar workers than among white-collar workers,[52-55] whereas MetS was less common in writers, athletes, engineers, and scientists.[53] In fact, occupation had a positive influence on health and well-being, which was reflected by better living conditions, access to quality healthcare and adoption of a healthier lifestyle.[56,57]

A strong genetic basis of the components of MetS has been revealed in several studies.[58-61] Family history reflects both inherited genetic susceptibilities and shared environmental exposures that include cultural factors.[62] In agreement with our findings, individuals with a family history of MetS were found to have abnormal BMI and lipid disorders.[60] Moreover, individuals with a parental history of hypertension, IHD, stroke, or DM were more likely to develop MetS or insulin resistance than subjects without a family history of these conditions.[58,60] Therefore, family history of chronic diseases may be used as a primary predictor for the onset of chronic diseases later in life. Typically, family history is associated with risk awareness and risk-reducing behaviors. Thus, it can be a useful tool to identify increased-risk individuals and target behavior modifications that could potentially delay disease onset and improve health outcomes. Young people with a family history of chronic disease should be regarded as being at higher cardiometabolic risk and included in early screening and preventive efforts to reduce those inter-relating and interacting risk factors.

Diet is thought to be the key modifiable determinant of the prevention and management of MetS.[63,64] Many nutritional elements have been credibly implicated in MetS, including refined food, red meat, and fried food.[65] Whole grains[66] and a polyphenol-rich diet have an established protective effect. In the present study, dietary habits did not differ significantly in relation to MetS. It has been proposed

Table 5. Performance of a Derived Model for the Prediction of Metabolic Syndrome (MetS) Versus Some Validated Risk Assessment Tool.

Risk Assessment Tool	Measure of Agreement		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
	κ[a]	*P*[b]				
MetS cluster criteria[1]	.528	<0.001	80.8	71.9	79.7	73.2
NAFLD screening score[11]	.385	<0.001	73.8	65.1	76.6	64.6
ASCVD algorithm[9]	.120	.010	61.5	61.1	91.1	19.6
AUSDRISK[10]						
Moderate to high risk	.110	<0.001	59.6	91.7	99.3	10.7
High risk	.425	<0.001	72.6	72.3	83.2	58.3

Abbreviations: PPV, positive predictive value; NPV, negative predictive value; NAFLD, nonalcoholic fatty liver disease; ASCVD, atherosclerotic cardiovascular disease; AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool.
[a]Kappa statistics denotes strength of agreement [poor (<0.0), slight (0.0-20.0), fair (21.0-40.0), moderate (41.0-60.0), substantial (61.0-80.0), almost perfect (81.0-100.0)].
[b]*P* is significant at < 0.05.

that the incidence of MetS is greatly reduced following a Mediterranean diet (MedDiet), which has long been found to be protective against several health outcomes.[67] Traditionally, the composition of the MedDiet guarantees balanced nutrition. The MedDiet is high in whole grains, vegetables, fruits, legumes, seeds and cereals. Oil is the main dietary fat. The intake of fish, poultry, and eggs is moderate, whereas that of meat, dairy products, sweetmeats and desserts are not regularly consumed.[68]

Recent decades have witnessed the progressive erosion of the traditional Egyptian diet that has been accelerated by soaring urbanization and rapid sociocultural transitions.[69] Modern foods were introduced, and western eating habits were adopted. Fast food and generously garnished foods are becoming more popular, particularly among university students,[14] and these dietary factors effectively contribute to weight gain and increased risk of MetS and its consequences.[70-72]

Caffeine-containing drinks are the most consumed beverages in the world. It is well documented that coffee consumption has a positive effect on chronic diseases. The relationship between coffee consumption and MetS and its components has been extensively investigated (Pimentel et al,[73] Shang et al,[74] Baspinar et al[75] and references therein). The inverse association is plausible since it has been consistently demonstrated in experimental,[76,77] observational, cross-sectional and longitudinal studies in diverse populations. Long-term coffee consumption causes improvement in glucose homeostasis and insulin sensitivity.[78] Coffee consumption was found to be effective for body weight and waist circumference reduction by increasing lipolytic activity and energy expenditure.[75] Furthermore, coffee is an important source of antioxidants.[79] More than 400 mg of caffeine/day has generally been associated with a decrease in the risk of type 2 DM.[73] Most of the studies suggest a dose-response relationship.[73] Interestingly, in the present model, the consumption of caffeine once per week reduced the odds of having MetS by 3.5-fold, while more frequent consumption did not differ significantly among the study participants. In fact, the type of coffee consumed, the method of preparation, its density and additives, and the components of coffee make the clarification of its effects difficult. In the Egyptian community, people are not aware of the importance of filtering the coffee to eliminate components that exhibit cholesterol-enhancing activity or that prolonged boiling time further enhances this effect. We should bear in mind that different studies use different diagnostic criteria for MetS, which has effectively resulted in contradictory findings.

Most factors leading to CVD have a silent course. More than half of those who die suddenly of IHD have no prior clinical symptoms of the condition.[80] In the present study, the clustering of cardiovascular risk factors, including hypertension, DM, and hyperlipidemia, was found in a considerable number of the participants with no prior cardiovascular events. Effective primary prevention requires an accurate assessment of IHD risk for more precise selection of the appropriate intervention and halting disease progression.

Study Limitations

We acknowledge several limitations. Small sample size and female preponderance bound the generalizability of the results. More females tended to participate because most of them were not working and hence were available to participate in the study. Large sample size with proportionate allocation of males and females is warranted to obtain more reliable results. The study is cross-sectional in nature; hence, causal relationships could not be ascertained. This probably did not bias the results substantially. Some of the known factors that contribute to MetS (sex, residence, smoking, dietary habits, physical activity, and occupation) were not detected as predictors in our multivariate analysis.

Moreover, genetic factors were not addressed in this study. Self-reporting bias in lifestyle practices such as diet, smoking habits, and physical activity may have affected the results. Investigating the effect of these factors on MetS and its components over the long term will elucidate the topic. There is no standardized measurement for the risk factors tested in the present study, which may be reflected in their inadequate measurement in routine primary care.

Conclusion and Recommendations

The magnitude of MetS in Egypt is alarmingly high. Several factors are involved in the etiology of MetS and should therefore be handled as a whole paying more attention to central obesity. Preventive and management plans may thus be implemented with a special emphasis on lifestyle interventions. Adequate and balanced nutrition, abandonment of harmful eating habits and regular physical activity are highly advisable to halt this emerging epidemic and prevent the spread of obesity in individuals with a normal body mass.

Authors' Note

All data are fully available without restriction by the corresponding author at ekramwassim@alexu.edu.eg and through the public data repository "Harvard Dataverse" at https://dataverse.harvard.edu/dataverse

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Author Contributions

EWAW: conceptualization, developed the theoretical framework and study design, took the lead for overall direction and planning, supervised the study implementation, data curation, analysis and interpretation of data, major contribution to writing, revised and approved final version of the manuscript.
HS: study direction and planning, supervised the study implementation, revised and approved final version of the manuscript.
FC: study direction and planning, training of the researchers, standardization of the data collection tools, supervised the study implementation, interpretation of data, revised and approved final version of the manuscript.

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Ethical Approval

The study was approved by the institutional review board and the ethics committee of the High Institute of Public Health affiliated with Alexandria University, Egypt [Ref no. 315-2018]. We sought the permission and support of the local health authorities to conduct the study in the selected districts in Alexandria. The study was conducted in accordance with the international ethical guidelines and of the Declaration of Helsinki. Informed written consent was obtained from each participant after explaining the aim and concerns of the study. Data sheets were coded by number to ensure anonymity and confidentiality of the participants' data.

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Supplemental Material

Supplemental material for this article is available online.

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