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Variation in Body Composition Parameters According to Type 2 Diabetes Risk Levels

Noël Désirée Mbango-Ekouta[1,2*], Sandrine Ongnessek[1], Vanessa Ngo Bikai[1,3], Wilfried Steve Ndeme Mboussi[4], Jacques Narcisse Doumbe[5]

[1]Faculty of Medicine and Pharmaceutical Science, University of Douala, Douala, Cameroon
[2]Douala Gynaeco-Obstetric and Pediatric Hospital, Douala, Cameroon
[3]Douala Laquintinie Hospital, Douala, Cameroon
[4]Faculty of Science, University of Douala, Douala, Cameroon
[5]Faculty of Medicine and Pharmaceutical Science, University of Dschang, Dschang, Cameroon
Email: *mbangoedisari@yahoo.fr

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Abstract

Context: Variations in body composition parameters can significantly impact the risk of developing type 2 diabetes (T2D). Proactive management of these parameters can play a crucial role in prevention. The objective of our study was to examine the variation in body composition parameters among patients at risk of type 2 diabetes. **Methods:** We conducted a cross-sectional study involving 333 patients. Diabetes risk was assessed using the FINDRISC score, and body composition was evaluated using bioelectrical impedance analysis (BIA). One-way analysis of variance (ANOVA) and Duncan's post hoc test (95% CI, alpha = 0.05) were performed for comparisons using R software. **Results:** The mean age of the patients was 47 ± 13 years, with a female predominance (63%). Of the participants, 48.4% had a low risk, 28.5% had a high risk, and 6% were at risk of developing T2D within 10 years. BMI was highest among patients at risk of T2D within 10 years (34.3 ± 3.6 kg/m^2). Muscle mass was highest in non-diabetic individuals (36 ± 6 kg) and lowest in the increased-risk group (22 ± 2 kg), while bone mass was highest in the same group (3.15 ± 0.51 kg). The percentage of body water was highest among non-diabetics (49.0% ± 6.7%), whereas the percentage of body fat reached its maximum in the increased-risk group (52% ± 4%). Visceral fat was also higher in patients at increased risk (13.7 ± 3.9 kg) and those at risk within 10 years (13.1 ± 1.1 kg). **Conclusion:** Body composition varies significantly according to the risk of developing type 2 diabetes.

Keywords

Body Composition, Type 2 Diabetes Risk, Bioimpedance, FINDRISC Score

1. Introduction

Type 2 diabetes (T2D) is a chronic metabolic disease resulting from a combination of insulin resistance and impaired insulin secretion by the pancreatic β-cells of the islets of Langerhans. This condition is often associated with behavioral and environmental factors such as obesity, a sedentary lifestyle, a high-calorie diet, and genetic predisposition [1]-[3]. T2D accounts for nearly 90% of diabetes cases worldwide, affecting millions of individuals and leading to severe chronic complications, including cardiovascular, renal, and neurological diseases [3] [4].

According to the International Diabetes Federation (IDF), 537 million adults had diabetes in 2021, and this number is projected to reach 783 million by 2045 [5]. Although Africa has a lower prevalence compared to other regions (approximately 4.5%), the continent is experiencing the fastest growth in diabetes cases, with a projected 129% increase by 2045 [6]. In Cameroon, the diabetes prevalence was estimated at 5.8% in 2019, predominantly in urban areas due to nutritional transition and modern lifestyles [7].

Body composition, including body mass index (BMI), muscle mass, bone mass, body water percentage, total body fat, and visceral fat, plays a central role in the development and progression of T2D. Excess visceral fat, in particular, releases inflammatory cytokines and free fatty acids that disrupt insulin signaling, thereby promoting insulin resistance [8] [9]. Simultaneously, reduced muscle mass lowers glucose uptake capacity, exacerbating hyperglycemia [10] [11]. These changes are accompanied by molecular alterations, including chronic activation of pro-inflammatory pathways (NF-κB, JNK) and decreased expression of GLUT-4 transporters in skeletal muscles [12].

Studying variations in body composition parameters based on T2D risk levels is essential for identifying predictive biomarkers and developing targeted preventive strategies. Given the growing prevalence of T2D, particularly in resource-limited settings like Cameroon, understanding how different body composition components influence disease risk is critical.

The primary objective of this study was to evaluate variations in body composition parameters (BMI, muscle mass, bone mass, body water percentage, body fat percentage, and visceral fat) based on T2D risk levels. This analysis aimed to identify significant differences among groups at low risk, increased risk, and individuals at 10-year risk, to better understand the role of body composition in the occurrence of T2D.

2. Materials and Methods

2.1. Study Type, Period, and Location

We conducted a cross-sectional study over one year, from January 2024 to December 2024, in the endocrinology department of the Douala Gyneco-Obstetric and Pediatric Hospital.

2.2. Study Population

The study population consisted of patients consulting for T2D in the department or diagnosed with T2D during hospitalization who freely and knowingly consented to participate in the study. Patients with symptoms unrelated to T2D or those who refused participation were excluded. The minimum sample size was calculated using Lorentz's formula [13]. A total of 333 patients were included, with diabetes risk assessed using the FINDRISC score and body composition measured by bioimpedance analysis.

2.3. Diabetes Risk Assessment Using the FINDRISC Score

Diabetes risk was assessed using the FINDRISC (Finnish Diabetes Risk Score), a simple and validated tool for estimating the risk of developing T2D. The score is based on a questionnaire encompassing clinical and sociodemographic parameters such as age, BMI, waist circumference, physical activity level, dietary habits (fruit and vegetable consumption), family history of diabetes, and previous elevated blood glucose levels. Each response is assigned a specific score, and the total points classify individuals into different risk levels: low (0 - 11, risk ≈ 5%), high (≥15, risk ≈ 33%), or at risk within 10 years (≥20) [14].

2.4. Measurement of Body Composition Parameters by Bioimpedance Analysis

Body composition parameters were measured by bioelectrical impedance analysis (BIA), which assesses the body's resistance and reactance to a low-intensity current [15]; the principle relies on the differential conductivity of tissues according to their water and electrolyte content, with fat—low in water—offering high resistance, unlike lean tissues. Patients stood on a BIA device with foot electrodes; the device recorded impedance to estimate muscle mass, bone mass, total body water, body fat percentage, and visceral fat [16], with calculations based on predictive equations incorporating age, sex, weight, and height [17]. To limit selection bias, recruitment was consecutive within the same source population for both diabetic and non-diabetic subjects, with frequency matching (sex/age bands) and biological confirmation of non-diabetic status; a screening log recorded approached, included, refused, and ineligible individuals. Measurements were performed using a Smart Wireless Digital Bathroom Scale (foot-to-foot, single-frequency), after zeroing, weekly verification of weight accuracy (5- and 10-kg standard masses), and under standardized conditions (morning 7:00-11:00, fasting ≥4 h, no alcohol for 24 h, no vigorous exercise for 12 h, bladder voided within 30 min, barefoot with dry soles, 22˚C - 26˚C); 10% of participants had duplicate readings, a third measurement was taken if differences exceeded 0.5 kg for weight or 1 percentage point for body fat, and the mean/median was retained, with no manual alteration of device estimates.

2.5. Data Collection Procedure

Data were collected using a structured survey form. After obtaining informed consent during a 5-minute interview, we began by collecting sociodemographic data (age, sex, residence, marital status). We then assessed T2D risk and measured body composition according to the methodologies described earlier. Data were recorded and analyzed in an Excel spreadsheet.

3. Statistical Analysis

Data were analyzed using R software version 4.4.2 and GraphPad version 8.4.3 for Windows. Qualitative variables were presented as frequencies (N, n) and percentages (%). Quantitative variables were presented as means ± standard deviations (SD). The Kruskal-Wallis rank sum test, Pearson's chi-squared test, Fisher's exact test, one-way ANOVA, and Duncan's post hoc test were conducted to explore associations and make comparisons. For these tests, the confidence interval for the null hypothesis was set at 95%, with a significance threshold of 5% (p-value significant if $p < 0.05$).

4. Results

4.1. Distribution of the Study Population by Diabetic Status

The majority of patients (48.4%, n = 161) were at low risk, followed by those at increased risk (28.5%, n = 95). Non-diabetic participants accounted for 17.1% (n = 57), while only 6% (n = 20) were classified in the group at risk of developing type 2 diabetes within the next 10 years (**Figure 1**).

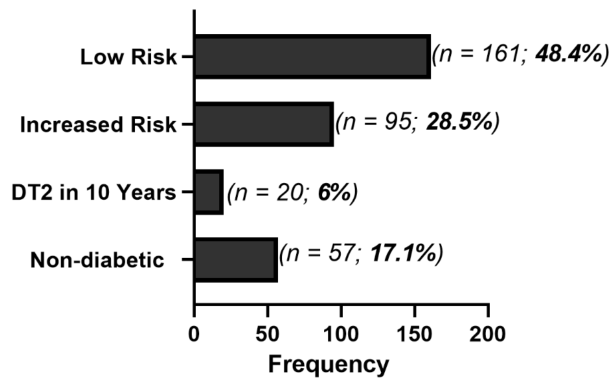

Figure 1. Distribution of the study population according to diabetic status.

4.2. Sociodemographic Factors of the Study Population

The mean age of the patients was 47 ± 13 years and varied significantly between groups, with non-diabetic patients being younger (47 ± 13 years) than those at risk of developing diabetes within 10 years (55 ± 11 years, $p < 0.001$). Sex also showed a significant association with diabetes risk ($p = 0.001$), with women being predominant across all groups, although the low-risk group had a higher proportion of women (29%). Marital status differed slightly between groups, with a majority of participants being married across all risk levels (56% overall). Residence, however, did not show a significant difference between groups ($p = 0.2$), with the majority of participants living in urban areas (88%) (**Table 1**).

Table 1. Sociodemographic factors of the study population.

Sociodemographics Factors	Overall (N = 333)	Non-diabetic (n = 57)	DT2 in 10 Years (n = 20)	Increased Risk (n = 95)	Low Risk (n = 161)	p-value
Age (years)	47 ± 13	55 ± 11	51 ± 6	51 ± 10	40 ± 12	<0.001
Gender						0.001
Female	210 (63%)	43 (13%)	19 (5.7%)	52 (16%)	96 (29%)	
Male	123 (37%)	14 (4.2%)	1 (0.3%)	43 (13%)	65 (20%)	
Marital status						
Married	186 (56%)	34 (10%)	12 (3.6%)	66 (20%)	74 (22%)	
Single	120 (36%)	12 (3.6%)	8 (2.4%)	22 (6.6%)	78 (23%)	
Widowed	27 (8.1%)	11 (3.3%)	0 (0%)	7 (2.1%)	9 (2.7%)	
Residence						0.2
Urban	294 (88%)	53 (16%)	20 (6.0%)	81 (24%)	140 (42%)	
Rural	39 (12%)	4 (1.2%)	0 (0%)	14 (4.2%)	21 (6.3%)	

DT2: Type 2 diabetes. The data were presented as mean and standard deviation, count and frequency (N, n), and percentage (%). p-value: The Kruskal-Wallis rank sum test, Pearson's chi-squared test, and Fisher's exact test were performed to compare and examine the association between sociodemographic factors and the risk of diabetes. For these tests, the confidence interval was set at 95% and the margin of error at 5%.

4.3. Variation in Body Composition Parameters

Body mass index (BMI) was significantly higher in patients predicted to develop type 2 diabetes within 10 years (34.3 ± 3.6 kg/m^2) compared to other groups. Muscle mass varied significantly, with the highest value observed in non-diabetic individuals (36 ± 6 kg) and the lowest in the increased-risk group (22 ± 2 kg). Bone mass was significantly higher in the increased-risk group (3.15 ± 0.51 kg). The percentage of body water was highest in non-diabetic individuals (49.0% ± 6.7%) and lower in other patients. Body fat percentage was highest among patients in the increased-risk group (52% ± 4%). Lastly, visceral fat was significantly higher in patients at increased risk (13.7 ± 3.9 kg) and in those at risk of diabetes within 10 years (13.1 ± 1.1 kg) compared to non-diabetic individuals (11.5 ± 1.9 kg) and the low-risk group (10.1 ± 4.5 kg) (Table 2).

Table 2. Variations in body composition parameters based on diabetic status.

Body Composition Parameters	Non-diabetic (N = 57)	DT2 in 10 Years (N = 20)	Increased Risk (N = 95)	Low Risk (N = 161)
Body mass index (kg/m^2)	29.4 ± 3.8^a	34.3 ± 3.6^b	28.9 ± 5.0^a	28.7 ± 5.7^a
Muscle mass (kg)	36 ± 6^d	30 ± 7^c	22 ± 2^b	27 ± 5^a
Bone mass (kg)	2.63 ± 0.42^a	2.76 ± 0.54^a	3.15 ± 0.51^b	2.62 ± 0.43^a
Body water percentage (%)	49.0 ± 6.7^b	42.9 ± 3.7^a	42.5 ± 5.3^a	42.0 ± 4.5^a
Body fat percentage (%)	40 ± 11^a	35 ± 11^c	52 ± 4^b	42 ± 12^a
Visceral fat (kg)	11.5 ± 1.9^{ab}	13.1 ± 1.1^{ac}	13.7 ± 3.9^c	10.1 ± 4.5^b

The data are presented as mean ± Standard Deviation (SD); Ordered analysis of variance and Duncan's post hoc test were used for comparisons. Within the same row, means with the same letter are not statistically significant at $p < 0.05$.

5. Discussion

The results of this study highlight a significant variation in body composition parameters based on T2D risk levels, emphasizing their critical role in the pathogenesis and prediction of diabetes. These findings confirm the importance of monitoring and intervening on these parameters to prevent T2D.

Body mass index (BMI) was significantly higher in patients at risk of T2D within 10 years (34.3 ± 3.6 kg/m^2), consistent with previous studies establishing a direct link between obesity and T2D [18] [19]. Excess body fat, particularly visceral fat, promotes chronic inflammation and releases inflammatory cytokines (such as TNF-α and IL-6), which disrupt insulin signaling and contribute to insulin resistance [20] [21].

Muscle mass, on the other hand, was highest in non-diabetic individuals (36 ± 6 kg) and lowest in the increased-risk group (22 ± 2 kg). This can be explained by the role of skeletal muscles as the primary sites for glucose uptake under insulin stimulation [22] [23]. Reduced muscle mass decreases this uptake, exacerbating hyperglycemia and increasing T2D risk [24].

Bone mass was significantly higher in the increased-risk group (3.15 ± 0.51 kg), which may seem paradoxical. However, some studies suggest that higher bone mass levels might be associated with metabolic alterations due to insulin resistance in bones, affecting bone formation and remodeling [25].

The percentage of body water was highest in non-diabetic individuals (49.0% ± 6.7%), reflecting better hydration and a more balanced body composition. Patients in the increased-risk group had lower values, suggesting altered body fluids, often observed in individuals with excess body fat or inflammation [26].

Body fat percentage was highest in the increased-risk group (52% ± 4%). A high proportion of body fat, especially visceral fat, is a key factor in T2D development. It disrupts metabolic balance by releasing free fatty acids and inflammatory mediators that exacerbate insulin resistance [27].

Finally, visceral fat was significantly higher in the increased-risk group (13.7 ± 3.9 kg) and in patients at risk of T2D within 10 years (13.1 ± 1.1 kg). Visceral fat is particularly harmful as it is metabolically active and directly associated with the risk of metabolic diseases, including T2D [28]. Excessive visceral fat accumulation promotes hyperinsulinemia and elevated blood glucose levels.

Clinically, these patterns support low-cost, scalable actions that target visceral adiposity reduction and preservation of lean mass: enroll high-risk adults in structured lifestyle programs delivering ≥150 min/week of moderate aerobic activity plus ≥2 weekly resistance-training sessions, pair this with a calorie-controlled, high-fiber eating pattern, and integrate FINDRISC with routine waist-circumference and BIA tracking every 3 - 6 months to trigger referral to prevention programs; address sleep and smoking cessation; and, for very-high-risk individuals with persistent dysglycemia, consider metformin as per ADA prevention guidance (individualized) [29]-[31]. These steps are aligned with international recommendations and feasible in resource-limited primary care [31] [32].

To situate these results in the African context, recent data from Uganda (2023) and South Africa (2024) show that BIA-derived adiposity—especially visceral fat—and lower total body water are associated with type 2 diabetes or higher cardiometabolic risk, reinforcing the value of monitoring body composition alongside BMI in Sub-Saharan Africa [29] [30].

6. Conclusion

Our findings underscore the importance of monitoring body composition parameters as indicators of T2D risk. Proactive management, including interventions targeting BMI, muscle mass, and visceral fat reduction, could significantly lower the incidence of T2D, particularly in high-risk populations.

Ethical Approval and Consent to Participate

Our study was reviewed and approved by the Institutional Ethics Committee of Douala Gynaeco-Obstetric and Pediatric Hospital (N˚2024/1626/HGOPED/DG/CEI). Written informed consent for participation in this study was obtained from each participant. Given that our study involved experiments on human subjects and/or the use of human tissue samples, we confirm that all experiments were conducted in accordance with applicable guidelines and regulations.

Availability of Data and Materials

The data used in this study can be made available upon request by the reviewers.

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The authors declare that the research was conducted without external funding.

Authors' Contributions

Noël Désirée Mbango-Ekouta and Wilfried Steve Ndeme Mboussi conceptualized the study, designed the experimental approach, and developed the writing plan. Noël Désirée Mbango-Ekouta, Vanessa Ngo Bikai and Sandrine Ongnessek were responsible for participant recruitment and laboratory analyses. Statistical analysis was performed by Wilfried Steve Ndeme Mboussi. Noël Désirée Mbango-Ekouta drafted the initial manuscript, while Sandrine Ongnessek and Jacques Narcisse Doumbe critically reviewed and revised it. All authors made substantial, direct, and intellectual contributions to the work and approved the final version of the manuscript for publication.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be interpreted as a potential conflict of interest.

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