Original Article

Optimal waist circumference cutoff points for the determination of abdominal obesity and detection of cardiovascular risk factors among adult Egyptian population

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A B S T R A C T

Objective: To determine the best anthropometric measurement of obesity, and its optimal cutoff, that best predicts the presence of cardiovascular risk factors among adult Egyptian population. **Methods:** This is a cross-sectional study including a representative randomly chosen sample of the adult Egyptian population from all Alexandria Districts (the second largest governorate in Egypt) based on the multistage random technique. It included 3209 subjects (1567 men, 1642 women) aged 18–80 years from urban and rural areas. The response rate was 80.2%. History, blood pressure, and anthropometric measurements were taken. Laboratory investigations included fasting lipid profile, fasting plasma glucose, and serum uric acid. Different criteria of metabolic syndrome were used and compared. Receiver operator characteristic curve and Youden index were used to determine predictability and cutoffs. **Results:** Waist circumference (WC) is the best to predict at least two other components of the metabolic syndrome as defined by the International Diabetes Federation (IDF). The optimal WC cutoffs were 100.5 and 96.25 cm for Egyptian men and women, respectively. The Joint Interim Statement definition (JIS) of metabolic syndrome was the best to predict cardiovascular disease in both genders and diabetes mellitus in women. The prevalence of metabolic syndrome and abdominal obesity was 42.5%, 61%, respectively (ATPIII definition); 43.8%, 61% (American Heart Association definition); 44.3%, 76.4% (IDF definition); 33.8%, 51.7% (IDF definition with Egyptian cutoffs); and 41.5%, 51.7% (JIS with Egyptian cutoffs). **Conclusion:** WC cutoffs in Egyptians differ from those currently recommended. Prevalence of metabolic syndrome and abdominal obesity is high in Egypt, despite being lower on using the Egyptian cutoffs.

Key words: Abdominal obesity, cutoff point, Egypt, metabolic syndrome, waist circumference

INTRODUCTION

The metabolic syndrome is a complex of interrelated risk factors for atherosclerotic cardiovascular disease (CVD) and type 2 diabetes. These factors include dysglycemia, raised blood pressure (BP), elevated triglycerides, low high-density lipoprotein (HDL) cholesterol, and obesity (particularly central adiposity).[1-4] Over the last two decades, there has been a continuous dispute over which measure of obesity is best able to identify individuals being at increased cardiovascular risk. Compared to BMI, anthropometric measures of abdominal obesity; waist circumference (WC),

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waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) seem to be more strongly associated with metabolic risk factors, incident CVD events, and death.[5-7]

The cardio-metabolic risk associated with abdominal obesity is mainly due to the presence of visceral adipose tissue, which promotes insulin resistance, hypertension, dyslipidemia, prothrombotic state, dysregulated adipokine secretion or function, and a proinflammatory state.[8] Visceral adiposity can be precisely measured by magnetic resonance imaging, computed tomography scan, or dual energy X-ray absorptiometry; however, these techniques are too expensive and impractical for routine use. WC and WHR are the most common alternatives correlating with visceral adiposity; however, WC is more strongly associated.[9]

Many studies[5,10-13] revealed the importance of WC in predicting cardiometabolic risk factors and the adverse outcomes themselves, e.g., diabetes mellitus (DM), CVD, and mortality. However, the relations between WC and cardiometabolic risk factors or health outcomes are affected by demographic variables, most importantly race-ethnicity, sex, and age.[14] Thus, different populations may differ in the level of risk associated with a particular WC.

The International Diabetes Federation (IDF) highlighted that the cutoff level used for WC to define central obesity and metabolic syndrome should vary among different ethnic groups and suggested also that the European cutoff points would be used for Middle East countries until more specific data are available from this region.[3] However, these cutoffs may not fit for our Egyptian or Arab population.

In this study, we intended to identify which anthropometric measurement of obesity, and its cutoff points, best predicts risk factors clustering. Also, to determine which definition of metabolic syndrome best predicts the presence of DM and CVD in Egyptian population. Finally, we aimed at identifying the prevalence of abdominal obesity and metabolic syndrome comparing different definitions.

RESEARCH DESIGN AND METHODS

Study design and setting
This is a cross-sectional household survey. It was conducted in the years 2009–2011 on a representative sample of the population of Alexandria. Alexandria is the second-largest governorate in Egypt with an estimated population around 5 million in 2009. It is composed of urban, rural, and Bedouin Districts; and represents the Egyptian population from a demographic and socioeconomic perspective with male to female distribution similar to the national one (51%, 49% respectively).

Choosing the study sample was based on the multistage random technique. All the 14 districts of Alexandria Governorate were included, where the sample was distributed proportionally among them. In each district, streets were randomly selected, and a systematic random sampling method was used to select houses from among the list of houses' numbers present in the selected streets. All households were approached, and those who were eligible to the study and accept to participate were included until we reached the prespecified sample size. Exclusion criteria were pregnancy and ascites from any cause. Out of 4000 eligible subjects approached, 3209 (80.2%) agreed and came to Alexandria Main University Hospital to carry out physical examination and blood sampling; the main reason for nonresponse was lack of time. The total study sample sums up to 1567 men and 1642 women aged 18–80 years.

Data collection
The study was performed according to the guidelines of the Helsinki Declaration and approved by The Ethics Committee of the Alexandria Faculty of Medicine. All participants who freely accepted to participate in the study signed a written informed consent. All subjects were interviewed by a physician to complete a questionnaire about demographic data (age, sex, occupation, and education), brief dietary and exercise history, history and family history of DM, hypertension, dyslipidemia, angina and/or ischemic heart disease (IHD), stroke, and peripheral arterial disease. Physical examination was done by a physician and included measurement of BP, weight, height, WC, and hip circumference.

Blood pressure was measured in the right arm, in the sitting position after 5 min rest, using standardized and calibrated mercury sphygmomanometer. A mean of two measurements was taken. Weight and height were measured in light clothing without shoes, using calibrated instruments, and then BMI was computed. WC was measured using a nonstretchable tape, placed horizontally midway between the inferior rib margin and the superior border of the iliac crest.[3] Measurement was taken while the subject is standing after exhaling with the arms hanging freely. Hip circumference was measured at the widest area around the hips (over the femoral greater trochanters) while the subject standing, using the same tape.[15] WHR and WHtR were calculated.

Venous blood samples were withdrawn from every subject after an overnight fast. Serum triglycerides assay was done by enzymatic colorimetric tests with glycerol phosphate oxidase. Total serum cholesterol was assayed by enzymatic colorimetric tests with cholesterol esterase and cholesterol oxidase. HDL-cholesterol was measured after precipitation of the apolipoprotein B-containing lipoproteins with

phosphotungstic acid. Low-density lipoprotein cholesterol was calculated by the Friedewald formula. Uric acid was measured using colorimetric tests. Plasma glucose was measured by a glucose oxidase method.

Definition of obesity-associated risk factors

High BP was defined as self-reported use of antihypertensive medications or a systolic BP ≥130 mmHg and or diastolic BP ≥85 mmHg.[1-3] Diabetes was defined as a fasting plasma glucose ≥126 mg/dl, or use of antidiabetic medications. Hyperglycemia was defined as a fasting plasma glucose ≥of 110 mg/dl for National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATPIII),[1] and ≥100 mg/dl as per American Heart Association (AHA) and IDF definitions of the metabolic syndrome.[2,3] Low HDL-cholesterol was defined for men as <40 mg/dl, and for women as <50 mg/dl.[1-3] Hypertriglyceridemia was defined as ≥150 mg/dl or self-reported use of antihypertriglyceridemia medications.[1-3]

Statistical analysis

Data analysis was done using Statistical Package for Social Sciences (SPSS) software (version 16, SPSS, Inc, Chicago, IL, USA). Continuous data were expressed as mean ± standard deviation. Differences between males and females in means of WC, and other quantitative variables related to the metabolic syndrome with 95% confidence interval were presented. Percentiles of WC for males and females were calculated. For assessment of agreement between different definitions of the metabolic syndrome, the Kappa statistic test (κ) was used.

The receiver operator characteristic (ROC) curve was used to describe the overall predictive value of WC, BMI, WHR, and WHtR to predict the presence of each cardiovascular risk factor, and the clustering of two or more cardiovascular risk factors which identifies metabolic syndrome. The area under the ROC curve (AURC) was used as a general measure of discrimination of a predictor. The best cutoff point was identified by calculating the Youden index (Youden index = sensitivity + specificity−1). The WC value at which the Youden index is maximal was considered the chosen cutoff point.

Odds ratio (OR) with 95% confidence interval (CI) was calculated as an estimate for the relative risk of CVD and type 2 DM in the presence (versus absence) of the metabolic syndrome according to different definitions.

Results

The study included 3209 subjects (1567 males and 1642 females). Table 1 summarizes the demographic, clinical,

and biological data of the study population. The percentile distribution of WC in adult males and females revealed equal 5th, 50th, and 75th percentiles in both genders with WC of 75, 100, and 110 cm, respectively. Other percentiles were persistently higher in females than males by 0.5–3 cm.

Accuracy of anthropometric measurement for prediction of cardiovascular risk factors:

Using the area under ROC curve (AUC), four anthropometric measurements such as WC, WHR, WHtR, and BMI were assessed regarding the ability to predict cardiovascular risk. In both genders, the four measurements could significantly predict clustering of 2 or more risk factors ($P = 0.000$). However, in males, the AUC was highest with WC, followed by WHtR, WHR, and BMI; while in females, WC had the highest AUC, followed by WHtR, BMI, and WHR. Table 2 shows the predictability of these measurements regarding each risk factor and the clustering of two or more cardiovascular risk factors. Interestingly, WC also had the highest AURC to predict general obesity and overweight in both genders.

Waist circumference cutoff points

The point with the highest Youden index was selected to represent the cutoff with highest overall accuracy for predicting at least two other components of the metabolic syndrome. In males, the optimal WC cutoff was 100.5 cm (sensitivity 59.1%, specificity of 69%) [Figure 1]. The same cutoff was the optimal one to predict general obesity (BMI ≥30 kg/m²) as well, (sensitivity 86.1% and specificity 85.5%). In females, the optimal cutoff was 96.25 cm (sensitivity 71.8%, specificity 55.4%). The cutoff point that predicted general obesity was very near to this (96.75 cm). Since WC is more importantly related

Table 1: Characteristics of the study population (*n*=3209) by sex			
Variable	Males (*n*=1567)	Females (*n*=1642)	95% CI
Age (years)	45.6±12.8	44.0±12.5	0.74-2.49
Weight (kg)	86.75±17.95	81.26±17.22	4.02-6.98
Height (meters)	1.72±0.079	1.59±0.065	0.12-0.13
Body mass index (kg/m²)	29.23±5.61	32.16±6.76	2.49-3.35
Waist circumference (cm)	98.8±14.4	99.6±14.6	−1.81-0.22
Waist to hip ratio	0.92±0.091	0.87±0.081	0.04-0.06
Waist to height ratio	0.57±0.087	0.61±0.092	0.04-0.05
Systolic BP (mmHg)	126.6±17.3	123.9±20.1	1.47-4.08
Diastolic BP (mmHg)	82.2±10.8	80.8±12.4	0.56-2.17
Total cholesterol (mg/dl)	192.6±43.7	200.2±41.8	4.61-10.53
HDL- cholesterol (mg/dl)	38.3±10.5	44.2±10.0	5.18-6.60
LDL- cholesterol (mg/dl)	127.0±37.6	132.3±35.9	2.78-7.87
Triglycerides (mg/dl)	138.8±84.4	118.4±71.6	14.97-25.97
Fasting plasma glucose (mg/dl)	106.9±53.1	105.8±49.6	−2.45-4.66
Uric acid (mg/dl)	5.1±1.6	4.1±1.4	0.91-1.12

Data are means±SD. 95% CI is the 95% Confidence Interval of the mean difference. BP: Blood pressure; HDL: High-density lipoprotein; LDL: Low-density lipoprotein

to cardiometabolic risk factors than the general obesity, we chose a WC cutoff of 96.25 cm in Egyptian females as the optimal cutoff to identify those with 2 or more cardiovascular risk factor clustering and to a good extent, the presence of general obesity.

A previous endeavor has been done by Ibrahim *et al*. on 2313 individuals.[16] However, two-thirds of them were hypertensive which would certainly affect the study outcome. Furthermore, issuing cutoff points for hypertensive versus normotensive individuals is not the usual procedure for determination of the optimal WC cutoff points in a certain population. Another point is that the data in this study was collected from files of patient studied during phase-2 of the Egyptian National Hypertension Project which was conducted 20 years ago (1991–1993); the results should have certainly changed if derived from recent data (2009–2011) since prevalence of obesity and type 2 diabetes has significantly increased in Egypt over the past two decades.[17]

The best definition to detect metabolic syndrome in the Egyptian population

Metabolic syndrome has many sets of criteria. In order to determine the best definition that could be adopted

Table 2: Accuracy of waist circumference - waist-hip ratio - waist to height ratio and body mass index - presented as area under the ROC curve - with 95% confidence interval in predicting different criteria of metabolic syndrome (according to the IDF 2005 definition) in the study population (*n*=3209) by sex

	WC		WHR		WHtR		BMI	
	AUC (CI 95%)	*P*	AUC (CI 95%)	*P*	AUC (CI 95%)	*P*	AURC (CI 95%)	*P*
Males (*n*=1567)								
Hypertension	0.725 (0.696-0.754)	0.000	0.709 (0.678-0.740)	0.000	0.697 (0.664-0.730)	0.000	0.678 (0.646-0.710)	0.000
Triglycerides	0.722 (0.697-0.748)	0.000	0.633 (0.605-0.660)	0.000	0.666 (0.631-0.700)	0.000	0.682 (0.656-0.708)	0.000
Decreased HDL- cholesterol	0.574 (0.545-0.604)	0.000	0.568 (0.538-0.598)	0.000	0.585 (0.545-0.625)	0.000	0.541 (0.512-0.571)	0.006
FPG (IDF)	0.621 (0.593-0.649)	0.000	0.591 (0.562-0.619)	0.000	0.542 (0.492-0.592)	0.109	0.583 (0.554-0.612)	0.000
Presence of ≥2 risk factors (IDF)	0.693 (0.666-0.719)	0.000	0.666 (0.639-0.692)	0.000	0.674 (0.639-0.709)	0.000	0.610 (0.582-0.638)	0.000
BMI ≥25 kg/m²	0.929 (0.915-0.943)	0.000	0.772 (0.742-0.801)	0.000	0.918 (0.899-0.937)	0.000	Non applicable	
BMI ≥30 kg/m²	0.919 (0.904-0.933)	0.000	0.707 (0.681-0.731)	0.000	0.912 (0.894-0.931)	0.000	Non applicable	
Females (*n*=1642)								
Hypertension	0.749 (0.723-0.774)	0.000	0.675 (0.647-0.704)	0.000	0.685 (0.655-0.715)	0.000	0.708 (0.681-0.735)	0.000
Triglycerides	0.663 (0.635-0.690)	0.000	0.601 (0.580-0.639)	0.000	0.625 (0.591-0.659)	0.000	0.630 (0.601-0.659)	0.000
Decreased HDL- cholesterol	0.544 (0.511-0.578)	0.008	0.539 (0.506-0.572)	0.020	0.532 (0.493-0.570)	0.101	0.519 (0.485-0.552)	0.269
FPG (IDF)	0.686 (0.660-0.712)	0.000	0.641 (0.614-0.688)	0.000	0.588 (0.543-0.633)	0.000	0.644 (0.617-0.671)	0.000
Presence of ≥2 risk factors (IDF)	0.683 (0.657-0.709)	0.000	0.615 (0.588-0.643)	0.000	0.631 (0.599-0.663)	0.000	0.619 (0.592-0.646)	0.000
BMI ≥25 kg/m²	0.936 (0.921-0.951)	0.000	0.707 (0.670-0.745)	0.000	0.921 (0.900-0.941)	0.000	Non applicable	
BMI ≥30 kg/m²	0.916 (0.902-0.930)	0.000	0.667 (0.640-0.695)	0.000	0.898 (0.880-0.915)	0.000	Non applicable	

WC: Waist circumference; WHR: Waist-hip ratio; WHtR: Waist to height ratio; BMI: Body mass index; AUC: Area under the ROC curve; CI: Confidence interval; IDF: International diabetes federation
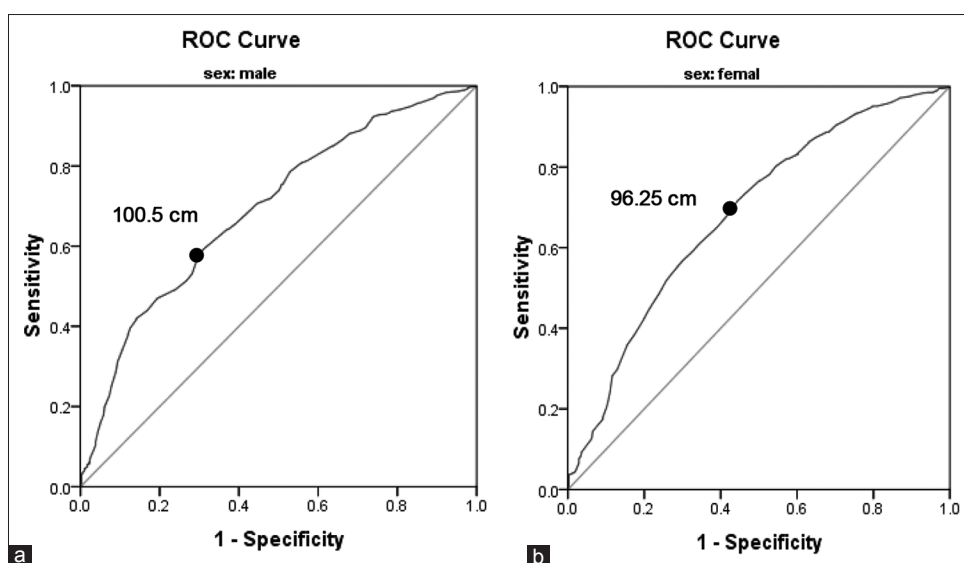

Figure 1: Receiver operator characteristic curves for waist circumference to predict the presence of at least two other components of the metabolic syndrome, as defined by the International Diabetes Federation 2005, in men (a) and women (b). Area under the receiver operator characteristic curve: 0.693 in men (a) and 0.683 in women (b). Waist circumference cutoff point: 100.5 cm in men (sensitivity 59.1%, specificity 69%) (a) and 96.25 cm in women (sensitivity 71.8%, specificity 55.4%) (b)

for the Egyptian population, we studied the ability of each definition to predict the presence of CVD and DM in the study population. In addition to NCEP-ATPIII, AHA, and IDF (with European cutoffs) definitions, we assessed two definitions using the suggested Egyptian cutoffs; the IDF, and the new 2009 definition of the Joint Interim Statement (JIS) force of the IDF Task on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; AHA; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity.[4] Table 3 shows the OR with 95% CI, in each definition.

It was found that the JIS definition with Egyptian cutoff could predict the presence of CVD in males and females better than all other definitions. Also, it was the best to predict the presence of DM in females and the third in males. IDF definition with European cutoffs was the least to predict CVD in females. IDF definition with Egyptian cutoffs was the least to predict DM in both genders and CVD in males. Thus, we recommend that the JIS definition with Egyptian cut-off points of WC is the most suitable for defining metabolic syndrome in Egyptians.

Prevalence of abdominal obesity and metabolic syndrome

Based upon NCEP-ATPIII, the prevalence of abdominal obesity was 43.3%, 78%, and 61% in men, women, and total population, respectively. It was 62.7%, 89.5%, and 76.4%, respectively according to IDF definition with European cutoffs. On applying the suggested Egyptian cutoff points using IDF or JIS definition, the prevalence was 44.9%, 76.4%, and 51.7% in men, women, and total population, respectively. Hence, it seems that NCEP-ATPIII, AHA, and the IDF definitions (with European cutoffs) have highly overestimated the prevalence of abdominal obesity, especially for females. However, using the new suggested Egyptian WC cutoff points, a more "realistic" prevalence is reached. It was noticed that the prevalence was significantly higher in females than males according to all definitions.

Similarly, the prevalence of metabolic syndrome was lower on using the suggested Egyptian cutoffs and was also significantly higher in females. Prevalence in men, women, and total population was 38.7%, 46.2%, and 42.5%, respectively according to ATPIII definition; 39.3%, 48.2%, and 43.8%, respectively according to AHA definition; 38.2%, 50.1%, and 44.3%, respectively according to IDF definition; 29.9%, 37.5%, and 33.8%, respectively according to IDF definition with Egyptian cutoffs; and finally it was 39.7%, 43.3%, and 41.5%, respectively according to JIS definition with Egyptian cutoffs definition.

Assessment of agreement between JIS and other definitions of metabolic syndrome

In the present study, we concluded that the JIS definition (with Egyptian cutoffs) is the best to be used for defining metabolic syndrome. Thus, agreement between this definition and others was assessed using Kappa statistic test. The highest grade of agreement was found between the JIS definition (with Egyptian cutoffs) and the AHA definition both in males (κ =0.992 [P = 0.000]) and females (κ = 902 [P = 0.000]), followed by ATPIII (κ = 0.979 [P = 0.000]) and (κ = 882 [P = 0.000]) respectively, then IDF (κ = 0.828 [P = 0.000]) and (κ = 826 [P = 0.000]) respectively, and lastly IDF with Egyptian cutoffs (κ = 0.787 [P = 0.000]) and (κ = 859 [P = 0.000]) in males and females respectively.

Table 3: Odd ratio and 95% CI for the presence of Cardiovascular disease and type 2 DM, presented according to different definitions of metabolic syndrome in males (*n*=1567) and females (*n*=1642)

Definitions of metabolic syndrome	Males		Females	
	CVD	Type 2 DM	CVD	Type 2 DM
ATPIII				
OR	5.488	4.407	2.629	6.575
CI	(3.889-7.745)	(3.445-5.638)	(2.021-3.420)	(5.043-8.572)
AHA				
OR	5.314	4.237	2.611	5.995
CI	(3.767-7.499)	(3.313-5.417)	(2.040-3.413)	(4.598-7.818)
IDF				
OR	4.32	3.893	2.47	6.158
CI	(3.108-6.005)	(3.052-4.965)	(1.892-3.225)	(4.691-8.083)
IDF with Egyptian cutoffs				
OR	3.574	2.714	2.595	4.96
CI	(2.614-4.886)	(2.131-3.456)	(2.008-3.353)	(3.899-6.312)
JIS with Egyptian cutoffs				
OR	5.555	4.139	2.644	7.265
CI	(3.917-7.863)	(3.237-5.291)	(2.039-3.429)	(5.585-9.452)

OR: Odds ratio; CI: Confidence interval; AHA: American heart association; CVD: Cardiovascular disease; IDF: International diabetes federation; JIS: Joint interim statement; DM: Diabetes mellitus

Relations between the prevalence of metabolic syndrome and other potential risk factors

The prevalence of metabolic syndrome was found to have a significant relation with age in both genders (higher in older groups), level of education in females (higher in illiterate), and occupation in both genders (higher in nonworking). It also has a significant relation with marital status in both genders (higher among married than single) and with residency (higher in urban than rural areas). Prevalence of metabolic syndrome was significantly higher in those with positive family history of DM, hypertension, and CVD in both genders while family history of obesity and dyslipidemia in males only. Metabolic syndrome was also more prevalent among nonexercising individuals and those with lower duration of work hours. There was no significant relation between the presence of metabolic syndrome and neither smoking, eating vegetables or fruits, nor polycystic ovary syndrome.

CONCLUSION

To our knowledge, this is the first Egyptian study that identifies WC cutoff points that best predict the presence of cardiovascular risk factors in a representative sample of adult Egyptian population regardless the presence of other co-morbidities. WC is the best anthropometric measurement that predicts clustering of two or more cardiometabolic risk factors and general obesity as well. The cutoffs are 100.5, 96.25 cm in men and women, respectively. These are higher than the Europid cutoffs currently recommended by the IDF for the Middle Eastern populations (94, 80 cm for men and women respectively).[3]

The Egyptian cutoffs differ from those reported in other Middle Eastern and African countries, e.g. Iran (89, 91 cm),[18] Oman (80, 84.5 cm),[19] Iraq (97, 99 cm in men and women, respectively),[20] Tunisia (85 cm for both genders),[21] and the recently reported South African cutoffs (86, 92 cm in men and women respectively).[22] This may be explained by the difference in ethnic origin of the Egyptians (Hamitic-Semetic)[23] from other countries in Africa or the Arab Gulf Region. Also, social and nutritional factors play a crucial role. Another contributing factor may be the difference in statistical methods used to identify the cutoff points.

Using the suggested Egyptian WC cutoffs avoids the overestimated prevalence of abdominal obesity resulting from European cutoffs. Thus, it yields a more accurate reflection of the prevalence in Egypt, yet still high especially in females. The metabolic syndrome prevalence in Egypt is high according to all definitions with women more affected than men. The JIS definition (with Egyptian cutoffs for WC) is the best to define metabolic syndrome in the Egyptian population as judged by its highest predictive ability for the presence of IHD and type 2 DM.

The prevalence in Egypt is comparable to that in some Arab countries such as Saudi Arabia (39.6% ATPIII) and United Arab Emirate (39.3% ATPIII, 40.5% IDF); however, higher than Qatar, Oman, Kuwait, Jordan, and Tunisia.[24] It is also higher than the prevalence in many European, American, and Asian countries, however, comparable to Greece, the Netherland, Brazil, and India.[25]

The high prevalence of abdominal obesity and metabolic syndrome, with its subsequent reflection on increasing CVD and diabetes burden, is explained by the socioeconomic, lifestyle, and nutritional changes which have been occurring in the Egyptian community; and some other Arab countries, toward the unhealthy pattern. Thus, national health authorities should urgently implement the proper preventive and curative plans for this emerging epidemic.

Limitations of this study include its cross-sectional design and noninclusion of subjects from all Egyptian governorates.

Conflicts of interest
There are no conflicts of interest.

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