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Prediction and Prevalence of Metabolic Syndrome in Overweight and Obese Subjects in Cameroon

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ABSTRACT

Metabolic syndrome (MS) has reached pandemic proportion and has an impact on the incidence and severity of cardiovascular pathologies. The present study evaluates the prevalence of MS, and determines the appropriate definition for the evaluation of MS in overweight and obese subjects in Cameroon. The study is cross sectional, involving 1519 subjects (18–70 years), and body mass index (BMI) (25.01 to 62.50 Kg/m²). Physiological and anthropometrical measures were taken at the first visit of the subject. Glucose and lipid parameters were analysed from the plasma of fasting subjects. NCEP-ATPIII, AHA/NHLBI, and IDF criteria were used to evaluate MS. Receiver-operating characteristic curve analysis was used to evaluate the ability of the 5 definitions to predict the prevalence of MS in Cameroon. It was observed that the prevalence of MS and its individual component's prevalence among participants vary widely across definitions. The use of the IDF definition of the metabolic syndrome leads to a higher prevalence of the metabolic syndrome than other definitions. The IDF criteria were adopted as the appropriate definition of MS in Cameroon with a prevalence of 19.80 and an ROC area of 0.79.

Keywords: anthropometry, cardiovascular diseases, hypertension, lipid profile, physiology
Abbreviations: AHA, American Heart Association; **BMI**, body mass index; **BW**, body weight; **CD**, cardiovascular diseases; **EGIR**, European Group for Study of Insulin Resistance; **IDF**, International Diabetes Federation; **MS**, metabolic syndrome; **NCEP**, National Cholesterol Education Program; **NHLBI**, National Health Lung And Blood Institute

INTRODUCTION

Metabolic Syndrome (MS) has rapidly become a household name since its introduction a decade ago by the World Health Organization (WHO) (Alberti and Zimmet 1998). MS is a constellation of metabolic abnormalities or factors such as visceral obesity, dyslipidaemia, and hyperglycaemia (Eckel *et al.* 2005). At present MS cannot be diagnosed with a single test. Several classification schemes based on cardiovascular risk factors have been proposed for the identification of the MS in clinical practise. In 1998, the WHO provided a definition of the metabolic syndrome (Alberti and Zimmet 1998). In response, the European Group for the Study of Insulin Resistance modified the WHO definition by excluding people with diabetes and including hyperinsulinaemia (Balkau and Charles 1999). In 2001, the National Cholesterol Education Program (NCEP) released a less glucocentric definition than the two others with a focus on risk of cardiovascular disease (N.I.H. 2001). The NCEP definition was revised by the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) (Einhorm *et al.* 2003; Grundy *et al.* 2004). The proliferation of definitions suggested that a single unifying definition was desirable (Ford 2004). In the hope of accomplishing this, the International Diabetes Federation (IDF) proposed a new definition of MS in April 2005 (IDF 2005). In many developing countries, MS and MS morbidity are increasing becoming a problem of importance. In China, the prevalence rate is 13% while the reported incidence in Iran is 30% (Tan *et al.* 2004). In Europe and in the USA, the prevalence rates are 15% and 25%, respectively (Deen 2004; Hu *et al*. 2004). In Cameroon very little has been reported on MS. The variation of prevalence between different definitions led Fezeu *et al.* (2006) to state that most of the existing MS definitions are not appropriate for the African population. Thus, this paper evaluates the current prevalence of MS and individual MS components in Cameroon and searches for the appropriate definition of MS in overweight and obese Cameroonians.

MATERIALS AND METHODS

The survey was conducted from May 2006 to April 2008. Participants (males and females aged 18-70) from different socioeconomic and cultural backgrounds were recruited by volunteering, after signing an informed consent form. Measurements of different parameters were done at the Laboratory of Nutrition and Nutritional Biochemistry, University of Yaoundé I, Cameroon. Delivery of nutritional advice and medical follow up were provided in compensation for participating. Pregnant, lactating women were excluded from the study.

Questionnaires

The questionnaires set comprised socio-demography, health status on hypertension, diabetes, dyslipidaemia and current medication.

Ethics

The Cameroon National Ethics committee approved this study. All measurements and questionnaire were in accordance with the Helsinki Declaration (1983 version).

Anthropometry

The anthropometric measurements were taken by the same lab workers. The height was measured with a stadiometer to the nearest millimetre (Siber Hegner, Zurich, Switzerland). Body weight and body fat were determined in 12-h fasted participants (with very light clothing on) using a Tanita™ scale. The ratio between

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Table 1 Definitions of metabolic syndrome by different organisations.

WHO 1999	EGIR 1999	NCEPATP III 2001	AHA/NHLBI 2003	IDF 2005
IR*+ ≥ 2 other criteria	IR or hyperinsulinemia (ND only) + 2 other criteria	≥ 3 criteria	3 criteria	Obesity + ≥ 2 criteria
1- IR type II diabete mellitus, IFG, IGT	1- FG at > 6.1 mmol/l (110 mg/dl)	1- FG at > 6.1 mmol/l (110 mg/dl)	1- FG at ≥ 5.6 mmol/l (100 mg/dl) and/or treatment for hyperglycaemia	1- FG at ≥ 100 mg/dl or diagnosis of diabetes mellitus
2- Dyslipidemia -Triglycerides > 1.7 mmol/l	2- Dyslipidemia -Triglycerides > 2 mmol/l and/or: -HDL < 1.0 - medical treatment	2- Hypertriglyceridemia - Triglycerides > 1.7 mmol/l and/or medical treatment	2- Triglycerides > 1.7 mmol/l (150 mg/dl) and or medical treatment	2- Hypertriglyceridemia Triglycerides > 1.7 mmol/l (150 mg/dl) and/or medical treatment
3- Low HDL < 35 mg/dl (men) < 40 mg/dl (women)		3- Low HDL < 40 mg/dl (men) < 50 mg/dl (women)	3- HDL level < 40 mg/dl (men) < 50 mg/dl (women) and/or medical treatment	3- HDL level < 40 mg/dl (men) < 50 mg/dl (women) and/or medical treatment
4- Blood pressure > 140/90 mmHg	3- Blood pressure > 140/90 mmHg and/or medical treatment	4- Blood pressure > 130/85 mmHg and/or medical treatment	4- Blood pressure > 130/85 mmHg and/or medical treatment	4- Blood pressure > 130/85 mmHg and/or medical treatment
5- Obesity > 30 Kg/m² and WHR or > 0.9 (men), 0.85 (women)	4- Abdominal obesity WC > 94 cm (men), 80 cm (women)	5- Abdominal obesity WC > 102 cm (men), 88 cm (women)	5- WC > 102 cm (men), 88 cm (women)	5- WC* ethnic specificity

AHA/NHLBI = American Heart Association/National Heart, Lung, and Blood Institute, BMI = Body Mass Index, EGIR = European Group for the Study of Insulin Resistance, Europeans, IDF = International Diabetes Foundation; IFG = impaired fasting glucose, IR = insulin resistance, NCEP ATP III = National Cholesterol Education Program Adult Treatment Panel III, ND = none diabetics, WC = Waist Circumference, WHO = World Health Organisation, WHR = waist to hip ratio.
WC* = waist circumference risk cutoffs for different ethnic groups: Men = 94 cm, Women = 80 cm; South Asia: Men = 90 cm, Women = 80 cm; Chinese: Men = 90 cm, Women = 80 cm; Japanese: Men = 85 cm, Women = 90 cm; Central America and of the south: Men = 90 cm, Women = 80 cm; Sub-Saharan Africa: Men = 94 cm, Women = 80 cm; Mediterranean of the east and Arabs: Men = 94 cm, Women = 80 cm.

the weight (Kg) to height (m) was used to evaluate body mass index (BMI). Waist and hip circumferences were taken with the subject in a standing position, to the nearest millimetre, using a non-stretchable tape measure.

Physiological measurements

Systolic and diastolic blood pressures were measured in a resting position on three different visits (day 1, 7 and 10) using a mercury sphygmomanometer. An appropriate adult cuff was applied 2 to 3 cm above the antecubital fossa of the right arm. Blood pressure was measured to the nearest 2 mm Hg, reading the calibration below the meniscus. Systolic and diastolic blood pressures were read at the 1^{st} and 5^{th} Korotkoff phases, respectively. The mean of the 3 blood pressure values obtained from the 3 visits was taken as the participant's true blood pressure.

Biochemical analyses of plasma

Fasting venous blood (5 ml) was collected from participants into heparinised tubes. After centrifugation (3000 × *g*) for 10 min, plasma collected was stored in aliquots at –80°C, and analysed within one week. Total cholesterol and triglycerides in plasma were measured using previously described methods (Buccolo and David 1973; Alain *et al.* 1974). HDL-cholesterol was determined using a heparin manganese precipitation of Apo B-containing lipoproteins (Warnick and Alberers 1978). The Friedwald formula was used to calculate the concentration of LDL-cholesterol (Friedwald *et al.* 1972). Fasting blood glucose was determined using glucose test strips (Johnson and Johnson). Insulin resistance was assessed as described by McLaughlin *et al.* (2003).

Definition of MS

Metabolic syndrome was defined as outlined by the modified WHO, EGIR, NCEP-ATPIII, AHA/NHLBI, IDF criteria (**Table 1**).

Statistical analysis

Statistical analyses were done using the STATA® 8.2 and SPSS 10.1 software, and all analyses were stratified by sex. Results are presented as means ± standard deviation, percentages (95% CI) and adjusted odds ratios (95% CI). Means and percentages between groups were compared using the Student's *t*-test. Areas under the ROC curves were compared using the method of Hanley and McNeil (1983); p values less than 0.05 were considered statiscally significant.

RESULTS

Table 2 summarizes the sex-specific values for the anthropometric and physiological variables. After adjustment for age, a significant difference was observed between men and women for some anthropometric measurements such as body fat (*P*=0.000), body mass index (*P*=0.000), waist circumference (*P*=0.040) and hip circumference (*P*=0.000). For blood lipids, only total cholesterol exhibited a significant difference (*P*=0.001) between males and females. The

Table 2 General characteristics of the study population.

Clinical and biological variables	Men (326)	Women (1193)	p value
Age (years)	34.87 ± 10.97	36.82 ± 11.28	0.006*
Body fat (%)	28.29 ± 8.28	42.40 ± 6.53	0.000*
BMI (kg/m²)	28.91 ± 3.15	30.20 ± 4.58	0.000*
Waist circumference (cm)	92.94 ± 11.66	94.50 ± 13.07	0.040*
Hip circumference (cm)	108.23 ± 10.70	112.65 ± 13.26	0.000*
WHR	0.85 ± 0.08	0.85 ± 0.30	0.506
Systolic pressure (mmHg)	126.96 ± 22.66	126.20 ± 20.76	0.549
Diastolic pressure (mmHg)	85.17 ± 16.30	83.80 ± 15.44	0.178
Glycaemia (mg/dl)	92.46 ± 29.33	90.96 ± 24.89	0.413
Total cholesterol (mg/dl)	153.25 ± 56.49	141.29 ± 47.62	0.001*
Triglycerides (mg/dl)	101.03 ± 34.73	104.48 ± 38.61	0.122
HDL cholesterol (mg/dl)	45.30 ± 17.47	47.52 ± 17.91	0.054

Data are means ± standard errors of the mean, BMI = weight/stature.
* *t*-test of the differences between means of men and women: p <0. 05.

Table 3 Prevalence of individual components of metabolic syndrome by organisational definitions.

Organisation	Men	Women	Total
Obesity			
IDF definition	40.5	85.7	76.0
WHO definition	34.7	52.1	48.4
NCEP definition	16.0	60.4	50.9
AHA definition	19.9	63.5	54.2
EGIR definition	38.4	84.1	74.1
High blood pressure			
IDF definition	58.0	53.1	54.2
WHO definition	16.0	12.2	13.0
NCEP definition	58.0	53.1	54.2
AHA definition	58.0	53.1	54.2
EGIR definition	16.0	12.2	13.0
Insulin Resistance	12.0	11.1	11.6
High blood glucose			
IDF definition	32.2	28.4	29.2
WHO definition	7.1	6.5	6.6
NCEP definition	19.3	19.7	19.6
AHA definition	32.2	28.4	29.2
EGIR definition	19.3	19.7	19.6
High lipids (High Triglycerides)			
IDF definition	9.8	10.8	10.6
WHO definition	9.8	10.8	10.6
NCEP definition	9.8	10.8	10.6
AHA definition	9.8	10.8	10.6
Low HDL			
IDF definition	7.7	7.0	7.1
WHO definition	6.7	5.2	5.5
NCEP definition	7.7	7.0	7.1
AHA definition	7.7	7.0	7.1
Dyslipidemia			
EGIR definition	46.0	43.5	44.0

The classification of central obesity or obesity for all groups where as follows: WHR (M > 0.90/ W > 0.85), WC (M > 102 cm, W > 88 cm), BMI ≥ 30 Kg/m²

Table 4 Prevalence of metabolic syndrome.

	Men (%)	Women (%)	Total (%)
IDF definition	14.1	21.4	19.8
WHO definition	4.6	5.3	5.1
NCEP definition	7.4	14.5	13.0
AHA definition	10.7	18.0	16.5
EGIR definition	6.4	8.6	8.2

Table 5 Comparison of Areas under the Receiver-Operating Characteristic Curves for different definitions of metabolic syndrome.

Definition	Area under the ROC Curve ± Standard error	Specificity %	Sensibility %
IDF	0.79 ± 0.01	96.67	15.30
WHO	0.67 ± 0.02	100.00	0.00
NCEP	0.75 ± 0.01	98.93	6.52
AHA	0.76 ± 0.03	98.13	6.06
EGIR	0.69 ± 0.01	100.00	0

ROC: Receiver-Operating Characteristic

prevalence of individual components of MS as defined by the different organisations, varied with sex as presented in **Table 3**. In general the prevalence of these components was higher in men than in women with the exception of obesity hypertriglyceridemia and hyperglycaemia as defined by EGIR and NCEP respectively. For central obesity or BMI, the IDF and EGIR cut offs gave the highest prevalence while the lowest prevalence was observed with the WHO cut offs. The high blood pressure definition and cut offs are similar for IDF and NCEP (systolic 140 mmHg, diastolic 90 mmHg) as well as for WHO and EGIR (systolic 135 mmHg, diastolic 85 mmHg). This explains the reason for observing identical prevalence for high blood pressure among the participants. Similarity in prevalence of hyperglycaemia is also observed using the IDF and AHA cut offs of 100 mg/dL, which is different from the higher WHO cut off of 126 mg/dL. For low HDL cholesterol level, IDF, AHA NCEP gave the same highest prevalence indicating similar defining cut off values while the lowest prevalence was with WHO cut offs. WHO definition lowers the diagnostic criteria of HDL cholesterol from 40–35 mg/dL in men and 50–40 mg/dL in women. With the exception of WHO, all the other definitions consider low HDL at values lower than 40 mg/dL. Only the WHO definition takes into account insulin resistance, which was observed to be higher in men than in women.

According to all MS definitions, the prevalence of MS increases from the first definition to the most recent one. Also MS prevalence is higher in women than in men (**Table 4**). In comparison, the largest difference in prevalence was found among IDF, NCEP and AHA definition and the lowest difference in prevalence was found in WHO definition. When the AHA criterion for hyperglycaemia is used with the NCEP definition, the unadjusted prevalence of the metabolic syndrome increases significantly (P=0.000) from 13% with NCEP definition to 16.5%, with AHA definition 13. **Table 5** presents the areas under the ROC curves rank-ordered. The greatest areas were for IDF definition followed by AHA definition and NCEP. These areas were statistically significantly greater than those of the other 2 definitions.

Figures below show the ROC curves for all potential definitions evaluated (**Figs. 1-5**). Sensibility represents the positive outcome. Specificity represented the negative outcome. If the area under the ROC curve equals 0.5, then there is no discrimination. If the area under the ROC curve is between 0.7 and 0.8, then the discrimination is acceptable. If the area under the ROC curve is between 0.8 and 0.9, the discrimination is excellent; if the area under the ROC curve is superior or equal to 0.9, then the discrimination is exceptional. MS was discriminated by logistic regression. The independent variables were other potential MS risk factors (socio-demographic characteristics).

DISCUSSION

The prevalence of MS varies across definitions of various medical societies like in many other studies such as those by James *et al.* (2006) or Athyros *et al.* (2005). That variation in the definition of MS inevitably leads to substantial confusion and absence of comparability in epidemiological studies, especially since we notice an increase in prevalence with each newly published definition. Therefore, in the present study, the lowest prevalence of MS was reported using the WHO definition (5.5). The ROC area, according to the WHO definition gave a bad discrimination of 0.69 (**Fig. 1**). The limited use of their definition may be linked to the use of higher blood pressure and fasting blood glucose cut points. Following the ROC curve (**Fig. 2**) the discrimination obtained with the EGIR definition was 0.69 which is below the value of 0.7 considered to be the acceptable discrimination. The increasing prevalence obtained with the EGIR definition (8.6) comparatively to the WHO definition was expected because The EGIR also modified the WHO definition by using the waist circumference, rather than the waist-to-hip ratio, to define central obesity. The waist-to-hip ratio is a direct measure of visceral adiposity (Pouliot *et al.* 1994) and is closely link to cardiovascular disease. Though EGIR gave the lowest prevalence, it is not the best criteria for defining MS since it excludes diabetic subjects (in 6.6% of the studied population in which MS is more prevalent (Isomaa *et al.* 2001; Alexander *et al.* 2003). The NCEP definition takes into consideration overall obesity with at least three MS components. It increases the prevalence of MS because in their criteria, there are no prerequisites and also the threshold value of systolic and diastolic blood pressure are lower than the two previous definitions. In our study, the NCEP definition gave an acceptable discrimination of 0.75 (**Fig. 3**) with an MS prevalence of 13.0. The AHA definition modifies the NCEP blood glucose concentration from 110 to 100 for hyperglycaemic patients. In the present study, the prevalence of MS as defined by AHA was 16.5. This definition is applicable since the ROC curve gave a discrimina-

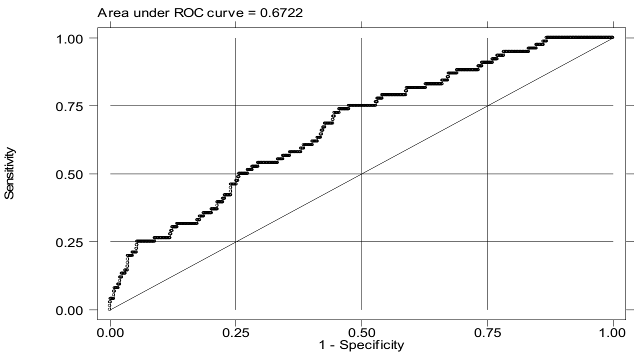

Fig. 1 Receiver-operating characteristic curves for MS criteria definition (WHO).

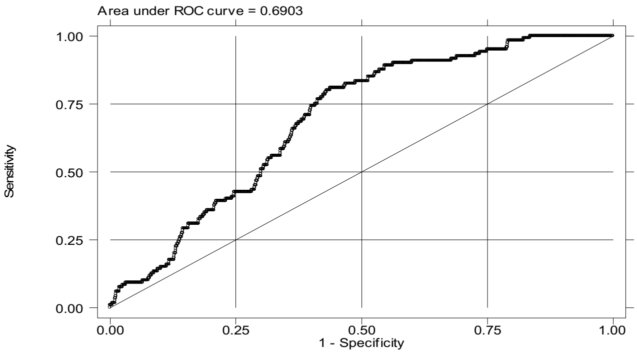

Fig. 2 Receiver-operating characteristic curves for MS criteria definition (EGIR).

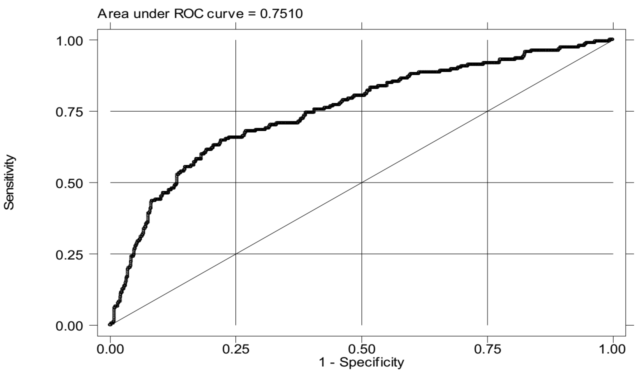

Fig. 3 Receiver-operating characteristic curves for MS criteria definition (NCEP).

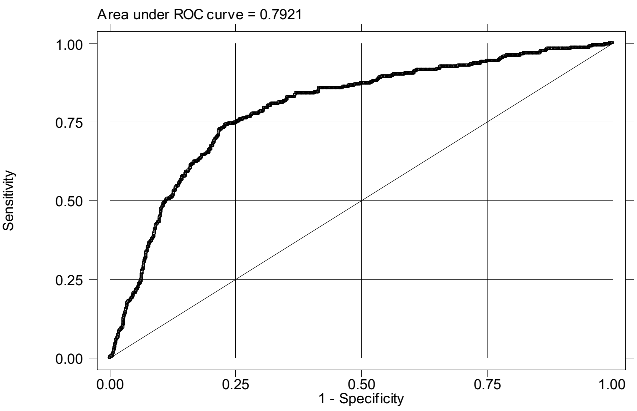

Fig. 4 Receiver-operating characteristic curves for MS criteria definition (IDF).

tion of 0.76 (**Fig. 5**) which is within the acceptable range (0.7 and 0.8) considered for the definition of MS. This definition can be applicable in Cameroon because a patient may be obese and hyperglycaemic without presenting other complications of obesity such dyslipidaemia, diabetes and

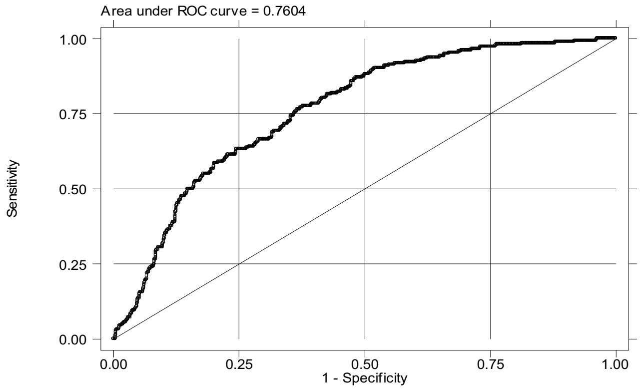

Fig. 5 Receiver-operating characteristic curves for MS criteria definition (AHA).

decreased HDL cholesterol levels. AHA, by decreasing the cut off level of blood sugar, permits the identification of pre-MS. The IDF definition takes into consideration the waist circumference as a prerequisite. The highest prevalence of MS (19.8) was obtained with IDF's definition, as in many studies (Adams *et al.* 2005; Athyros *et al.* 2005; Ford 2005; Ko *et al.* 2005; Harzallah *et al.* 2006; Ko *et al.* 2006).

High prevalence is linked to the lower thresholds of waist circumference used by the IDF for defining central obesity compared with other definition. Considering that waist circumference has ethnic specificity, the IDF definition, which has an excellent discrimination of 0.79 (**Fig. 4**), can be considered to be exceptional for defining MS, and could be the most suitable for defining MS in Cameroon. The IDF definition, by lowering the threshold value of waist circumference, blood glucose and blood pressure can predict an earlier stage determination of MS. The prevalence of MS in Cameroon was found to be 19.8. This prevalence is different from the 1.5 value previously obtained by Fezeu *et al.* (2006). This difference in results may be caused by the number and the nutritional status of the study population. In fact, Fezeu's sample size was 935 individuals including both underweight and normal weight. Another explanation can be the urbanisation growth rate recognised to be high (UN 1993). Independently of the definition used, the prevalence of MS in Cameroon is lower than that of other developing countries such as India and China (Balkau *et al.* 2002; Ford 2004) as well as developed countries such as the USA (Tan *et al.* 2004).

CONCLUSION

The variation across MS prevalence can be attributable to the selection and application of specific criteria in definition. Regardless of which definition is used, few overweight and obese Cameroonians have MS. This fact underscores the importance of promoting early healthy lifestyles (proper nutrition, weight management, and adequate physical activity) among the adult population. The IDF definition could be an appropriate definition to use for diagnosis of MS in overweight and obese Cameroonians adults.

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