# Evaluating Metabolic Syndrome Criteria in Gabonese Type 2 Diabetes Patients

Mbang Bengone A.S.[1*], Nikiema-Ndong R.[1], Nsame D.[3], Batou S.[1], Nsi Emvo E.[2] and Ovono Abessolo F.[1]

*[1]Department of Chemistry-Biochemistry, Faculty of Health Sciences, University of Health Sciences Libreville;[2]Department of Chemistry, Faculty of Sciences, University of Sciences and Techniques of Masuku, Franceville-Gabon.; [3]Unit of Endocrinology of the Centre Hospitalier Universitaire de Libreville- Gabon*

***Corresponding author**: Mbang Bengone Aude Syntia. Email address: haudess@yahoo.fr
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## Abstract

**BACKGROUND**

**Metabolic syndrome (MS) is the association of several cardiovascular risk factors. It aggravates cardiovascular complications, in diabetic subjects. Its prevalence depends on the definition used to describe it. This study aimed to compare four definitions of metabolic syndrome in type 2 diabetic subjects in Gabon.**

**MATERIALS AND METHODS**

**It was a prospective, observational study of type 2 diabetic subjects, followed at the University Hospital of Libreville. The MS was defined according to the criteria of the WHO, the National Education Program on NCEP ATP III Cholesterol, those of the International Diabetes Federation FID and the harmonized definition. Cohen's Kappa test was used to assess the two-to-two concordance between definitions and differences were significant for a p value< 0.05.**

**RESULTS**

**The panel was composed of 100 diabetics. The 4 definitions, showed the respective SM values of 41%, 71%, 64% and 78%. All methods showed that women were more affected and that abdominal obesity was the most common metabolic abnormality. The best concordance was found between the NCEP definition and the harmonized one (k= 0.82 p=0.000).**

**CONCLUSION**

**The prevalence of metabolic syndrome showed female predominance according to the 4 definitions. The NCEP ATP III and harmonized definitions gave the most consistent results within this population.**

***Keywords**: Metabolic Syndrome, Agreement, Type 2 Diabetes, Cardiovascular Risk.*

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## Introduction

The metabolic syndrome (MS), arising from dysfunction of lipid and carbohydrate metabolism, is a combination of abnormalities such as dyslipidemia, abdominal visceral obesity, insulin resistance, and hypertension. Among the origin of MS, one is, throughout the world and more particularly in Gabon, a change in lifestyle due to the increasing urbanization of the population.[1, 2] Many consequences emerge from MS, including cardiovascular diseases and diabetes, which are difficult to manage medically.[1] In addition, type 2 diabetes, the most common form of diabetes, and MS are individually associated with the risk of stroke and heart disease.[3] This implies a considerable increase in the risk of cardiovascular disease among diabetic subjects with MS.[4, 5, 6] Therefore, a growing increase in the consequences of the presence of MS in diabetics has been reported.[4, 7, 8] Indeed, the prevalence of diabetes has increased from 108 million in 1980 to 537 million in 2021 and could increase by

51% worldwide and 143% in Africa by 2045.[9] In Gabon, the prevalence of diabetes was 7% for a population of 2 million and represented one of the highest prevalence's in Africa.[9]

Nevertheless, several criteria for defining MS have been established. First, those of WHO in 1999, followed by the National Cholesterol Education Program, Adult Treatment Panel III (NCEP ATP III) in 2001, then the International Diabetes Federation (IDF) in 2005 and harmonized in 2009.[10, 11, 12, 13] However, studies have shown that the prevalence of MS varied according to different diagnostic criteria's used.[14] Therefore, a more precise diagnosis of MS in diabetics would be important to initiate adequate preventive and therapeutic measures. Thus, this work was initiated to compare four definitions of the metabolic syndrome among type 2 diabetics in Gabon in determining the prevalence of MS.

## Materials and Methods

This was a prospective observational study carried out between September and November of 2020. Among people declared diabetic according to ADA (American Diabetes Association) criteria, from 2020.[15]

Patient recruitment took place at the Endocrinology Department of the University Hospital of Libreville (CHUL) and the analyses were carried out at the Chemistry-Biochemistry Laboratory of the University of Health Sciences (USS). Type 2 diabetic patients over 20 years of age were included, after giving their consent. All were followed and treated at the CHUL endocrinology department. In addition, all patients declared as type 1 diabetics, pregnant women and those who refused to participate in the study were excluded from the study. A questionnaire on socioeconomic status, health behaviour, and lifestyle, supplemented by anthropometric measurements and blood sampling was performed on each individual.

Body weight was measured using a scale (TEFAL) and height in meters using a measuring tape. The body mass index in $kg/m^2$ (BMI) was calculated by dividing the weight (kg) by the height ($m^2$) squared. Then abdominal circumference was measured using a tape measure, according to the method of Luca and Schlienger, 2010. Waist circumference (WC), was measured using a flexible but non-stretchable graduated tape, with an accuracy of 0.1 cm. The measurement was taken midway between the last rib and the iliac crest. Blood pressure (BP) was measured with a sphygmomanometer (BEURER) after 5 minutes of rest. Glucose, total cholesterol and triglycerides, were measured with a Mindray BS 200® spectrophotometer by colorimetric and enzymatic methods using BIOLABO reagent kits.[16, 17] HDL cholesterol was obtained after precipitation of the other fractions by phosphotungstic acid.[18] Then LDL cholesterol was obtained by calculation using Friedwald's formula, after making sure that the serum concentration of triglycerides was below 4 mM.[19]

Metabolic syndrome was diagnosed according to 4 definitions (Table 1). Data were entered into Excel 2013, then analyzed on Epi Info version 7 and Med Calc. Quantitative variables were expressed as the mean and its standard deviation, and compared by ANOVA test and qualitative variables were expressed as percentages with 95% CI by Chi-square test. Cohen's Kappa (K) test was used to assess the pairwise agreement between the 4 definitions used. The agreement between the two tests was qualified as very poor, poor, moderate, strong, and excellent according to threshold values, $\leq$ 0.20, [0.21-0.40], [0.41-0.60], [0.61- 0.80], >0.80, respectively.[20] The difference in results was significant for p-value <0.05.

### Ethical considerations

The National Ethics Committee approved the study with the reference number: PROT N°015/2018/PR/CNE. All diabetics who met the inclusion criteria and consented to participate in the study signed an informed consent form before being included.

## Results

The sample consisted of 100 diabetics, with a female predominance of 57% and a mean age of 55.7 ± 10.4 years. The mean body mass

index was 26.9 ± 9.0 kg/m$^2$ with a mean abdominal circumference of 97.1 ±14.1 cm. Almost all patients did not smoke (99%). Nevertheless, nearly 15% of the patients consumed alcohol (p=0.023). Biological parameters showed that the study population had, in general, a normal lipid balance, however, the average blood glucose level was high (8.0 ± 4.1 mmol/L) (Table 2).

After the assessment of the different criteria, it was observed that the highest proportions were provided by the harmonized definition (JIS), followed by the IDF; while the WHO had the lowest prevalence, with values of 78%, 71% and 41% respectively. In addition, all 4 definitions showed that women were more affected by the metabolic syndrome than men (Table 3).

For this work, the most represented metabolic abnormality was the latter according to the 3 most recent definitions used (NCEP ATP III, IDF, JIS), followed by hypertension, whereas HDL hypocholesterolemia and hypertriglyceridemia were in the minority with proportions of 49% and 6%, respectively. This would mean that the majority of the population was hypertensive, associated with abdominal obesity (Table 3).

In addition, the kappa test showed that the best agreement was found between the NCEP definition and that of the JIS, while the lowest was found between the IDF and the WHO (Table 4).

***Table 1:***
Different criteria for metabolic syndrome diagnosis. [10, 11, 12, 13]

| Diagnostic criteria of MS | Blood pressure (mmHg) | Fasting blood glucose (mmol/L /mg/dl) | Insulin resistance or Glucose intolerance | Micro-albuminuria (mg/min) | TG (mmol/L /mg/dl) | Rapport Weight/Height or BMI (lg/m)/(kg/m²) | HDL (mmol/L /mg/dl) | Abdominal perimeter (cm) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | **M** ***W*** | **M** ***W*** | **M** ***W*** |
| WHO (1999) (Diabetic or GI obligatory and 2 other criteria) | ≥140/90 | - | Yes | ≥ 20 | ≥ 1.7/150* | > 0.90 Or ≥ 30 *> 0.85Or≥ 30* | < 0.9/35 *< 1.0/39* | - - |
| NCEP-ATP III (2001) (Presence of 3/5 criteria) | ≥130/85 * | ≥ 6.1/110* | - | - | ≥ 1.7/150* | - - | < 1.03/40 *< 1.29/50* | ≥102 *≥88* |
| IDF (2005) (Abdominal obesity obligatory + 2 others criteria) | ≥130/85* | ≥ 5.6 /100* | - | - | ≥ 1.7/150* | - - | < 1.03/40 *< 1.29/50* | ≥94 *≥80* |
| JIS (2009) (Presence of 3/5 criteria) | ≥130/85* | ≥ 5.6 /100* | - | - | ≥ 1.7/150* | - - | < 1.03/40 *< 1.29/50* | ≥90 *≥80* |

NB: *=or under treatment
TG: Triglyceride; BMI: Body mass index; HDL: High Density Lipoprotein;
M: Men; ***W: Women***
Abdominal perimeter values are African ones
JIS: Joint Interim Statement
IDF: International Diabetes Federation
NCEP-ATP III: National Cholesterol Education Program, Adult Treatment Panel III

***Table 2:***
Sociodemographic and biological parameters of the study population

| Parameters | Men | Women | P | Total |
|---|---|---|---|---|
| N (%) | 43 (43) | 57 (57) | | 100 (100) |
| Age (years) | 54 ± 10.6 | 566 ± 10.3 | 0.320 | 55.7 ± 10.4 |
| Weight (kg) m ± SD | 77.4 ±16.2 | 77.7 ±18.6 | 0.940 | 77.6 ± 17.5 |
| Body mass index (kg/m²) m ± SD | 25.9 ± 63 | 27.8 ± 10.7 | 0.330 | 26.9 ± 9.0 |
| Abdominal perimeter (cm) m ± SD | 95.8 ± 12.4 | 98.1 ± 15.4 | 0.440 | 97,1 ± 14,1 |
| Systolic blood pressure (mmHg) m ± SD | 141.2 ± 20.2 | 144.5 ± 28.4 | 0.023 | 143.1 ± 25.16 |
| Diastolic blood pressure (mmHg) m ± SD | 88.3 ± 15.2 | 86.4 ± 11.2 | 0.038 | 87.47 ± 13.6 |
| Total Cholesterolemia (mmol/L) | 4.4 ± 1.3 | 4.9± 1.3 | 0.053 | 4.7 ± 1.3 |
| HDL Cholesterolemia (mmol/L) | 1.2 ± 0.4 | 1.2 ± 0.5 | 0.946 | 1.2 ± 0.4 |
| Blood glucose (mmol/L) | 8.8 ± 4.7 | 7.4 ± 3.5 | 0.095 | 8.0 ± 4.1 |
| Triglyceridemia (mmol/L) | 0.9 ± 0.6 | 0.8± 0.5 | 0.672 | 0.9 ± 0.6 |
| LDL Cholesterolemia (mmol/L) | 4.4 ± 1.2 | 4.9 ± 1.3 | 0.053 | 4.7 ± 1.3 |
| Alcohol consumption (%) | | | 0.023 | |
| Yes | 25.6 | 8.8 | | 16 |
| No | 74.4 | 91.2 | | 84 |
| Tobacco consumption (%) | | | 0.430 | |
| Yes | 100 | 0 | | 1 |
| No | 57.6 | 42.4 | | 99 |

***Table 3:***
Proportion of metabolic abnormalities according to gender

| Parameters | N (%) | | | P |
|---|---|---|---|---|
| | *Men* | *Women* | *total* | |
| MS (WHO) | | | | 0.321 |
| Yes | 16(39.02) | 25(60.98) | 41 | |
| No | 27 (45.76) | 32 (54.24) | 59 | |
| MS(IDF) | | | | 0.005 |
| Yes | 21(32.81) | 43(67.19) | 64 | |
| No | 22 (61.11) | 14 (38.89) | 36 | |
| MS(NCEP ATP III) | | | | 0.000 |
| Yes | 23 (32.39) | 48 (67.61) | 71 | |
| No | 20 (68.97) | 9 (31.03) | 29 | |
| MS(JIS HARMONISED) | | | | 0.024 |
| Yes | 29 (37.18) | 49 (62.82) | 78 | |
| No | 14 (63.64) | 8 (36.36) | 22 | |
| Hypocholesterolemia HDL | | | | 0.149 |
| Yes | 18 (36.73) | 31 (63.27) | 49 | |
| No | 25 (49.02) | 26 (50.98) | 51 | |
| Hypertriglyceridemia | | | | 0.519 |
| Yes | 3 (50) | 3 (50) | 6 | |
| No | 40 (42.55) | 54 (57.45) | 94 | |
| Blood pressure | | | | 0.402 |
| Yes | 26 (41.27) | 37 (58.73) | 63 | |
| No | 17 (45.95) | 20 (54.05) | 37 | |
| Abdominal obesity JIS | | | | 0.002 |
| Yes | 27 (35.53) | 49 (64.47) | 76 | |
| No | 17 (70.83) | 7 (29.17) | 24 | |
| Abdominal obesity NCEP ATP III | | | | 0.000 |
| Yes | 12 (21.43) | 44 (78.57) | 56 | |
| No | 32 (72.73) | 12 (27.27) | 44 | |
| Abdominal obesity IDF | | | | 0.000 |
| Yes | 22 (30.99) | 49 (69.01) | 71 | |
| No | 22 (75.86) | 7 (24.14) | 29 | |

MS (Metabolic Syndrome)

## Discussion

The presence of diabetes in type 2 diabetics increases their risk of cardiovascular disease and aggravates the complications induced by this disease. The study population had a female predominance, this result is in agreement with those of the literature.[21] Moreover, the panel, had a mean age of 55.6 ± 10 years. This result is similar to those reported in India[22, 24], Saudi Arabia[23], and Burkina Faso[25]. These authors found respectively averages of, 55.6 ± 10.9; 55.6 ± 10.9; 54.7 ±9.9 and 53.5 ±13.5 years. Age is known as a factor of diabetes that could multiply the risk of the appearance of type 2 diabetes among diabetic subjects.[1] The average body mass index of the study population was 26.9 ± 9.0 kg/m², which shows a general overweight, but more accentuated at the abdominal level demonstrated by an average abdominal perimeter that was 97.1 ± 14.1 cm. This observation was also found in a previous study, [24] and could be explained by the fact that obesity is a common factor between insulin resistance of type 2 diabetes and metabolic syndrome.

Regarding the prevalence of type 2 diabetes, the harmonized and IDF definitions showed the highest proportions while the WHO definition gave the lowest. Indeed, Mohammed *et al*. made the same observation in 2022, with 78.8% for the harmonized. Moreover, Gahlan *et al*. found respectively 76.1%, 68.7%, and 26.3% for IDF, JIS and WHO.[26, 24] However, the Birrara study in 2018 and the Wondimeneh study in 2020 have shown a similar interpretation with a different order of proportions.[4, 27]

These works showed respectively that the highest prevalences were for NCEP-ATP III and IDF, while WHO had always the lowest proportion. The respective figures were 70.3%; 57% and 45.3%. However, a 2018 study conducted by Herath *et al*. proved the opposite among the Asian population with a higher WHO prevalence (70.6%), than NCEP-ATP III and IDF.[8] In addition, all 4 definitions showed that women were more affected by MS than men. This result corroborates with those of several works such as Timothy Agandah in 2022, Zineb in 2021, Gahlan in 2019, and Birrara in 2018.[28, 29, 24, 4] The impairment of women could be explained by a maldistribution of adiposity favoured by estrogen in pre-menopause. Type 2 diabetes is a collection of metabolic abnormalities. In this work, the most common abnormality was abdominal obesity, regardless of the definition used, followed by hypertension, while hypertriglyceridemia was in the minority. Android obesity is a known factor in type 2 diabetic subjects, which could explain this observation. The studies by Sebai *et al*. and Yameogo *et al*. found similar results.[30, 25] The finding of a low proportion of hypertriglyceridemia was confirmed by Ovono and colleagues in 2012.[31] However, it disagrees with most of the proportions found by other works, which found hypertriglyceridemia among the majority of abnormalities in diabetic subjects.[32] The variation of all these results confirms the observation of Wang in 2020, who showed that the prevalence of MS varied according to the definition used, sex, age and ethnicity.[33]

***Table 4:***
Degree of concordance between 4 definitions

| Definitions | Concordance | | |
|---|---|---|---|
| | Kappa indices [CI 95%] | p-value | Agreement |
| NCEP-ATPIII and JIS | 0.82 [0.69-0.94] | 0.000 | Excellent |
| IDF and JIS | 0.62 [0.46-0.78] | 0.000 | Moderate |
| IDF and NCEP-ATP III | 0.57 [0.39-0.73] | 0.000 | Moderate |
| OMS and NCEP-ATPIII | 0.29 [0.14-0.42] | 0.000 | Poor |
| OMS and JIS | 0.26 [0.12-0.39] | 0.000 | Poor |
| OMS and IDF | 0.18 [0.01-.0.35] | 0.034 | Very Poor |

Concerning the variation according to the definitions, the concordance of the results between them was studied by the Kappa test (K). It showed that the best agreement was between NCEP-ATP III and the JIS harmonized definition, while the lowest agreement was between WHO and IDF.

Pokharel *et al*. found the same results in 2014 with respective figures of k= 0.62 and k= 0.26.[6] The high concordance between the first two definitions could be explained by the fact that both use almost the same thresholds of diagnostic criteria for MS, except the threshold level of abdominal circumference which has a higher threshold in the NCEP-ATP III definition. In effect, this implies that all individuals who qualify as abdominal obese according to the NCEP-ATP III criteria were also qualified according to the harmonized definition. Abdominal obesity is a major risk factor for diabetes in the study population, further supporting this strong agreement. Moderate agreement was also found between the IDF definition and the harmonized definition for similar reasons. Here the decrease in the degree of agreement could be explained by the fact that not only is there a difference in the threshold of abdominal circumference in men, but also that this criterion is imposed in the diagnosis of the metabolic syndrome for the IDF, which is not the case in the other definition. Between the FDI and the NCEP-ATP III, the degree of concordance was moderate (k= 0, 57). This observation would be due to the same arguments listed in the previous comparison. As for WHO, it was found with the lowest degrees of agreement with the other definitions (k= 0.29; k= 0.26; k= 0.18), respectively with NCEP -ATP III, JIS and IDF. This discrepancy between WHO from the other definitions could be due to the absence of abdominal circumference among the listed WHO criteria, whereas it was taken into account in the other definitions while noting that this parameter was the predominant risk factor for MS in this population. In addition, the cut-off values for hypertension, the second major risk factor in this study, were higher according to the WHO definition than in the other definitions. This could reflect a late diagnosis of this metabolic abnormality by this definition compared with the others and could be the cause of late management, responsible for the severity of cardiovascular complications due to the latter. Metabolic Syndrome is the set of several metabolic anomalies responsible for the increase and aggravation of cardiovascular complications. Thus, for the population studied, the management of type 2 diabetic subjects could be more focused on the 2 most representative anomalies, namely abdominal obesity and arterial hypertension. That is to say, promote preventive methods to fight against overweight and hypertension among the subjects concerned. Then insert the diagnosis of MS in their follow-up to allow its early management to prevent or reduce the extension of their cardiovascular complications.

## Limitations of study

The difficulty rested on the lack of African threshold values of the waist circumference on the other criteria of definition of the metabolic syndrome.

## Conclusion

The prevalence of the metabolic syndrome is a reality in type 2 diabetics, with a female predominance. The predominant abnormality was abdominal obesity, followed by hypertension. Therefore, the management of these subjects will be more focused on these 2 risk factors to reduce the aggravation of type 2 diabetes complications caused by their association. The NCEP ATP III and harmonized definitions have given the most concordant results within this population. Thus, these two criteria could be used for evaluating metabolic syndrome among type 2 diabetes in Gabon.


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### Author's contribution

Aude Syntia MBANG BENGONE and Daniella NSAME conducted patient recruitment and blood sampling; Aude Syntia MBANG

BENGONE and Sibylle BATOU performed the analysis; Rosalie NIKIEMA-NDONG. contributed to the interpretation of the results and reviewed the article: Aude Syntia MBANG BENGONE wrote the article; and Edouard NSI EMVO, Félix OVONO ABESSOLO conceived the project. Félix OVONO ABESSOLO, had valided final content. All authors have read and approved the final article.

**Author contact email:** Aude Bengone. Email: haudess@yahoo.fr; Rosalie Nikiema-Ndong. Email: rosalienikiema@yahoo.fr; Daniela NSAME. Email: Daniela_nsame@yahoo.fr; Sibylle Batou. Email: aubedeos@yahoo.fr; Edouard NSI Emvo. Email: edouardnsi2@gmail.fr; Félix Ovono Abessolo. Email:ovonoabessolofelix@gmail.com

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