Body composition of type 2 diabetes patients in Uganda: A case-control study

Ronald Buyinza,[1] Jonathan Nsamba,[2,8] Anthony Muyingo,[3] Nicholas Matovu,[4,5] Gloria Nabirye,[6] Adellah Kantengwa,[3] Sandra Akandunda,[3] Wenceslaus Sseguya,[7] Elezebeth Mathews[8]

[1]Pharmacy Department, Mbarara Regional Referral Hospital, Mbarara, Uganda; [2]Department of Clinical Research, Jeuticals Research and Consulting (U) Ltd., Kampala, Uganda; [3]Diabetes Clinic, Mbarara Regional Referral Hospital, Mbarara, Uganda; [4]Department of Community Health and Behavioural Sciences, School of Public Health, Makerere University, Kampala, Uganda; [5]Centre for Public Health, Queens University Belfast, Belfast, United Kingdom; [6]Department of Nursing, Faculty of Health Sciences, Busitema University, Busitema, Uganda; [7]Diabetes Clinic, St. Francis Nsambya Hospital, Kampala, Uganda; [8]Department of Public Health and Community Medicine, Central University of Kerala, Periya, India

Abstract

Introduction: The prevalence of obesity among people diagnosed with Type 2 Diabetes Mellitus (T2DM) has been widely documented. However, the specific composition of this bodyweight remains largely unknown. The study aimed to understand the body composition of T2DM patients using the bioelectric impedance analysis technique, comparing findings to sex and age-matched controls.

Materials and Methods: A comparative case-control study was carried out among 139 known cases of Type 2 diabetes aged 18 to 78 years randomly sampled from the diabetic clinic of Mbarara Regional Referral Hospital. We matched them to 139 hospital controls who were healthy non-diabetic attendants. Body composition parameters were computed and summarized as medians and interquartile ranges. Differences in the medians of body composition parameters were further assessed using the Mann-Whitney U test. Fat-free and fat mass indices were derived to offer a precise estimation of body composition parameters adjusted for height differences among study participants.

Results: Cases had significantly higher median systolic blood pressure, pulse rate, weight, Body Mass Index (BMI), Waist-Hip Ratio (WHR), total fat percentage, fat mass amount, Fat Mass Index, visceral fat, and metabolic age than their counterparts, whereas controls had significantly higher median total body water percentage versus cases. The highest significant differences occurred in fat percentage composition (Cases: β: 6.9 (95% C.I: 4.4, 9.4); Controls: Ref) followed by visceral fat (Cases: β: 3.5 (95% C.I: 2.5, 4.4); controls: Ref) and Fat Mass Index (Cases: 95% C.I: 2.6 (95% C.I: 1.6, 3.7). Cases had significantly higher Fat Mass Index, visceral fat and fat percentage (all $p<0.05$) than controls.

Conclusions: Routine assessment of body composition of T2DM patients needs to be done to assess the amount, type and pattern of weight gain to prevent increases in adiposity.

Correspondence: Ronald Buyinza, Pharmacy Department, Mbarara Regional Referral Hospital, Mbarara, Uganda.
E-mail: buyinzaronald@yahoo.com

Contributions: RB, conceptualization, data collection, analysis, writing of the manuscript, editing, proofreading; JN, data collection, analysis, writing of manuscript, editing, proofreading; AM, technical guidance and oversight; NM, data analysis, writing of manuscript, editing, proofreading; AK, SA, GN, data collection; WS, technical guidance, editing, proofreading; EM, technical advice and oversight. All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: The authors declare no potential conflict of interest.

Funding: This study was supported by a capacity building research grant extended through Mbarara Regional Referral Hospital and Mbarara University of Science and Technology 2020 by Hansjoerg Wyss and Massachusetts General Hospital.

Ethics approval and consent to participate: The study obtained ethical clearance from the Mbarara University of Science and Technology Research Ethics Committee (MUREC 1/7). Informed written consent was obtained from the participants. Privacy and confidentiality were maintained. Pregnant women were not enrolled due to a lack of evidence for the unborn child's safety regarding bioelectrical impedance.

Informed consent: Informed written consent was obtained from the participants. Privacy and confidentiality were maintained.

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

Acknowledgements: We thank our study participants, research assistants and clinic staff for their dedication and participation in the study.

Received for publication: 4 June 2022.
Accepted for publication: 28 June 2022.

Journal of Public Health in Africa 2023; 14:2249
doi:10.4081/jphia.2023.2249

Introduction

Type 2 Diabetes Mellitus (T2DM) is a common metabolic disorder associated with aberrations such as hyperglycaemia, hyperlipidaemia and obesity. While the underlying causes of T2DM are multifactorial, the cardinal features are a decline in insulin production by pancreatic beta cells and peripheral insulin resistance.[1] The prevalence of overweight among people diagnosed with T2DM has persistently remained high over time.[2,3] This is partly attributed to adipocytes releasing excess fatty acids that are resistant to insulin action,[4] low levels of physical activity,[5] poor dietary practices,[6] and the lipogenic effects of anti-diabetic medicines,[7] among others.

Obesity, overweight and abnormal fat accumulation are critical precursors for T2DM. Following diagnosis and initiation of anti-diabetic medications such as sulfonylureas, biguanides, and insulin therapy, patients still show a higher preponderance of weight gain,[7] further exacerbating the already poor glycaemic control. This, in turn, can undermine the goal of medical therapy to achieve tight glycaemic control without adverse weight changes among diabetic patients.

Evidence in Uganda shows a high rate of overweight among T2DM patients.[8] Unfortunately, the specific composition of this bodyweight remains largely unknown. We are unsure whether it is fat mass or fat-free mass compartments. Since the quality of weight depends hugely on its composition, increases in fat mass have a negative side effect for many patients with diabetes who aim to achieve glycaemic control. Fat mass is strongly associated with increased cardiovascular risk,[9] while fat-free mass is associated with better glycaemic control, muscular strength, immunity and survival.[10]

This study therefore aimed to understand the body composition of T2DM patients attending the diabetic clinic of Mbarara Regional Referral Hospital and compare it to sex and age-matched healthy controls. Understanding the body composition is essential in harnessing glycaemic control while avoiding the deliberating effects of weight gain and guiding targeted health and dietary advice.

Materials and Methods

Study design

A comparative case-control study was carried out between December 2020 and March 2021.

Study participants

We recruited 139 known cases of Type 2 diabetes aged 18 to 78 years randomly sampled from the diabetic clinic of Mbarara Regional Referral Hospital. We matched them to 139 sex and age hospital controls who were healthy non-diabetic healthy attendants. Participants who were pregnant women, patients with pacemakers, heart diseases and bodybuilders were excluded from participating in the study.

Body measurements

Body composition was measured using a duo frequency Bioelectrical Impedance Machine (Tanita DC-430 MA TANITA Corporation, Tokyo, Japan). Bodyweight was measured on a Seca portable electronic scale to the nearest 0.1 kg and height to the nearest 0.1 cm. Bodyweight (kg) and height (cm) were measured with the subjects wearing light garments and standing erect, respectively.

Waist and hip circumferences were measured in the midline between the lower rib margin and the iliac crest and the widest diameter over the greater trochanters. Mid upper arm circumference was measured at the mid-point between the tip of the shoulder and the tip of the elbow. All measurements were taken using standard equipment's and protocol.

Physical activity was measured using the World Health Organisation Global Physical Activity Questionnaire.[11] Data collection involving body composition and glucose measurements was done in the morning after an overnight fast. All data collection tools and equipment were pretested and calibrated before data collection. A team of well-trained health workers undertook measurements.

Data analysis

We used descriptive statistics (frequencies and percentages, mean and standard deviation) to summarise participants' socio-demographic and lifestyle characteristics stratified by the study arm. Associations between the study arm and the different socio-demographic and lifestyle characteristics were assessed using the chi-square test for categorical variables and independent sample t-tests for continuous variables. We also applied the two-sample test for proportions to test differences in proportions of certain lifestyle practices among cases versus controls as appropriate.

Clinical and body composition parameters were computed and summarised as medians and Interquartile Range (IQR) due to the non-normality of the respective data established using the Shapiro-Wilk normality test. Differences in the medians of clinical and body composition parameters were further assessed using the Mann-Whitney U test. Fat-Free and Fat Mass Indices were derived (kilograms/height in metres^2)[12] to offer a precise estimation of body composition parameters adjusted for height differences among study participants.

Body composition parameters that showed statistically significant differences between cases and controls in the Mann-Whitney U tests were modelled in simple and multiple regression models to establish the differences in the mean of these parameters in patients versus controls. Initially, unadjusted beta coefficients were computed, and resultant findings comparing cases and controls were displayed using box plots. After that, these estimates were adjusted for Body Mass Index (BMI) and Waist To Hip Ratio (WHR) in model 1. Further adjustments for several sociodemographic characteristics and lifestyle variables were made to assess if statistically significant differences in body composition parameters of cases versus controls are retained (Model 2).

Ethical considerations

The study obtained ethical clearance from the Mbarara University of Science and Technology Research Ethics Committee (MUREC 1/7). Informed written consent were obtained from the participants. Privacy and confidentiality were maintained. Pregnant women were not enrolled due to a lack of evidence for the unborn child's safety regarding bioelectrical impedance.

Results

A total of 278 participants were recruited and analyzed with a 1:1 ratio of the case to controls. Cases and controls did not significantly differ in mean age and sex distribution as these were matched at recruitment. The median (IQR) fasting blood glucose of the cases was 7.5 (3.9) mmol/L, while the median (IQR) random blood glucose of the controls was 6.2 (1.8) mmol/L. Cases had a median duration of diabetes of 4 years (IQR: 8). Cases were more likely to have a smaller household size and be physically inactive than controls (all $p<0.05$). The rest of the demographic and lifestyle characteristics are presented in Table 1.

Demographic and lifestyle characteristics of the participants

Results from the comparison of several clinical and body composition parameters among cases and controls revealed that cases had significantly higher median systolic blood pressure, pulse rate, weight, BMI, WHR, total fat percentage, Fat Mass Amount, Fat Mass Index, visceral fat, and metabolic age compared to their counterparts. In contrast, controls had significantly higher median total body water percentage versus cases. There were no statistically significant differences between diastolic blood pressure, height, fat-free mass, fat-free mass index, skeletal muscle mass, bone mass, and basal metabolic rate among cases and controls (Table 2).

Simple linear regression was conducted to obtain unadjusted mean differences in body fat composition parameters between cases and age-sex matched controls. Results showed that the highest significant differences occurred in fat percentage composition (Cases: β: 6.9 (95% C.I: 4.4, 9.4); Controls: Ref) followed by visceral fat (Cases: β: 3.5 (95% C.I: 2.5, 4.4); controls: Ref) and Fat Mass Index [Cases: 95% C.I: 2.6 (95% C.I: 1.6, 3.7), Figure 1].

After adjustment for BMI and WHR (Model 1), cases still had significantly higher Fat Mass Index, visceral fat and fat percentage (all $p<0.05$) compared to controls. Even after further adjustment for certain demographic and lifestyle variables (Model 2), no change in strength and direction of association was noticed between the cases and controls (Table 3).

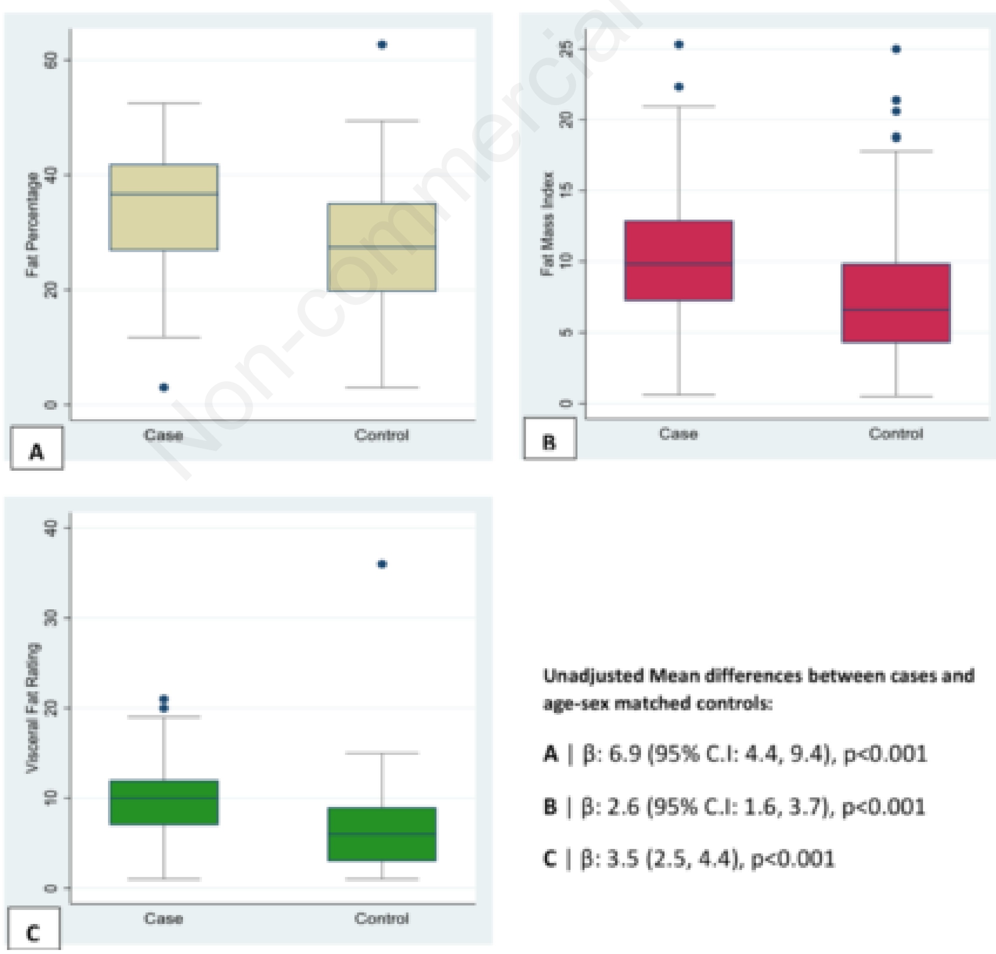
Discussion

The study aimed to understand the body composition of Type 2 Diabetes patients compared to the healthy, closely matched controls. The findings of the study indicate that cases had a higher BMI and weight. Waist Hip Ratios, Fat Mass Index, visceral fat and higher metabolic age values than their healthy counterparts. These findings are similar to those from previous studies[2,13] where T2DM patients were overweight and had a higher BMI than their healthy counterparts. A recent study[14] observed a similar occurrence with higher fat mass among diabetic patients. Similarly, other authors[15] reported more visceral fat and total body fat in T2DM patients than in healthy controls.

The study also revealed that diabetic patients had significantly higher systolic median blood pressure and pulse rate than their healthy counterparts. This observation has been witnessed among people with diabetes since diabetes damages blood vessels causing the walls to stiffen, leading to elevated blood pressure. Studies show that there is twice the risk of developing blood pressure among people with diabetes than the healthy non-diabetic populations. Controlling blood pressure is of paramount importance among people with diabetes to prevent adverse outcomes such as metabolic syndrome, congestive heart failure, and stroke.[2,16]

Despite the elevated levels of fat mass and high blood pressure, we observed that diabetic patients were less likely to be physically active, which does not support weight loss. Since physical inactivity is a primary risk factor for metabolic disorders, T2DM patients must be supported to engage in an active lifestyle that improves

Figure 1. Comparison of fat body composition parameters among Type 2 Diabetes cases *versus* age-sex matched healthy controls.



peripheral insulin sensitivity, decreases visceral fat, and improves glycaemic control.[5]

Results from the study illustrate the need to manage weight gain among T2DM patients. Clinicians need to engage patients in health education sessions, equipping them with information on the risks and patterns of weight gain. Insulin-related weight gain has been attributed to the anabolic effects of high-dose insulin, low physical activity and appetite increases. Understanding the cause and pattern of weight gain at an early stage can revert these life-threatening complications among diabetic patients later in life. The assessment of body composition and pattern of body fat distribution is critical in understanding the body fat distribution to reduce complications associated with high adiposity among T2DM patients.

Among key strengths of this study include the use of robust methods of body composition analysis and statistical tests. To our knowledge, this is the first study to carry out a comprehensive assessment of body composition among T2DM patients and compare the results with sex and age-matched controls in Uganda.

Table 1. Demographic and lifestyle characteristics of the participants.

Parameter	All	Case (n=139)	Controls (n=139)	p-value
Age median	278	53 (12)	46 (15)	0.004
Age (mean ± SD)	278 (100)	51.3 (9.14)	49.4 (12.46)	0.154
Sex				0.612
Male	94 (33.81)	45 (32.4)	49 (35.3)	
Female	184 (66.19)	94 (67.6)	90 (64.7)	
Religion				0.021*
Protestant	123 (44.24)	71 (51.08)	52 (37.41)	
Catholic	90 (32.37)	37 (26.62)	53 (38.13)	
Muslim	38 (13.67)	22 (15.83)	16 (11.51)	
*Others	27(9.71)	9 (6.47)	18 (12.95)	
Residence status				0.719
Rural	141 (50.72)	69 (49.64)	72 (51.80)	
Urban	137 (49.28)	70 (50.36)	67 (48.20)	
Household size (members)				<0.001*
1-5	142 (51.08)	76 (54.68)	66 (47.48)	
6-10	100 (35.97)	56 (40.29)	44 (31.65)	
>10	36 (12.95)	7 (5.04)	29 (20.86)	
Occupation				0.377
Skilled worker	27 (9.71)	13 (9.35)	14 (10.07)	
Semi-skilled worker	56 (20.14)	25 (17.99)	31 (22.30)	
Manual worker (unskilled)	142 (51.08)	68 (48.92)	74 (53.24)	
Retired	33 (11.87)	20 (14.39)	13 (9.35)	
None	20 (7.19)	13 (9.35)	7 (5.04)	
Education level				0.525
Degree level and above	20 (7.19)	9 (6.47)	11 (7.91)	
Certificate or diploma	48 (17.27)	20 (14.39)	28 (20.14)	
Secondary school	72 (25.90)	35 (25.18)	37 (26.62)	
Primary	110 (39.57)	58 (41.73)	52 (37.41)	
None	28 (10.07)	17 (12.23)	11 (7.91)	
Housing status				0.370
Own house	222 (79.86)	114 (82.01)	108 (77.7)	
Rented house	56 (20.14)	25 (17.99)	31 (22.30)	
Current alcohol consumption[a]	66 (22.30)	26 (18.71)	36 (25.90)	0.149
Current tobacco use[a]	12 (4.32)	5 (3.60)	7 (5.04)	0.555
Engagement in physical activity[a]	185 (66.55)	81 (58.27)	104 (74.82)	0.001*

All data are frequencies and percentages unless otherwise stated; p-values obtained by independent sample t-tests (continuous variables) and Chi-square test (categorical variables) unless otherwise stated; [a]p-values obtained by the two-sample test for proportions. *Statistically significant association. *Others include atheists, Seventh Day Adventists, and Buddhists.

Table 2. Comparison of clinical and body composition parameters among Type 2 Diabetes patients and healthy age-sex controls.

Body composition parameter	Cases (n=139) median (IQR)	Controls (n=139) median (IQR)	p-value
Systolic BP (mmHg)	140 (124 – 151)	127 (118 – 141)	<0.001*
Diastolic BP (mmHg)	81 (76 – 92)	83 (77 – 94)	0.7330
Pulse rate (bpm)	83 (74 -98)	78 (71 – 89)	0.0153*
Weight (kg)	73 (66 – 82)	66.8 (58 – 75.8)	< 0.001*
Height (cm)	161.5 (156 – 167)	162 (156 – 167.5)	0.6991
BMI (kg/m^2)	28.0 (25.5 – 31.5)	25.1 (20.9 – 28.8)	<0.001*
Waist to Hip Ratio	0.92 (0.87 – 0.96)	0.88 (0.84 – 0.91)	<0.001*
Fat percentage	36.7 (26.8 – 41.9)	27.4 (19.7 – 35.1)	<0.001*
Fat mass (Kg)	24.8 (19.8 – 32.6)	18.4 (11.3 – 23.7)	<0.001*
Fat Mass Index (kg/m^2)	9.8 (7.2 – 12.9)	6.6 (4.3 – 9.7)	<0.001*
Fat-free mass (kg)	46.1 (41.7 – 52.4)	47.4 (41.2 – 54.1)	0.7208
Fat-Free Mass Index (kg/m^2)	17.9 (16.5 – 19.6)	17.8 (16.3 – 19.4)	0.7153
Muscle mass (kg)	43.6 (39.5 – 49.7)	45.0 (39.1 – 51.4)	0.5270
Bone mass (kg)	2.3 (2.1 – 2.7)	2.4 (2.1 – 2.7)	0.8096
Total body water (%)	45.1 (41.5 – 52.6)	50.5 (44.0 – 55.5)	0.0003*
Visceral fat rating	10 (7 – 12)	6 (3 – 9)	<0.001*
Basal metabolic rate (kcal)	1407 (1267 – 1582)	1417 (1277 – 1586)	0.7275
Metabolic age	58 (47 – 65)	39 (28 – 49)	<0.001*

p-values for comparison between cases and controls obtained by Mann-Whitney U test; *Significant association.

Table 3. Differences in mean fat body composition parameters between Type 2 Diabetes cases *versus* age-sex matched controls.

Fat body composition parameter	β coefficient (95% C.I) p-value Model 1	β coefficient (95% C.I) p-value Model 2
Fat Mass Index (kg/m^2)		
Controls	Ref	Ref
Cases	1.27 (0.52, 2.03), p=001	1.37 (0.53, 2.20), p=0.001
Visceral fat rating		
Controls	Ref	Ref
Cases	1.86 (1.00, 2.73), p<0.001	1.39 (0.48, 2.31), p=0.003
Fat percentage		
Controls	Ref	Ref
Cases	4.87 (2.76, 6.98), p<0.001	5.57 (3.27, 7.87), p<0.001

Model 1: Adjusted for BMI and WH ratio.
Model 2: Model 1 with additional adjustment for physical activity status, systolic and diastolic BP, Alcohol use, tobacco use, household size and religion.

Conclusions

Our results indicate that patients with T2DM, compared to healthy age and sex-matched controls, show a considerably higher fat mass level. Clinicians and other public health practitioners need to pay particular attention to these individual parameters when treating and managing T2DM patients. We hope that body composition assessment can be included as a primary anthropometric measure while managing metabolic derangements of Type 2 Diabetes in Uganda.

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