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# Metabolic Syndrome Abnormalities and Associated risk Factors in Newly Diagnosed Diabetic Patients in Two sub-Saharan African Hospitals

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## ABSTRACT

***Introduction:*** *Metabolic syndrome (MetS) is a group of medical conditions that increase cardiovascular risk. This study aimed to describe metabolic syndrome abnormalities and to identify associated risk factors among newly diagnosed diabetic patients in two tertiary hospitals in sub-Saharan Africa.*

***Methodology:*** *This study constitutes an independent exploratory epidemiological analysis conducted in 60 patients aged 18 to 65 years, consecutively recruited, newly diagnosed with diabetes, presenting metabolic syndrome (MetS), and enrolled in the internal medicine departments of two sub-Saharan African hospitals as part of a broader research program: the Souro Sanou University Hospital Center (CHUSS) in Burkina Faso and the Yaoundé University Teaching Hospital (CHUY) in Cameroon. Anthropometric, physiological, and biochemical parameters were measured in the fasting state, in accordance with the International Diabetes Federation (IDF) 2009 consensus definition of metabolic syndrome.*

***Results:*** *The mean age of the participants was 46.3 ± 9.6 years (median 46.5) with 53.3% women. Most participants were married (88.3%), employed (81.7%) and 48.3% had a university degree. Finally, 85% reported practicing physical activity. Advanced age and female gender increased the risk of having more than 5 MetS anomalies (OR = 1.10, p = 0.006). Pupils and students were mostly in the group with fewer than 6 anomalies (OR = 0.13, p = 0.092). A history of obesity (OR = 3.00, p = 0.071), hypertension (OR = 3.06, p = 0.057), tended to increase this risk without statistical significance. All participants had hyperglycemia, 80% had hypertension, 46.7% had hypertriglyceridemia and 70% had hypo-HDL cholesterolemia. Abdominal obesity affected 18.3%, elevated CRP 26.7%, and 90% had normal albumin levels.*

***Conclusion:*** *Female gender, age, and obesity history tended to increase the risk, without statistical significance (OR = 3.00, p = 0.071). MetS was distributed differently among these diabetic patients, with hypertension being the second most common abnormality.*

## Keywords
Metabolic syndrome, Obesity, Hyperglycemia, High blood pressure, Risk factors.

## Introduction
Metabolic syndrome (MetS) is a concept that brings together several metabolic, physiological, biochemical, asymptomatic disorders, which can coexist with genetic and acquired factors[1]. It is recognized as a major public health problem due to its major role in the occurrence of type 2 diabetes and cardiovascular diseases [2,3]. Most definitions agree on essential components including glucose intolerance and/or diabetes, obesity, high blood pressure and dyslipidemia (low HDL-cholesterol and high triglycerides) [4–7]. Globally, the prevalence of MetS ranges from 1.2% to 22.6% in young people and from 9% to 35% in adults [8–10]. Lifestyle changes with lack of physical activity, high-calorie diet and genetic predispositions play a major role in the genesis of MetS. According to World Health Organization (WHO) estimates, non-communicable diseases including high blood pressure and type 2 diabetes affect nearly 22% of the world's population.[11] Africa is currently experiencing one of the most rapid demographic and epidemiological transitions in world history. The future impact of this situation on the prevalence of MetS remains unknown and is of concern with the increase in cardiovascular diseases. [12–14]. To cope with the advancement of metabolic syndrome, populations resort to hygienic-dietary measures and the practice of physical activity and the use of certain conventional medications. [15,16]. However, these treatments remain expensive, sometimes unavailable and poorly tolerated, which limits their accessibility in sub-Saharan Africa.[17,18]. Numerous studies have documented MetS in sub-Saharan Africa [7,19,20]; however, the rapid evolution of dietary habits, sedentary lifestyles and demographic transitions justifies the regular conduct of epidemiological surveys in order to detect changes in trends early and adapt prevention and management strategies accordingly. In this context, it appears essential to have up-to-date data from the hospital environment. The general objective of this study was to describe metabolic syndrome abnormalities and to identify associated risk factors among newly diagnosed diabetic patients in two tertiary hospitals in sub-Saharan Africa, respectively in Cameroon (CHUY) and Burkina Faso (CHUSS).

## Materials and Methods
### Study design
This study constitutes an independent exploratory epidemiological analysis, a transversal and analytical study over a period of 3 years from August 2020 to 2023. We consecutively recruited, newly diagnosed with diabetes, presenting metabolic syndrome (MetS), and enrolled in the internal medicine departments of two sub-Saharan African hospitals as part of a research program: the Souro Sanou University Hospital Center (CHUSS) in Burkina Faso and the Yaoundé University Teaching Hospital (CHUY) in Cameroon.

### Inclusion and exclusion criteria
Our study included patients aged between 18 and 65 years, seen in the internal medicine department, with new-onset diabetes and at least 3 MetS criteria without organ failure and who had not received any prior treatment. Participation in the study was voluntary, and informed consent was obtained from each patient. Our study did not include patients lost to follow-up, patients with a situation that prevented data collection and biological tests from being carried out, or patients with certain complications.

### Data collection
MetS was defined according to the new harmonized definition of 2009. Based on this criterion, a person has MetS if they have at least three of the following symptoms: an elevated waist circumference > 94 cm for men or > 88 cm for women; elevated triglycerides (or treatment for elevated triglycerides) ≥ 150 mg/dL (1.7 mmol/L); reduced HDL cholesterol level (or treatment to lower HDL) < 40 mg/dL (1.0 mmol/L) in men and < 50 mg/dL (1.3 mmol/L) in women; elevated blood pressure (or history of hypertension) - systolic ≥ 130. We also measured Fibrinogen 2 to 4 g/L, Albumin 34 to 54 g/dL and CRP ≤ 6 mg/L [21–24].

Each participant answered a pre-established questionnaire, saved in Excel and allowing data to be collected according to the following plan:

- Sociodemographic data (age, sex, residence, region of origin of parents),
- Personal history (diabetes, high blood pressure, obesity, tobacco and alcohol consumption),
- Type of physical activity, eating habits and lifestyle.
- A clinical examination with measurement of anthropometric parameters (weight, height, hip circumference, waist circumference) and hemodynamic parameters (heart rate and blood pressure). The weight load measurement was carried out using an ADE pharao Analytic brand impedance meter scale. The height measurement was made using a height chart. The waist circumference was taken using a dressmaker's tape measure on an adult in a standing position in gentle and unforced exhalation (without pulling in the stomach), halfway between the lower costal margin and the iliac crest. The hip circumference was measured with the tape measure, parallel to the ground at the strongest point of the hips just above the gluteal muscles [25].
- We calculated: Body Mass Index (BMI) = weight (kg)/height² (m²); Waist to Height Ratio (WHtR) = waist circumference (cm) / height (cm) and Waist to Hip Ratio (WHR) = waist circumference / hip circumference (cm) [26-28].
- Biological tests (capillary blood sugar, HDL-C, LDL-C, triglycerides, CRP, fibrinogen and albuminemia). Blood samples were taken in the morning and a minimum of 8 hours of fasting was recommended for measuring blood sugar, triglycerides and HDL cholesterol [29-32].
- Anthropometric parameters and blood pressure were measured by a nurse, independent of the research team. Blood pressure measurement was taken after the individual had rested for 10 minutes, in a sitting position. Three consecutive readings at 5-minute intervals were collected using an electronic blood pressure monitor from the "Omron" brand with a WHO category indicator and an automatic pressurization cuff adapted to their arm [26-28].

For blood pressure measurement, the participants were advised not to exercise for 48 hours before the measurements. They were asked to avoid caffeine or stimulants for 24 hours before the measurements. All measurements were performed on hospital premises, in a quiet room with adequate lighting. Blood pressure was measured on the subjects' upper arm using an Omron electronic blood pressure monitor with a WHO category indicator and an automatically pressurized cuff fitted to their arm [26–28].

### Sampling and Statistical analysis

Participants were consecutively recruited, resulting in a total sample of 60 patients, including 30 in Burkina Faso and 30 in Cameroon, within the framework of a research program. This study was designed as an independent exploratory epidemiological analysis. Data were presented respectively as mean ± standard deviation (SD) and percentage (%) in tables.

Pearson's Chi-square test of independence and Fisher's exact probability were used to compare proportions from unpaired samples. Student's t-test on unpaired series was used to compare mean values between two groups. The significance threshold was set at P-value < 0.05. Multivariable logistic regression was performed to identify factors independently associated with having ≥6 MetS abnormalities (dependent variable). All variables with p < 0.20 in univariate analysis were entered into the multivariate model using a forward stepwise method. Results are expressed as odds ratios (OR) with 95% confidence intervals.

## Results

### Description of socio-demographic data, background and physical activity

The overall mean age of participants was 46.3 ± 9.6 years, with a median of 46.5 years (IQR: 40.0 - 53.3) (p=0.525). The distribution between men and women showed 53.3% women (p>0.999), many participants were married (88.3 %). The proportions of single, widowed and cohabiting people varied between the two sites (p=0.432). Employees represented 43.3% of the population in each site. A higher proportion of self-employment was observed in Yaoundé (46.7%) compared to Bobo-Dioulasso (30.0%) (p=0.169). Nearly half of the participants had a university level (48.3%), with a higher proportion in Yaoundé (53.3%). In Bobo-Dioulasso, 16.7% of participants had no formal education compared to 0% in Yaoundé (p=0.183). Overall, 91.7% of participants were employed; in both Bobo-Dioulasso and Yaoundé, the proportions were similar between the two sites, with 93.3% employed in Bobo-Dioulasso and 90.0% employed in Yaoundé. Participants worked an average of 6.8 ± 2.6 hours per day, with a median of 7.0 hours (IQR: 6.0 - 8.0). In Bobo-Dioulasso, the average was 6.5 ± 2.8 hours, compared to a mean of 7.0 ± 2.4 hours for Yaoundé. Participants worked an average of 4.9 ± 1.6 days per week. It emerged that 73.3% of participants reported a history of obesity, with a higher proportion in Yaoundé (80.0%) than in Bobo-Dioulasso (66.7%) (p=0.243). The mean duration of high weight was 5.7 ± 5.2 years (median: 4 years), with no significant difference between Bobo-Dioulasso (6.2 ± 5.6 years) and Yaoundé (5.2 ± 5.0 years; p=0.554). The overall prevalence of a personal history of diabetes was 26.7%, with no cases reported in Bobo-Dioulasso (0%), while 53.3% of participants in Yaoundé had a history of diabetes (p<0.001). Overall, 50.0% of participants reported a history of hypertension. These antecedents were more frequent in Bobo-Dioulasso (60.0%) than in Yaoundé (40.0%) (p=0.121). Family history of diabetes was significantly more frequent in Yaoundé (83.3%) than in Bobo-Dioulasso (56.7%; p=0.024). Regarding familial hypertension, although 85.0% of participants reported this history, the difference between Bobo-Dioulasso (76.7%) and Yaoundé (93.3%) was not significant (p=0.145). Tobacco consumption was low in both groups (13.3% overall) and did not differ significantly between Bobo-Dioulasso (16.7%) and Yaoundé (10.0%). In contrast, alcohol consumption was significantly higher in Yaoundé (86.7%) than in Bobo-Dioulasso (56.7%; p=0.010).

### Distribution according to physical activity and eating habits

Overall, 85.0% of participants reported engaging in physical activity. In Bobo-Dioulasso, 90.0% of participants engaged in physical activity, compared to 80.0% in Yaoundé.

Participants from Bobo-Dioulasso were more active than those from Yaoundé (p=0.472). The physical activities practiced were mainly domestic (40.0%) or leisure (43.3%). Professional physical activities were marginal (1.7% overall) and absent in Yaoundé. In Bobo-Dioulasso, domestic activities predominated (53.3%), while they were less frequent in Yaoundé (26.7%). In Yaoundé, leisure activities were more frequent (53.3%) compared to Bobo-Dioulasso (33.3%) (p=0.084). In our study, the practice of physical activity at work was reported by 78.3% of participants, with a significant difference between Bobo-Dioulasso (90.0%) and Yaoundé (66.7%) (p=0.028). Most participants reported low intensity (80.0%), the proportions were similar between Bobo-Dioulasso (76.7% low intensity) and Yaoundé (83.3%) (p=0.519). The overall mean daily physical activity duration was 2.3 ± 2.8 hours, with a median of 1.0 hour. The duration was significantly higher in Bobo-Dioulasso (2.5 ± 2.1 hours) than in Yaoundé (2.2 ± 3.4 hours, p=0.041). Participants practiced weekly physical activity approximately 3.5 ± 2.2 days per week. However, Bobo-Dioulasso displayed a higher frequency (4.3 ± 1.8 days) than Yaoundé (2.7 ± 2.3 days, p=0.006). Mean entertainment hours were similar between Bobo-Dioulasso (3.9 ± 2.4 hours) and Yaoundé (4.1 ± 5.2 hours) (p=0.378), with a median of 3.0 hours in both groups. Mean sleep duration was comparable between the two sites, Bobo-Dioulasso (6.5 ± 1.1 hours) and Yaoundé (6.4 ± 1.0 hours) (p>0.999). The number of meals per day was the only variable with a statistically significant difference (p = 0.003). This could reflect cultural and socioeconomic differences between the groups. High snacking (73.3%) and the frequency of eating away from home tended to influence diet quality, although this was not statistically significant. In contrast, fruit and vegetable consumption remained modest and stable between the groups.

### Description of risk factors associated with abnormalities of metabolic syndrome

The results in Table 3 showed that older age and female gender increased the probability of belonging to the group with more than

5 metabolic syndrome abnormalities (OR = 1.10, p = 0.006). While men most often had fewer (OR = 0.27, p = 0.025). Marital status was not significantly associated with the distribution of the groups, although single people had a lower probability of belonging to the group with 6 or more MetS abnormalities compared to married people (OR = 0.30, p = 0.139). Regarding professional status, pupils and students were most likely to belong to the group with fewer than 6 MetS abnormalities, but this trend was not statistically significant (OR = 0.13, p = 0.092). Analysis of medical history and lifestyle habits shows that individuals with a history of obesity (OR = 3.00, p = 0.071), hypertension (OR = 3.06, p = 0.057), had more than 5 MetS-associated abnormalities although this association was not statistically significant. A personal history of diabetes (OR = 2.48, p = 0.204) and family history had no significant impact on the distribution between groups. Smoking (OR = 0.22, p = 0.057) and alcohol consumption (OR = 0.86, p = 0.813) were not significantly associated with the number of MetS-associated abnormalities. No significant associations were observed with frequency (p = 0.662), duration (2.4 ± 2.9 h vs. 2.0 ± 2.7 h) (p = 0.595), or intensity of physical activity (p = 0.225). Participants in the group with the most MetS abnormalities spent an average of 4.2 ± 4.6 hours per day on recreational activities, compared with 3.6 ± 2.5 hours in the group with the fewest MetS abnormalities. The group with more than 5 MetS abnormalities slept an average

**Table 1:** Description of socio-demographic data and background in the study population.

| **Variables** | **Overall**, N = 601 | **Bobo-Dioulasso**, N = 301 | **Yaounde**, N = 301 | **p-value**[2] |
|---|---|---|---|---|
| Age in years | | | | 0.525 |
| Mean ± SD | 46.3 ± 9.6 | 45.8 ± 10.7 | 46.7 ± 8.5 | |
| Median [IQR] | 46.5 [40.0 - 53.3] | 45.5 [39.0 - 54.0] | 47.0 [42.0 - 53.0] | |
| Range | 23.0 - 64.0 | 26.0 - 64.0 | 23.0 - 59.0 | |
| Sex | | | | >0.999 |
| Female | 32 (53.3%) | 16 (53.3%) | 16 (53.3%) | |
| Male | 28 (46.7%) | 14 (46.7%) | 14 (46.7%) | |
| Marital status | | | | >0.999 |
| Married | 53 (88.3%) | 27 (90.0%) | 26 (86.7%) | |
| Bachelor | 7 (11.7%) | 3 (10.0%) | 4 (13.3%) | |
| Professional status | | | | |
| Student | 4 (6.7%) | 4 (13.3%) | 0 (0.0%) | 0.133 |
| Employee | 49 (81.7%) | 22 (73.3%) | 27 (90.0%) | |
| Unemployed/retired | 7 (11.7%) | 3 (10.0%) | 4 (13.3%) | |
| Educational level | | | | |
| None | 5 (8.3%) | 5 (16.7%) | 0 (0.0%) | 0.104 |
| Primary | 13 (21.7%) | 5 (16.7%) | 8 (26.7%) | |
| Secondary | 13 (21.7%) | 7 (23.3%) | 6 (20.0%) | |
| University | 29 (48.3%) | 13 (43.3%) | 16 (53.3%) | |
| Current employment | | | | >0.999 |
| Yes | 55 (91.7%) | 28 (93.3%) | 27 (90.0%) | |
| Working hours/day | | | | 0.255 |
| Mean ± SD | 6.8 ± 2.6 | 6.5 ± 2.8 | 7.0 ± 2.4 | |
| Median [IQR] | 7.0 [6.0 - 8.0] | 6.0 [5.0 - 8.0] | 7.5 [6.0 - 8.0] | |
| Range | 0.0 - 13.0 | 0.0 - 13.0 | 0.0 - 11.0 | |
| Working days per week | | | | 0.762 |
| Mean ± SD | 4.9 ± 1.6 | 4.9 ± 1.4 | 4.9 ± 1.8 | |
| Median [IQR] | 5.0 [4.0 - 6.0] | 5.0 [4.0 - 6.0] | 5.0 [4.0 - 6.0] | |
| Range | 0.0 - 7.0 | 0.0 - 7.0 | 0.0 - 7.0 | |
| Duration of overweight | | | | 0.554 |
| Mean ± SD | 5.7 ± 5.2 | 6.2 ± 5.6 | 5.2 ± 5.0 | |
| Median [IQR] | 4.0 [1.5 - 8.0] | 4.0 [2.0 - 9.5] | 3.5 [1.0 - 7.3] | |
| Range | 0.0 - 22.0 | 1.0 - 22.0 | 0.0 - 20.0 | |
| Family history of hypertension | | | | 0.145 |
| Yes | 51 (85.0%) | 23 (76.7%) | 28 (93.3%) | |
| Family history of diabetes | | | | 0.024 |
| Yes | 42 (70.0%) | 17 (56.7%) | 25 (83.3%) | |
| Current tobacco use | | | | 0.706 |
| Yes | 8 (13.3%) | 5 (16.7%) | 3 (10.0%) | |
| Current alcohol consumption | | | | **0.010** |
| Yes | 43 (71.7%) | 17 (56.7%) | 26 (86.7%) | |

1n (%) 2Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test.

**Table 2:** Description of physical activity and eating habits in the population.

| Variables | Overall, N = 601 | Bobo-Dioulasso, N = 301 | Yaounde, N = 301 | p-value[2] |
|---|---|---|---|---|
| Physical activity | | | | |
| Yes | 51 (85.0%) | 27 (90.0%) | 24 (80.0%) | 0.472 |
| Type of physical activity | | | | |
| None | 9 (15.0%) | 3 (10.0%) | 6 (20.0%) | 0.084 |
| Domestic | 24 (40.0%) | 16 (53.3%) | 8 (26.7%) | |
| Leisure | 26 (43.3%) | 10 (33.3%) | 16 (53.3%) | |
| Professional | 1 (1.7%) | 1 (3.3%) | 0 (0.0%) | |
| Physical activity at work | | | | |
| Yes | 47 (78.3%) | 27 (90.0%) | 20 (66.7%) | **0.028** |
| **Work intensity** | | | | |
| Weak | 48 (80.0%) | 23 (76.7%) | 25 (83.3%) | 0.519 |
| Average | 12 (20.0%) | 7 (23.3%) | 5 (16.7%) | |
| Time in hours of physical activity | | | | |
| Mean ± SD | 2.3 ± 2.8 | 2.5 ± 2.1 | 2.2 ± 3.4 | 0.041 |
| Median [IQR] | 1.0 [0.5 - 3.3] | 2.0 [1.0 - 3.8] | 0.8 [0.0 - 3.0] | |
| Range | 0.0 - 15.0 | 0.0 - 8.0 | 0.0 - 15.0 | |
| Day of physical activity /week | | | | |
| Mean ± SD | 3.5 ± 2.2 | 4.3 ± 1.8 | 2.7 ± 2.3 | 0.006 |
| Median [IQR] | 4.0 [2.0 - 5.0] | 5.0 [4.0 - 6.0] | 2.5 [0.0 - 5.0] | |
| Range | 0.0 - 7.0 | 0.0 - 7.0 | 0.0 - 6.0 | |
| Sleep time/day | | | | |
| Mean ± SD | 6.4 ± 1.1 | 6.5 ± 1.1 | 6.4 ± 1.0 | >0.999 |
| Median [IQR] | 6.0 [6.0 - 7.0] | 6.0 [6.0 - 7.0] | 6.5 [6.0 - 7.0] | |
| Range | 4.0 - 9.0 | 5.0 - 9.0 | 4.0 - 8.0 | |
| Fruit consumption/week | | | | |
| Mean ± SD | 3.4 ± 2.4 | 3.2 ± 2.3 | 3.5 ± 2.4 | 0.771 |
| Median [Q1 - Q3] | 3.0 [1.0 - 5.0] | 3.0 [1.0 - 5.0] | 3.0 [1.0 - 6.0] | |
| Min - Max | 0.0 - 7.0 | 0.0 - 7.0 | 0.0 - 7.0 | |
| Vegetable consumption/week | | | | |
| Mean ± SD | 3.1 ± 2.0 | 3.4 ± 2.0 | 2.7 ± 1.9 | 0.141 |
| Median [Q1 - Q3] | 3.0 [1.0 - 4.0] | 3.0 [2.0 - 4.0] | 2.0 [1.0 - 4.0] | |
| Min - Max | 0.0 - 7.0 | 1.0 - 7.0 | 0.0 - 7.0 | |
| Number of meals/day | | | | |
| Mean ± SD | 2.8 ± 0.7 | 3.0 ± 0.6 | 2.7 ± 0.7 | 0.119 |
| Median [Q1 - Q3] | 3.0 [2.0 - 3.0] | 3.0 [3.0 - 3.0] | 3.0 [2.0 - 3.0] | |
| Min - Max | 1.0 - 4.0 | 2.0 - 4.0 | 1.0 - 4.0 | |
| Number of breakfasts/day | | | | |
| Mean ± SD | 5.0 ± 2.4 | 4.9 ± 2.3 | 5.0 ± 2.6 | 0.646 |
| Median [Q1 - Q3] | 6.0 [3.0 - 7.0] | 5.5 [3.0 - 7.0] | 6.5 [3.0 - 7.0] | |
| Min - Max | 0.0 - 7.0 | 0.0 - 7.0 | 0.0 - 7.0 | |
| Meals away from home / week | | | | |
| Mean ± SD | 3.7 ± 2.5 | 3.2 ± 2.4 | 4.2 ± 2.5 | 0.089 |
| Median [Q1 - Q3] | 4.0 [1.5 - 6.0] | 3.5 [1.0 - 5.0] | 5.0 [2.0 - 7.0] | |
| Min - Max | 0.0 - 7.0 | 0.0 - 7.0 | 0.0 - 7.0 | |
| Snacking / week | | | | |
| Yes | 44 (73.3%) | 20 (66.7%) | 24 (80.0%) | 0.243 |
| **Biggest meal of the day** | | | | |
| The morning | 1 (1.67%) | 1 (3.33%) | 0 (0%) | 0.666 |
| At noon | 35 (58.3%) | 19 (63.3%) | 16 (53.3%) | |
| The evening | 19 (31.7%) | 8 (26.7%) | 11 (36.7%) | |
| The night | 5 (8.33%) | 2 (6.67%) | 3 (10.0%) | |

1n (%) 2 Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test.

of 6.5 ± 1.1 hours, compared with 6.2 ± 1.0 hours.

**Table 3:** Description of risk factors associated with ≥6 metabolic syndrome abnormalities multivariable logistic regression analysis.

| Variables | OR[2] | 95% CI[2] | p-value |
|---|---|---|---|
| **Age** | 1.10 | 1.03, 1.19 | 0.006 |
| 23-42 | — | — | |
| 43-52 | 4.00 | 1.07, 17.6 | 0.049 |
| >53 | 6.00 | 1.25, 44.7 | **0.041** |
| **Sex** | | | |
| Female | — | — | |
| Male | 0.27 | 0.08, 0.82 | **0.025** |
| **Marital status** | | | |
| Married | — | — | |
| Bachelor | 0.30 | 0.05, 1.49 | 0.139 |
| **Professional status** | | | |
| Active | — | — | |
| Student | 0.13 | 0.01, 1.14 | 0.092 |
| Unemployed/retired | 1.00 | 0.19, 7.55 | >0.999 |
| **Educational level** | | | |
| University | — | — | |
| None | 0.68 | 0.10, 5.80 | 0.693 |
| Primary | 0.53 | 0.13, 2.05 | 0.348 |
| Secondary | 2.48 | 0.52, 18.2 | 0.296 |
| Current employment | | | |
| Yes | 1.49 | 0.18, 9.80 | 0.677 |
| **Familial diabetes** | | | |
| Yes | 1.12 | 0.33, 3.57 | 0.856 |
| Family hypertension | | | |
| Yes | 1.92 | 0.42, 8.26 | 0.377 |
| Tobacco | | | |
| Yes | 0.22 | 0.04, 1.02 | 0.057 |
| Alcohol | | | |
| Yes | 0.86 | 0.24, 2.84 | 0.813 |
| Physical activity | | | |
| Yes | 0.57 | 0.08, 2.68 | 0.513 |
| Physical activity at work | | | |
| Yes | 0.95 | 0.23, 3.44 | 0.937 |
| Time in hours of physical activity | 1.06 | 0.87, 1.35 | 0.595 |
| Physical activity day | 1.06 | 0.82, 1.35 | 0.662 |
| Leisure screen time | 1.04 | 0.90, 1.30 | 0.633 |
| Hours of sleep | 1.32 | 0.78, 2.32 | 0.306 |

### Distribution of metabolic syndrome components, inflammatory markers, and anthropometric indicators

All participants in our study (100%) had high blood glucose, confirming generalized hyperglycemia in this population. Among the metabolic syndrome components, 80% of participants were hypertensive (HTA+). Nearly 70.0% had Hypo HDL cholesterolemia (p = 0.573), 46.7% had Hypertriglyceridemia (P = 0.301), and 18.3% of participants had abdominal obesity (p = 0.317). Regarding anthropometric indicators (p = 0.774), 53.3% according to the WHtR and 15.0% of participants had a very high risk of metabolic complications (p = 0.142). Abdominal obesity (defined by elevated waist circumference) was observed in 11 participants (18.3%). Regarding other biological disorders, 26.7% had high CRP versus 16.7%, 11.7% had high fibrinogenemia (p = 0.098), and 90% of participants had normal albuminemia (p > 0.999).

## Discussion

The general objective of this study was to describe metabolic syndrome abnormalities and to identify associated risk factors among newly diagnosed diabetic patients in two tertiary hospitals in sub-Saharan Africa (Cameroon and Burkina Faso).

Female participants with an intermediate age profile (46.3 ± 9.6 years) were the most represented, the distribution between men and women was balanced, guaranteeing representation of both sexes. Mandob et al., in 2018 in Cameroon, found a younger population with an average age of 34.47 ± 10.67 years for men and 36.92 ± 11.38 years for women [33]. On the other hand, Guira et al in Burkina Faso in 2016 found results close to ours with an average age of 55.7 ± 1.6 years, and a modal class of 51-60 years in women (44.1%) and 61-70 years in men (63.6%) [34].

The number of employees was identical at each site and the proportions of single, married, widowed and cohabiting people varied little between the two sites (p=0.432).

Yaoundé appeared to have a higher proportion of self-employed people with a university education, who associated a more sedentary lifestyle with a higher prevalence of obesity, diabetes, and alcohol consumption. Conversely, Bobo-Dioulasso presented a slightly different picture, with a higher proportion of people with high blood pressure.

Our results are different from those obtained in 2018 in Cameroon by Mandob et al where the study population was largely single with 64.29% compared to 35.71% married. Traders represented a little more than half of the population (57.25%) [33]. Civil servants and those employed in other professions were moderately represented with respective percentages of 20.51% and 19.97%. Patients with a higher education level (university) were poorly represented (10.28%) [33]. Our results are comparable to those of Abagre et al in Ghana (2022) who found more married participants (66%) than divorced, separated, or never married participants (34%) [35]. Agriculture was the main occupation of the participants (60%). Six percent were formally employed, while 15.4% were unemployed or retired, and 89.1% of participants had not completed secondary education [35]. Indeed, it is believed that the increase in the prevalence of metabolic syndrome on the African continent is due to the abandonment of traditional African lifestyles towards Western lifestyles. This could be explained by the fact of the mechanization of means of transport, the accessibility of leisure activities promoting a sedentary lifestyle such as video games or television, as well as the increasing adoption of a "fast food" type diet rich in calories and of poor nutritional quality [7,36–41]. In the workplace, the reduction in physical activity among employees associated with a sedentary lifestyle and a high-energy diet are responsible for the increase in the prevalence of obesity and diabetes mellitus, giving this population a high cardio-metabolic risk [42].

**Table 4:** Description of the main parameters of metabolic syndrome in the study population.

| Variables | **Overall** N = 601 | **Bobo Dioulasso,** N = 301 | **Yaounde,** N = 301 | **p-value** 2 |
|---|---|---|---|---|
| **Hyperglycemia** | | | | |
| | 60 (100.0%) | 30 (100.0%) | 30 (100.0%) | |
| **HTA** | | | | |
| HTA- | 12 (20.0%) | 6 (20.0%) | 6 (20.0%) | >0.999 |
| HTA+ | 48 (80.0%) | 24 (80.0%) | 24 (80.0%) | |
| **Triglyceride** | | | | |
| Low | 32 (53.3%) | 24 (80.0%) | 8 (26.7%) | **<0.001** |
| Raised | 28 (46.7%) | 6 (20.0%) | 22 (73.3%) | |
| **HDL cholesterol** | | | | |
| Down | 42 (70.0%) | 23 (76.7%) | 19 (63.3%) | 0.260 |
| Normal | 18 (30.0%) | 7 (23.3%) | 11 (36.7%) | |
| **Waist size** | | | | |
| Normal | 49 (81.7%) | 25 (83.3%) | 24 (80.0%) | 0.739 |
| Obesity | 11 (18.3%) | 5 (16.7%) | 6 (20.0%) | |
| **Fibrinogen** | | | | |
| Down | 8 (13.3%) | 6 (20.0%) | 2 (6.67%) | 0.066 |
| Raised | 7 (11.7%) | 1 (3.33%) | 6 (20.0%) | |
| Normal | 45 (75.0%) | 23 (76.7%) | 22 (73.3%) | |
| **Albumin** | | | | |
| Down | 6 (10.0%) | 3 (10.0%) | 3 (10.0%) | >0.999 |
| Normal | 54 (90.0%) | 27 (90.0%) | 27 (90.0%) | |
| **WHR** | | | | |
| Big | 31 (51.7%) | 15 (50.0%) | 16 (53.3%) | 0.836 |
| Moderate | 16 (26.7%) | 9 (30.0%) | 7 (23.3%) | |
| Little | 13 (21.7%) | 6 (20.0%) | 7 (23.3%) | |
| **WHtR** | | | | |
| Normal | 10 (16.7%) | 4 (13.3%) | 6 (20.0%) | **0.042** |
| Moderate obesity | 9 (15.0%) | 8 (26.7%) | 1 (3.33%) | |
| Severe obesity | 32 (53.3%) | 14 (46.7%) | 18 (60.0%) | |
| Slim | 2 (3.33%) | 2 (6.67%) | 0 (0%) | |
| Overweight | 7 (11.7%) | 2 (6.67%) | 5 (16.7%) | |
| **CRP** | | | | |
| Raised | 16 (26.7%) | 1 (3.33%) | 15 (50.0%) | **<0.001** |
| Normal | 44 (73.3%) | 29 (96.7%) | 15 (50.0%) | |
| **BMI** | | | | |
| Severe obesity | 2 (3.33%) | 1 (3.33%) | 1 (3.33%) | 0.057 |
| Normal weight | 13 (21.7%) | 10 (33.3%) | 3 (10.0%) | |
| Overweight | 45 (75.0%) | 19 (63.3%) | 26 (86.7%) | |
| **Total anomalies** | | | | |
| Mean ± SD | 4.6 ± 1.3 | 4.1 ± 0.8 | 5.2 ± 1.4 | **0.002** |
| Median [Q1 - Q3] | 4.0 [4.0 - 5.0] | 4.0 [4.0 - 5.0] | 5.0 [4.0 - 6.0] | |
| Min - Max | 3.0 - 8.0 | 3.0 - 6.0 | 3.0 - 8.0 | |
| **Total anomalies slices** | | | | |
| [3-6) | 47 (78.3%) | 28 (93.3%) | 19 (63.3%) | **0.005** |
| [6-10] | 13 (21.7%) | 2 (6.67%) | 11 (36.7%) | |
| 1n (%) | | | | |
| 2Pearson's Chi-squared test; Fisher's exact test; Wilcoxon rank sum test. | | | | |

A study conducted in Mali by Togo et al in 2017 found that 13% of patients had a family history of diabetes, 13% had high blood pressure, 42.6% had familial obesity, and 3 out of 54 patients had a history of current or quit smoking [43]. The fact that many patients are unaware of their family history of diabetes and high blood pressure in their ancestors could explain these low frequencies.

Regarding tobacco consumption, Raharinavalona et al., in Madagascar in 2020, found a large number of smoking patients (24.66%) who were active or had quit for less than three months, including 57.40% males and 42.6% females [14].

Overall, 85.0% of participants reported engaging in physical activity. In Bobo-Dioulasso, 90.0% of participants engaged in physical activity, compared to 80.0% in Yaoundé. In the context of metabolic syndrome, poor physical fitness was shown to be as powerful an indicator as conventional risk criteria. People who were inactive were twice as likely to develop cardiovascular disease as those who were active [44]. The protective effect of physical exercise against the risk of early death in individuals with metabolic syndrome has been clearly established [45]. Physical activity helps increase energy expenditure. Combining endurance sports with muscle strengthening can limit or even correct the components of metabolic syndrome, and therefore reduce the risk of metabolic syndrome itself [45]. A modest amount of moderate-intensity exercise, in the absence of dietary changes, significantly improved metabolic syndrome. A greater amount of vigorous exercise was found to have greater and more widespread benefits. Finally, there is some evidence that moderate-intensity exercise may be better than vigorous-intensity exercise for improving metabolic syndrome [46]. These results explain the favourable evolution of the metabolic syndrome in our study, because the participants significantly improved in duration, intensity and number of sessions of physical activity.

The association between older age, female sex, and the presence of more metabolic syndrome abnormalities may be explained physiologically by hormonal and metabolic effects after menopause by the decline in estrogen leads to a redistribution of body fat towards the abdomen, promoting visceral obesity, resistance or decreased sensitivity to insulin, and a chronic inflammatory state linked to metabolic syndrome. The relationship between blood sugar and age depends on many individual factors. As we age, blood sugar control can become more difficult due to physiological changes, such as insulin resistance (cells become less sensitive to insulin) [47,48]. On the other hand, high blood sugar levels can also accelerate the cellular aging process, lead to decreased insulin production by the pancreas, lead to an altered response of glucose metabolism with changes in body composition by decreased muscle mass and increased fat mass [47,48].

With age, it is common for waist circumference to increase due to hormonal changes, decreased muscle mass, basal metabolic rate, increased insulin resistance, and the tendency to store more fat around the waist [49]. Depending on gender, men tend to have a larger waist circumference (android) than women (gynoid) on average, partly due to the different distribution of fat in the body. High blood pressure can be the result of oxidative stress, inflammation, and be associated with fat accumulation around the waist. Obesity, particularly abdominal obesity, is strongly correlated with increased insulin resistance, high blood lipid levels, and chronic inflammation. It can be caused by a variety of factors, including an unbalanced diet, lack of exercise, and genetic factors [49].

Marital and professional status influenced the probability of having more than 5 MetS for unemployed people and a low level of education (OR = 0.13, p = 0.092). Analysis of medical history and lifestyle habits shows that people with a history of obesity (OR = 3.00, p = 0.071), hypertension (OR = 3.06, p = 0.057), had more than 5 abnormalities associated with MetS although this association was not statistically significant. These observations are in agreement with those of Mandob et al., in 2018 in Yaoundé, Cameroon whose results did not find a significant association between the level of education or employment and metabolic syndrome [33]. The results showed that female gender, age group above 45 years and duration of residence in Yaoundé above five years were risk factors, while marital status, ecological zone, employment and educational level were not associated with metabolic syndrome [33]. The lack of association with education level or employment could indicate that eating habits were more influenced by cultural and family factors than by occupation.

Sicree et al. (2008) found that high waist circumference, hip circumference, and BMI were associated with elevated 2-hour postprandial blood glucose levels in both men and women. These relationships are likely due to obesity-related disturbances in glucose metabolism. In particular, the visceral component of abdominal fat is strongly associated with insulin resistance [50].

A family history of diabetes can increase a person's risk of developing the disease. Genetic factors as well as shared lifestyle habits within a family can play a role in this predisposition [47].

A history of alcohol consumption may increase blood pressure through an effect on the sympathetic nervous system, which regulates heart rate and constriction of blood vessels [51,52]. An effect on hormones and vasoactive substances such as aldosterone and angiotensin II with dysfunction of the renin-angiotensin-aldosterone system (RAAS) increase the secretion of aldosterone (water and sodium retention) [51,53].

Smoking can cause constriction of blood vessels and increase oxidative stress (which reflects an imbalance between free radicals and antioxidants). These free radicals will alter the regulation of adipokines and cytokines, which can worsen high blood pressure [54]. Nicotine also causes hormonal changes that generate, among other things, an accumulation of fat in the abdomen, which itself contributes to insulin resistance, thus predisposing to the development of diabetes [55,56]. Smoking can alter blood lipid levels by increasing LDL ("bad") cholesterol levels and decreasing HDL ("good") cholesterol levels, contributing to dyslipidemia.

Intravenous nicotine and smoking increase plasma free fatty acid (FFA) levels through enhanced lipolysis resulting from sympathoadrenal stimulation [57].

The WHO recommends that adults achieve significant metabolic health benefits by engaging in at least 150 to 300 minutes of moderate-intensity physical activity per week or 75 to 150 minutes of vigorous-intensity physical activity per week. In addition to muscle-strengthening exercises, they should engage in at least two days a week [58].

Aune et al., in 2015 in a meta-analysis showed that 30 minutes of moderate physical activity per day reduces the risk of metabolic syndrome by 30% [59].

Hypertriglyceridemia, characterized by increased fasting and postprandial triglyceride-rich lipoprotein concentrations, and platelet hyperactivity are risk factors for atherothrombosis in patients with type 2 diabetes. A history of type 2 diabetes may increase serum triglyceride levels [60]. Fibrinogen is considered an acute-phase protein of inflammation, interacting with leukocytes and vascular endothelial cells. Fibrinogen has recently been shown to be involved in thrombogenesis and atherogenesis [61]. It can therefore be considered as a marker of coronary artery disease. Fibrinogen synthesis can increase significantly following stress, regular tobacco and alcohol consumption.

Our results are similar to those described by Raharinavalona et al. (2020) [14]. Indeed, they found that in all genders combined, metabolic syndrome had 3 components in 45.21% of cases, 4 components in 28.31% of cases and 5 components in 12.78% of cases. Hyperglycemia was the most common component, followed by hypertension, hypo-HDL cholesterolemia, abdominal obesity, and hypertriglyceridemia. These parameters were significantly associated with metabolic syndrome [14]. In Senegal, Cisse et al. (2020) found a prevalence of 6.57% with a female predominance (8.65% vs 4.72%) increasing with age. The most common components of metabolic syndrome are high blood pressure (86.2%) followed by abdominal obesity (72.41%) [62]. In Mali, Togo et al. (2017) found a prevalence of metabolic syndrome of 11.23%, the presence of the association obesity + diabetes + high blood pressure in families was seen in 27.8% of patients [43].

## Conclusion

The results obtained in this study show that the association of metabolic syndrome parameters depends on individual factors, advanced age and lifestyle. The urgency of implementing a preventive strategy based on universal measures to promote healthy eating habits and regular physical activity should begin at a young age, in homes, schools and public spaces.

### Limitations

Despite promising findings, several limitations should be considered.

- The relatively small sample size (n=60) may limit the statistical power to detect associations, particularly for variables with low prevalence in this population.
- The hospital-based recruitment may have introduced selection bias and may limit the generalizability of the findings to the overall population.
- Although standardized procedures were used, measurement bias and residual confounding could not be completely excluded.

### Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### What is already know on this topic

Metabolic syndrome is a cluster of interconnected cardiometabolic abnormalities that significantly increase the risk of type 2 diabetes and cardiovascular disease.

Current evidence highlights that metabolic syndrome is both preventable and reversible through lifestyle modification and targeted interventions.

### What this study adds

This study provides updated, context-specific epidemiological data on the burden, clinical presentation, and demographic distribution of metabolic syndrome among hospitalized adults in two sub-Saharan African internal medicine departments.

The study identifies specific risk patterns and comorbidity profiles associated with metabolic syndrome in sub-Saharan Africa.

## Authors' contributions

The author(s) acknowledged that:

1. All authors have read, understand and agreed to the submission guidelines, policies and submission declaration of the journal.
2. The manuscript is the authors' original work and has not been published or is not being submitted or considered for publication elsewhere.
3. All authors have checked the manuscript for plagiarism and declare that manuscript is plagiarism free and approved the manuscript as submitted.
5. All authors participated in the work in a substantive way and are prepared to take public responsibility for the work.
6. All authors of the manuscript have no conflict of interests to declare.
7. The manuscript submitted to the journal is not copied or plagiarized version of some other published work. All the data taken from other sources is written in authors own language and properly cited.

## Trial registration

- Regional Ethics Committee for Research on Human Health of the Centre Region, Cameroon

EC No. 007 / No. / CRERSHC / 2023, issued in Yaoundé on January 12, 2023

**- National Institute of Public Health:** Institutional Ethics Committee, Burkina Faso

Deliberation No. 2023 – 007 / MSP / SG / INS / CEI, issued in Ouagadougou on July 12, 2023

**- University of Douala**

No. 3159 E11 – UDO / 06 / 2022 / IT, issued in Douala on June 7, 2022

**- Regional Delegation of Health of Yaoundé**

0099 / AR / MINISTRY OF PUBLIC HEALTH / SG / DRSPC, issued on January 17, 2023

**- Sourô Sanou University Teaching Hospital, Bobo-Dioulasso**

No. 2021 / 0265 / MS / SG / CHUSS / DG / DRH on September 16, 2021

**- Yaoundé University Teaching Hospital**

No. 12 / AR / CHUY / DG / DGA / CAPRC

Director General / Director of Human Resources on January 11, 2023

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