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Factors associated with prediabetes in Congolese adults: a cross-sectional study in the Gombe Matadi health zone, Democratic Republic of Congo

Facteurs associés au prédiabète chez les adultes Congolais : une étude transversale de la zone de santé de Gombe Matadi, République Démocratique du Congo

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Résumé

Contexte et objectif. Le prédiabète est un facteur important de développement du diabète de type 2. Sa prévalence en République démocratique du Congo (RDC) est inconnue. Cette étude visait à déterminer la prévalence et les facteurs associés au prédiabète dans la zone de santé rurale de Gombe-Matadi. *Méthodes.* La présente étude transversale analytique a utilisé des données cliniques et biochimiques archivées de 1 531 personnes (809 femmes [52,8 %] ; âge médian : 50 ans ; intervalle : 19-96 ans) sélectionnées aléatoirement dans le cadre d'une enquête menée en mai 2019 dans la zone de santé rurale de Gombe-Matadi, en RDC. Le prédiabète était défini comme une glycémie deux heures après le test d'hyperglycémie provoquée par voie orale (HGPO) comprise entre 140 et 199 mg/dL chez toute personne non diabétique. *Résultats.* La prévalence du prédiabète était de 15,8 %. La consommation d'alcool (28,4%), l'hypertension artérielle (28,3%), le tabagisme (25%), l'obésité abdominale (22,1%), l'antécédent familial de diabète (15,8%), la sédentarité (15,1%) et le surpoids/obésité (13,6%) étaient les principaux facteurs de risque cardiovasculaire observés. La prévalence de l'hypertension artérielle, de l'obésité abdominale et du surpoids/obésité augmentait significativement avec la glycémie (P<0,001). Dans une analyse de régression logistique, la

Summary

Context and objective. Prediabetes is an important precursor to the development of type 2 diabetes. Its prevalence in the Democratic Republic of Congo (DRC) is unknown. This study aimed to determine the prevalence and factors associated with prediabetes in the rural health zone of Gombe-Matadi. *Methods.* This cross-sectional analytical study used archived clinical and biochemical data from 1,531 individuals (809 women [52.8%]; median age: 50 years; range: 19–96 years) randomly selected as part of a survey conducted in May 2019 in the rural health zone of Gombe-Matadi, DRC. Prediabetes was defined as a blood glucose level determined two hours after the oral glucose tolerance test (OGTT) and ranging between 140 and 199 mg/dL in any individual not known to have diabetes. *Results.* The prevalence of prediabetes was 15.8%. Alcohol consumption (28.4%), high blood pressure (28.3%), smoking (25%), abdominal obesity (22.1%), family history of diabetes (15.8%), sedentary lifestyle (15.1%), and overweight/obesity (13.6%) were the main cardiovascular risk factors observed. The prevalence of high blood pressure, abdominal obesity and overweight/obesity significantly increased with blood glucose category (p<0.001). In a logistic regression analysis, alcohol consumption (OR 1.669; CI 1.151-2.421; p=0.007) and high blood pressure (OR 1.360; 1.002-1.845; p=0.048) were significantly associated with prediabetes. *Conclusion.* The observed high prevalence of prediabetes requires preventive measures,

consommation d'alcool (OR :1,669 ; IC 95 % :1,151-2,421 ; p=0,007) et l'hypertension artérielle (OR :1,360 ; 1,002-1,845 ; p=0,048) étaient significativement associés au prédiabète. *Conclusion.* La forte prévalence observée du prédiabète nécessite des mesures préventives, notamment une alimentation saine, une pratique régulière de l'activité physique et une faible consommation d'alcool, pour lutter contre le surpoids/obésité, socle de l'insulinorésistance.
Mots-clés : prédiabète, adultes congolais, facteurs associés, République démocratique du Congo

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including a healthy diet, regular physical activity and low alcohol consumption, to combat overweight/obesity, the basis of insulinoresistance.
Keywords: prediabetes, Congolese adults, factors associated, the Democratic Republic of the Congo

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Introduction
Diabetes mellitus is a major public health problem with serious consequences. According to recent statistics, 537 million people aged 20 to 79 years suffer from diabetes worldwide, and more than three out of four adults live in low- and middle-income countries (1-2). Furthermore, the number of people with diabetes in Africa stands at 24 million, with an expected increase of 129% by 2045, the highest increase of any region according to the International Diabetes Federation's 2021 forecast (1). Thus, people with prediabetes who are at high risk of developing type 2 diabetes mellitus must be managed to reduce this heavy burden, although not all will develop it (3). In 2021, an estimated 541 million adults, or 10.6% of adults worldwide, were estimated to have impaired glucose tolerance. By 2045, this figure is expected to reach 730 million adults, or 11.4% of all adults (1). Furthermore, the regional prevalence of prediabetes in Africa was estimated at 7.8% (40.9 million) in 2021 and is projected to reach 8.0% (84.7 million) by 2030 (1, 4). Iin the Kabuyanda sub-county, rural Isingiro district in Uganda, the prevalence of prediabetes was 9.19% (95% CI 6.23–12.14) in 2021 (5). The prevalence of prediabetes varies considerably among East African populations, ranging from 2.0% to 43.2%, reflecting wide variation across different testing methods, diagnostic criteria, and residential settings (2, 6). The weighted prevalence of pre-diabetes was 18.7% in Namibia and 70.1% in South Africa (7). In the Democratic Republic of Congo (DRC), studies on prediabetes are almost nonexistent. Prediabetes is defined as a toxic state of intermediate hyperglycemia, constituting an important precursor to the development of type 2 diabetes, with an annual conversion rate

ranging from 5 to 10% and a similar proportion of patients returning to normoglycemia (8-9). In the recent pass, prediabetes included two specific parameters: impaired glucose tolerance (2-h blood glucose after ingestion of 75 g of anhydrous glucose 7.8-11.0 mol/L [140-199 mg/dL]) and moderate fasting hyperglycemia (fasting glucose 6.1-6.9 mmol/L [110-125 mg/dL]), based on the World Health Organization criteria used to define prediabetes (8-9). However, according to the 2024 edition of the American Diabetes Association (10), prediabetes is defined by an elevated fasting plasma glucose (FPG) concentration (≥100 and ≤ 126 mg/dl) or an elevated 2-h plasma glucose concentration (≥140 and < 200 mg/dl) after a 75-g glucose load on the oral glucose tolerance test or an elevated glycated hemoglobin (≥ 5.7 and < 6.5%). According to this latter definition, prediabetes can be considered based on any of these three criteria without the need to combine them. This latter definition inspired the present work. According to a recent meta-analysis, prediabetic individuals are six times more likely to develop diabetes than normal glycemic individuals (11). Nearly one-third of adults with prediabetes are between the ages of 20 and 39, implying that they will spend many years at high risk of developing type 2 diabetes mellitus and other health problems (12-13). Common determinants of prediabetes in low- and middle-income countries include globalization, unhealthy lifestyles, lack of awareness, and a lack of intervention programs (14). Modifiable risk factors can easily be improved by making recommended lifestyle changes or optimizing given pharmacotherapy (15). These risk factors include physical inactivity, poor diet, smoking, and alcohol consumption as the main behavioral risk factors, while obesity, high blood pressure, and dyslipidemia are the cardiometabolic risk factors (15). Recent research has revealed that some people with prediabetes develop chronic complications of diabetes, including microvascular and macrovascular complications (16). A meta-analysis included 53 prospective cohort studies with more than 1.6 million participants, showed that compared with normoglycaemia, prediabetes was associated with a higher risk of atherosclerotic cardiovascular disease and all-cause mortality (17). Other prospective cohort studies reveal that this cardiovascular risk would be higher in glucose intolerance; in fact, in a meta-analysis of 10 European studies, enrolling more than 22,000 subjects, the risk of mortality from cardiovascular disease was approximately 30% higher in people with glucose intolerance than in moderate fasting hyperglycemia or normoglycemic subjects (18).This study aimed to examine the prevalence and factors associated with prediabetes in Congolese adults in 2019 in a rural health zone of Gombe Matadi in the Kongo Central Province in the DRC.

Methods

This cross-sectional analytical study used archived data from a population-based household survey conducted in May 2019 in the rural health zone of Gombe-Matadi, located in Kongo Central Province, DRC. The sample was random.

After calculation, a sample of 1,600 individuals was obtained using proportional sampling according to health areas. The formula used was: $n=(Z^2pq/d^2)*g*1/1-f$. Z=1.96, the prevalence of diabetes p=0.05 (q=1-p) corresponds to that found in Kisantu (6), in the DRC. The desired precision was equivalent to 0.02, and g represented the correction coefficient for the cluster effect increasing to 2 (19). The non-response rate was estimated at 10%. To select survey participants, the team proceeded in five steps (20-21).

In the first stage, three health areas were selected by simple random sampling and considered as a cluster. In the second stage, villages within the clusters were selected according to demographic weight (> 200 inhabitants) and distance (< 4 km from the study site). In the third stage, a systematic selection of inhabited plots in each selected village was carried out after listing and numbering all inhabited plots. The sampling interval for each village health area was the number of inhabited plots divided by the proportional sample of the village. All identified plots were retained. In the fourth stage, after listing all households, a simple random selection of households was carried out in each plot. In the fifth stage, one eligible subject was drawn at random by simple random selection from each household. Of the 1600 individuals expected, only 1531 aged at least 19 years, including 809 women (52.8%) who had freely consented to participate, were included in the study (63 did not respond on the second day of the survey and 6 women were pregnant).

Data Collection

The survey was coordinated and supervised by members of the Kinshasa School of Public Health. The survey lasted 39 days. The selected field agents received a three-day training course on diabetes, hypertension, and questionnaire use. A pre-test was conducted with individuals not selected for the survey. Three sites were selected (health center, school, church) per health area. Participant registration and the first fasting blood glucose test were performed at home after obtaining the participant's consent. An appointment card was given to the participant to perform an oral glucose tolerance test, complete the questionnaire, take measurements, and perform a fasting blood glucose test. In the absence of the selected participant, the field agent returned the same day or the following day. If the selected participant did not meet the criteria, another participant was randomly selected, and a plot with no eligible participants was skipped in favor of the next one. At the end of each day, participants' names were coded and the code copied into the corresponding questionnaire. Clinical data collected included gender, age, personal history of diabetes mellitus, hypertension and related treatment, and alcohol and tobacco consumption. Measurements were taken at the study site. Two blood pressure measurements and heart rate were taken simultaneously using a well-calibrated electronic blood pressure monitor. The average of two blood pressure measurements was used for analysis. Height and weight were measured using standard methods using a height rod and scales. Waist circumference was measured at the navel using a tape measure. Two fasting capillary blood glucose measurements were taken using a well-calibrated Codefree glucometer daily as reported in the first article of the 2019 survey (22). Oral glucose tolerance testing was performed in all but 25 participants (two with a blood glucose level ≥ 200 mg/dL on day 1, two with a blood glucose level ≥ 200 mg/dL on day 2, and 21 known diabetics). A capillary blood glucose level was taken, and the participant ingested 75 g of anhydrous glucose in 250 mL of water over 5 min. After 2 hours, another capillary blood glucose level was taken. In accordance with American Diabetes Association (10), prediabetes is defined by an elevated 2-h plasma glucose concentration (≥140 and < 200 mg/dl) after a 75-g glucose load on the oral glucose tolerance test in any participant not known to have diabetes. Diabetes is defined as a blood glucose level two hours after an oral glucose tolerance test (OGTT) ≥ 200 mg/dL or a participant with a diabetic logbook or receiving antidiabetic treatment. Overweight/obesity is defined as a BMI ≥ 25 kg/m². Abdominal obesity is defined as a waist circumference ≥ 94 cm and ≥ 80 cm for men and women, respectively (23). Hypertension is defined as a systolic blood pressure (SBP) ≥ 140 mmHg and/or a diastolic blood pressure (DBP) ≥ 90 mmHg, or the use of antihypertensive treatment. Age is classified into < 40 years and ≥ 40 years.

Statistical Analysis

Data analysis was performed using SPSS software version 25.0. Descriptive and inferential statistical techniques were used for the analyses. Categorical data were expressed as absolute frequencies. The median and interquartile range were reported for quantitative variables with a skewed distribution. Normality of the distribution was determined using the Shapiro-Kolmogorov test. The chi-square test was used to examine the relationship between prediabetes and associated factors, and logistic regression was used to identify potential factors associated with prediabetes (age < 40 and ≥ 40 years, physical inactivity, alcohol consumption, smoking, abdominal obesity, overweight/obesity, family history of diabetes, occupation, hypertension, and gender). A test was considered statistically significant when p was < 0.05.

Ethics Statement

The survey protocol underlying this study was approved by the National Ethics Committee of the DRC under number 104/CNES/BN/PMMF/2018 of 23/01/2019. All participants provided informed consent, and their data were kept confidential.

Results

Clinical and Laboratory Characteristics of Participants

The clinical and laboratory characteristics of the participants are shown in Table 1. The median age was 49.57 years with a median daily walking time of 120 minutes (interquartile range (IQR) of 144 minutes). The median BMI, waist circumference and blood glucose 2 hours after Oral glucose tolerance test (OGTT) were 21 kg/m² with an IQR of 4 kg/m², 76 cm (IQR of 11 cm), and 115 mg/dL (IQR of 33.8 mg/dL), respectively.

Table 1. Clinical and biological Characteristics of participants

Characteristics	Median	EIQ	Minimum	Maximum	Kolmogorov Test
Age, years	49.6	21.1	19	96	0.006
Daily walking time, minutes	120	144	5	960	0.001
Weight, kg	53.3	13.4	28.7	123.6	0.001
Height, m	1.6	1.3	1.2	1.9	0.002
Body mass index, kg/m²	21	4	12	46	0.001
Weist, cm	76	11	59	161	0.001
SBP, mmHg	122	26.5	78.5	233.5	0.001
DBP, mmHg	75	15	47.5	136	0.001
FBG on day 1, mg/dL	94	15	31	300	0.001
FBG on day 2, mg/dL	95	18	28	301	0.001
Blood glucose 2 hours after OGTT, mg/dL	115	33.8	57	327	0.001

IQR: Interquartile range, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, BMI: body mass FBG: Fasting blood glucose; OGTT: Oral glucose tolerance test

Cardiovascular Risk Factors for All Participants and by Glycemic Status

Table 2 shows cardiovascular risk factors for all participants and by glycemic status. The proportion of participants aged 40 years and older increased with glycemic category. Normoglycemia, prediabetes and diabetes mellitus were observed in 80.9%, 15.8% and 3.3% of participants respectively. The main cardiovascular risk factors observed were alcohol consumption (28.4%), high blood pressure (28.3%), smoking (25%), abdominal obesity (22.1%), family history of diabetes (15.8%), physical inactivity (15.1%), and overweight/obesity (13.6%). The rate of alcohol consumption decreased, while the prevalence of high blood pressure, abdominal obesity, and overweight/obesity increased significantly with glycemic category (p<0.001).

Table 2. Cardiovascular risk factors for all participants and according to glycemic status

Cardiovascular risk factors	All N=1531	Normoglycemia N=1239 (%)	Prediabetes N=242 (%)	Diabetes N=50 (%)	p-value
Sex					0.226
Male	722 (47.2)	595 (48)	102 (42.1)	25 (50)	
Female	809 (52.8)	644 (52)	140 (57.9)	25 (50)	
Age, years					<0.001
< 40	417 (27.2)	361 (29.1)	53 (21.9)	3 (6)	
≥ 40	1114 (72.8)	878 (70.9)	189 (78.1)	47 (94)	
Alcohol consumption	435 (28.4)	378 (30.5)	47 (19.4)	10 (20)	<0.001
Hypertension	433 (28.3)	327 (26.4)	86 (35.5)	20 (40)	0.003
Smoking	383 (25)	319 (25.7)	51 (21.1)	13 (26)	0.304
Obdominal obesity	337 (22.1)	247 (19.9)	70 (28.9)	20 (40)	<0.001
Family history of diabetes	242(15.8)	188(15.2)	46(19.0)	8(16.0)	0.327
Sedentary lifestyle	232 (15.1)	185 (14.9)	37 (15.3)	10 (20)	0.617
Overweight/Obesity	208 (13.6)	150 (12.1)	41 (16.9)	17 (34)	<0.001

Values are absolute and relative frequencies in percentages in parentheses.

Factors associated with prediabetes

In a logistic regression analysis, alcohol consumption (p=0.007; OR 1.669; CI 1.151-2.421) and high blood pressure (p=0.048; OR 1.360; CI 1.002-1.845) were associated with prediabetes.

Discussion

This analytical cross-sectional study used archived data from 1,531 randomly selected individuals from a survey conducted in May 2019 in the rural health zone of Gombe-Matadi, DRC, to determine the prevalence and factors associated with prediabetes. Key findings include: 1. The prevalence of prediabetes was 15.8%. 2. A constellation of cardiovascular risk factors, such as alcohol consumption, high blood pressure, smoking, abdominal obesity, physical inactivity, and overweight/obesity, was observed. 3. The prevalence of high blood pressure, abdominal obesity, and overweight/obesity significantly increased with blood glucose level. 4. In a logistic regression analysis, alcohol consumption and high blood pressure increased the risk of prediabetes. In the present study, the prevalence of prediabetes was 15.8%. Similar prevalence has been reported by other authors (4, 24-27). In agreement with some authors (28-29), alcohol consumption increased the risk of prediabetes in this study. Several studies have demonstrated the interrelationships between alcohol consumption and diabetes mellitus (30). Alcohol may, on the one hand, exert a diabetogenic influence by increasing adiposity, a condition known to lead to insulin resistance, and, on the other hand, impair insulin sensitivity (31). Besides alcohol consumption, high blood pressure has also emerged as a risk factor for prediabetes. Aramo et al made a similar finding in Uganda (32). Studies conducted in East Africa (4) showed that compared to non-hypertensives, hypertensives were 2.4 times more likely to develop prediabetes. Other authors (33) found a positive association between high blood pressure and diabetes mellitus. High blood pressure induces microvascular dysfunction, which may contribute to the pathophysiology of diabetes development (34). Endothelial dysfunction, which is linked to insulinoresistance, is also closely associated with high blood pressure, and biomarkers of endothelial dysfunction have been shown to be independent predictors of type 2 diabetes mellitus (34). Insulinoresistance is a breeding ground for the development of hypertension, type 2 diabetes mellitus, and cardiovascular disease. In addition, inflammatory markers, particularly C-reactive protein, are linked to both incident type 2 diabetes and increased blood pressure levels. In the present study, the prevalence of overweight/obesity and abdominal obesity increased significantly with blood glucose category. Obesity is the most important modifiable risk factor underlying the development of insulinoresistance. Through insulinoresistance and impaired pancreatic insulin secretion, it promotes the development of prediabetes and, subsequently, type 2 diabetes mellitus. Through insulinoresistance and subsequent hyperinsulinemia, it leads to sympathetic hyperactivity, activation of the renin-angiotensin-aldosterone system, and impaired endothelial function, leading to the onset of hypertension (35-36). Furthermore, the median age of 50 years of the participants represented an additional risk factor favorable to the development of insulinoresistance. In accordance with the literature (37), the constellation of cardiovascular risk factors was observed in Congolese adults, making him a person at significant overall cardiovascular risk.

In the present study, 15% of participants were sedentary, and the rate of sedentary behavior was not significantly different across the three blood glucose categories. Yet, the prevalence of abdominal obesity and overweight/obesity was high and increased significantly with blood glucose category. Information on physical activity practice is an anamnestic and subjective data while the weight indices taken from a patient are objective signs. Misinterpretation by some participants of the administered questionnaire could provide erroneous information, particularly on the practice of physical activity. Physical activity can only have a positive impact on weight indices if it results in caloric expenditure that is greater than daily caloric intake. The high prevalence of abdominal obesity would indicate an imbalance in the energy balance in favor of intake. Our rural areas are increasingly being invaded by imported food products rich in sugars, fats and animal proteins from cities. A sedentary lifestyle can only influence the increase in blood sugar through obesity. However, in the present study, the prevalence of abdominal obesity increased significantly with the blood sugar category. Obesity results from the interaction between non-modifiable genetic factors and modifiable behavioral risk factors (high-calorie diet and a sedentary lifestyle).

This study has some limitations, including the fact that it is based on a single blood sugar measurement to conclude on prediabetes; considering that the definition of prediabetes was based only on the intermediate blood glucose level obtained in the oral glucose tolerance test, its prevalence could be underestimated compared to the results of two combined tests; the cross-sectional nature of the study does not allow a cause-effect relationship to be established; the absence of other biological parameters, including serum lipids, suggests an underestimation of the overall cardiovascular risk among participants. Given the sampling technique used, we do not know to what extent these results can be extrapolated to our entire country. However, this work has the merit of being one of the rare studies in our country that have examined the factors associated with prediabetes. The Step Wise methodology of the World Health Organization used and its sample size reinforce the results obtained.

Conclusion

The observed high prevalence of prediabetes requires preventive measures, including a healthy diet and regular physical activity, to combat overweight/obesity, the basis of insulinoresistance.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mikobi JPM and Bayauli PM conceived and wrote the article. Bayauli PM, NKongolo BK, and Mikobi JPM analyzed the data. Muyer TM and Mapatano AM coordinated data collection. Bayauli PM supervised the work. All authors approved the final version and revised the manuscript.

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