Characterization of Central Adiposity Among Women 50 Years and Older Living with HIV in Kenya

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Abstract

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Background: As life expectancy for people living and aging with HIV in sub-Saharan Africa is increasing, non-communicable diseases (NCDs) such as obesity are emerging as major contributors to morbidity and mortality. Effective assessment and management of obesity in routine clinical settings is critical to reducing cardio-metabolic risk.

Methods: This was a secondary data analysis of a 6-month observational study that enrolled women aged ≥ 50 years at the Kenyatta National Hospital (KNH) Comprehensive Care Clinic (CCC). Participants consented to an interview, examination, blood draw, and DEXA scan. Data were extracted on visceral adipose tissue (VAT) mass, total body fat percentage, BMI, and anthropometric measurements, including waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). Socio-demographic and clinical characteristics collected included ART regimen, viral load, date of HIV diagnosis, HbA1c, blood pressure, depression status, and cognitive function. Univariate and multivariable analyses using logistic regression were used to determine correlates of elevated VAT and waist-to-height ratio. Agreement between anthropometric measurements and VAT was assessed using receiver operating characteristic (ROC) analysis.

Results: Overall, 179 women were enrolled, with a median age of 58 years (IQR: 53-62). Most of the participants had at least a primary or secondary education (59.2%) and were widowed or currently married (62.5%). About half of the participants (50.3%) were employed, and most (68.7%) earned less than 10,000 Kenya shillings (about 77 USD) per month. The majority of participants had been living with HIV for more than ten years (81%), were on a DTG-based regimen (84.4%), and were virally suppressed (92.2%). Many participants had mild cognitive impairment (66.5%) and did not have depression (81.6%).

The majority of participants were overweight/obese according to body fat percentage (97.2%) and BMI (79.5%). Many had central obesity according to WC (66.3%) and by WHtR (86.0%). Cardiometabolic risk stratification by VAT had the majority in the low risk category (88.3%).

In univariate analysis, those with mild or moderate depression were more likely to have elevated VAT. Odds ratio [OR] = 3.26; 95% Confidence Interval [CI]: 1.15 – 9.18, p = 0.026. This association remained after adjusting for age; adjusted OR = 3.24; 95% CI: 1.14 - 9.23; p-value= 0.028. In univariate analysis, those participants who had been diagnosed with HIV more than ten years before the study were three times more likely to have an elevated waist-

to-height ratio (OR = 2.88; 95% CI: 1.13 – 7.33, p = 0.027). This remained significant in multivariable analysis adjusting for age; aOR was 2.82 (CI: 1.10 - 7.25) with a p-value of 0.028.

On ROC analysis, WHtR had an Area Under the Curve (AUC) of 0.852 (95% CI: 0.758 – 0.946), with an optimal cut-off of 0.60, the best balance of sensitivity (81%) and specificity (74.5%) for predicting VAT.

Conclusion:

A high obesity prevalence was seen using anthropometric measurements, with the majority having low cardiometabolic risk. Women who had longer duration of HIV and those with mild to moderate depression had increased odds of obesity. The waist-to-height ratio measure could be useful for cardiometabolic assessment in the clinic setting.

Introduction

The scale-up of antiretroviral treatment (ART) has transformed HIV into a chronic condition, resulting in a growing population of people living and aging with HIV in sub-Saharan Africa. As this population ages, non-communicable diseases (NCDs) such as obesity are emerging as major contributors to morbidity and mortality. The Kenya 2022 HIV prevention and treatment guidelines emphasize the importance of comprehensive assessments during clinic visits, including systematic assessment for non-communicable diseases. Obesity is a major modifiable risk factor for cardio-metabolic diseases. Obesity can be classified as general, measured by body mass index (BMI) and body fat percentage (BFP). Subcutaneous adipose tissue (SAT) is measured using skin-fold thickness.[1] Central obesity is characterized using waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR).[1] Visceral adiposity is measured using visceral adipose tissue (VAT) by dual-energy X-ray absorptiometry (DEXA).[1]

Obesity is becoming a public health concern in low- and middle-income countries as they industrialize and adopt a Western diet and lifestyle. In more than 70 countries, obesity rates have doubled, and it's increasingly a public health concern in many others, as it contributes to the leading causes of morbidity and mortality in these countries. In 2015, about 604 million adults worldwide were classified as obese.[2] Weight gain in people living with HIV is multifactorial, influenced by demographics, diet, exercise habits, medications, and possible comorbidities.[3] Traditionally, weight gain in people living with HIV has been associated with the side effects of ART and may contribute substantially to long-term morbidity and mortality among people living with and aging with HIV through increased risk for heart disease, including atherosclerosis and heart failure. This is particularly relevant as most patients are switched to dolutegravir-containing regimens. These are often first-line treatments in Sub-Saharan Africa and are associated with significant weight gain among the integrase strand transfer inhibitors.[4] Tenofovir alafenamide-containing regimens have also been implicated in weight gain, especially when combined with integrase inhibitors.[5]

The world is moving towards achieving the 2030 goal of 95-95-95 set by the joint United Nations program on HIV/AIDS (UNAIDS), which targets improved coverage of ART and retention in the HIV continuum leading to improved life expectancies. This has brought to the forefront the importance of diseases traditionally associated with aging and lifestyle. Women constitute around 60% of the total population living with HIV. Due to improved uptake and retention in HIV care, women living with HIV are living longer and experiencing diseases associated with advancing age a decade earlier compared to their age- and sex matched

counterparts living without HIV.[6] Integration of services for screening and management of non-communicable diseases is key for continued gains in the HIV treatment cascade. Screening and treatment of non-communicable diseases is now increasingly integrated into routine clinics for HIV treatment at the Comprehensive Care Centers (CCC) in Kenya.

Studies that were conducted in Western Kenya, where the highest prevalence of HIV is seen, have shown that women have the highest prevalence of obesity and overweight measured by BMI and WC as compared to men who are living with HIV.[7] This has been consistent in larger studies where obesity and overweight rates by BMI were greater for women living with HIV, in the same region of Western Kenya.[8] Other studies conducted in Western Kenya among ART-naïve and those on ART have found that the presence of an abnormal waist circumference was comparable between the two groups, with older age, female sex, and high BMI being independently associated with higher cardiometabolic risk.[9] Studies among men and women living with HIV in Ethiopia supported the risk of central obesity increasing with increases in BMI and female sex.

The integration of conventional measures such as body mass index (BMI) has shortcomings in cardiovascular risk assessment.[10] BMI alone is not a good surrogate for abdominal adiposity, which is often used as a proxy for cardiometabolic risk assessment.[2] Factors affecting adiposity include age, sex, ethnicity, and medications such as ART for HIV.[11] The other three body measurements, WC, WHR, and Waist to Height Ratio, perform better in cardiometabolic risk assessment.[12,13] These three anthropometric measurements serve as the central measures of obesity, and they have been shown to correlate better with cardiometabolic risk compared to general obesity measurements, such as BMI.[13] Body composition assessment is key in quantification and classification of obesity. Dual-energy X-ray absorptiometry (DEXA) is a technique that accurately measures total body composition and is used to quantify lipodystrophy and lipoatrophy.

Visceral adiposity assessment is key in cardio-metabolic risk assessment. Effective assessment and management of obesity in routine clinical settings is critical to reducing cardio-metabolic risk. However, implementation in busy clinical settings requires a simple, standardized anthropometric measure that can serve as a reliable proxy. This is key for cardio-metabolic risk stratification and clinical decision-making. This study seeks to address this gap by evaluating the prevalence of general and central obesity using DEXA-derived measurements as a gold standard and evaluating the level of agreement with conventional anthropometric measurements with clinical relevance among older women living with HIV in Kenya.

Methods

Study Design

This was a secondary analysis of cross-sectional data collected in a six-month cross-sectional study of a mixed-methods design.

Study Site

The parent study took place at the Comprehensive Care Center (CCC) of the Kenyatta National Hospital (KNH), in Nairobi County, Kenya. The Nairobi Hospital, a nearby private hospital, served as the study site for dual-energy X-ray absorptiometry (DEXA) scanning, because these facilities are not part of routine care at KNH. Study participants were accompanied by study staff to the DEXA scanning site.

Study Population

The study population included women living with HIV and aged 50 years and older on follow-up at the Comprehensive Care Clinic (CCC) at The Kenyatta National Hospital (KNH) who gave written informed consent in the parent study and had a DEXA scan report available. Those women without DEXA scan reports were excluded from the study.

Recruitment and Consenting Procedure

The current study used data from all women with available DEXA scan reports from the parent study. In the parent study, participants were identified, screened, and once eligible, were recruited during their routine clinic visits at Kenyatta National Hospital. The recruitment team consisted of study nurses and research assistants proficient in both English and Kiswahili who approached potential participants and explained the study procedures in a language preferred by the participant. Afterwards, participants were provided with a translated copy of the written consent form that ensured comprehension and informed decision-making.

Data Collection

In the parent study, study staff administered an electronic questionnaire in REDCap in a preferred language of study participants, collecting data on socio-demographic characteristics and HIV clinical data. In addition, in the parent study, during the physical exam in the clinic, blood pressure (BP), heart rate, anthropometric measurements, including height, weight, BMI, waist circumference, and hip circumference, were measured. The presence and severity of depression was measured using the Patient Health Questionnaire (PHQ-9) and cognitive function using the Montreal Cognitive Assessment (MOCA). Blood pressure and heart rate were measured using an electronic blood pressure machine with three different cuff sizes. BP measurements were taken twice on each arm while the participant was sitting comfortably and relaxed. Height was measured in centimeters using a stadiometer, and weight was measured using a digital scale. Waist circumference was measured using a tape measure at the smallest point between the anterior aspect of the lower rib cage and the iliac crest and recorded in centimeters. Hip Circumference was measured using a tape measure at the widest point of the hips and recorded in centimeters. Assessment of subcutaneous fat was done using skin calipers. The skin and subcutaneous fat were pinched at a 45-degree angle in the supra-iliac region. Measurements in millimeters were taken and compared to standard charts, and then repeated for comparison.

Participants were encouraged to come to the clinic with all current medications and discuss proper use and dosage with their clinician. The laboratory tests performed included glycated hemoglobin (HBA1C). This was assessed in the laboratory using blood drawn in the clinic in an ethylenediaminetetraacetic acid (EDTA) tube. DEXA scans were part of the radiology work-up. Blood draw was performed by the nurses at KNH-CCC. The DEXA scan was done at Nairobi Hospital, a private facility near KNH. The study staff accompanied eligible participants to the DEXA scanning site.

Measures

The primary outcome of the study was to determine the prevalence and correlates of general and central obesity using various anthropometric and DEXA measurements. The measures of obesity included visceral adipose tissue (VAT), total body fat percentage, BMI, waist circumference (WC), waist-to-hip ratio

(WHR), and waist-to-height ratio (WHtR), which were analyzed as categorical variables. Lab measurements included HbA1c, and clinical measurements included blood pressure, analyzed as categorical variables.

The socio-demographic characteristics included age, analyzed as a continuous variable; marital status, employment, income level, and education level, analyzed as categorical variables. Clinical data regarding ART regimen, latest viral load tests, length of time since HIV diagnosis, and ART use duration were analyzed as categorical variables. Presence and severity of depression were analyzed using the Patient Health Questionnaire (PHQ-9). Each question earned a score between 0 and 3, with mild, moderately severe, and severe depression having threshold scores of 5,10,15 and 20. Cognitive function status was analyzed using the Montreal Cognitive Assessment (MOCA). Threshold scores of 26, 18, 10, and below 10 denoted normal, mild, moderate, and severe cognitive impairment, respectively.

Data Analysis

Demographic characteristics were summarized using frequencies and percentages for grouped data, while continuous descriptive analysis was done subject to the distribution of the data. Descriptive data were analysed using median and interquartile range (IQR).

The prevalence of general and central obesity was analyzed using descriptive statistics using frequencies (n) and percentages (%). Logistic regression was used to determine correlates of central obesity and their statistical significance. Univariate logistic regression was conducted to investigate the factors associated with elevated VAT and elevated waist-to-height ratio (WHtR). The literature supported the use of WHtR for assessment of cardiometabolic risk among the three anthropometric measurements.[14–16] To determine the association between the dependent variable and each independent predictor, those found to be associated at a significance of <0.1 were included in a multivariable model. Reporting of P values, odds ratios, and 95% confidence intervals was done.

Continuous variables for visceral adipose tissue (VAT) mass and anthropometric measurements (WC, WHR, and WHtR) were utilized for Receiver Operating Characteristic (ROC) analysis to compute Area Under the Curve (AUC) to evaluate how well each anthropometric measurement predicts the gold standard in this study, which is VAT mass measured using DEXA.

Ethical Approval

Ethical approval for the parent study and secondary analyses was obtained from the Kenyatta National Hospital Ethics and Research Committee (ERC) and the University of Washington Institutional Review Board (IRB).

Results

Two hundred women were enrolled in the parent study at the KNH CCC from mid-year 2024 to mid-year 2025. Of these 200 women, 179 were included in this secondary analysis. A DEXA scan was not performed on the 21 women whose data were excluded from analysis.

The median age of the participants was 58 years (IQR 53-62). About half (47.5%) had a primary education level of 8 years or less. More than one-third of participants were widowed

(35.7%), and about a quarter were currently married (26.8%). About half of the participants (50.3%) were employed, and most (68.7%) earned less than 10,000 KSh (about 77 USD) per month.

The majority of participants had been living with HIV for more than ten years (81%), were on a DTG-based regimen (84.4%), and were virally suppressed (92.2%). Most had been on ART for more than 10 years (78.2%). Less than half of participants reported being diagnosed with hypertension (41.9%), and a smaller number reported diabetes (10.1%). Cognitive function assessment using the Montreal Cognitive Assessment (MOCA) showed that the majority had mild cognitive impairment (66.5%). According to the Patient Health Questionnaire (PHQ-9), most participants did not have depression (81.6%) (Table 1).

Table 1. Socio-demographic and clinical characteristics of 179 study participants

Study Variable	**Median (IQR) or n (%)** **N=179**
Socio-demographic Characteristics	
Age, years	58 (53–62)
Age > 65 years	35 (19.6)
Education level	
No formal schooling	5 (2.8)
Less than/Primary school completed	85 (47.5)
Secondary/high school completed	55 (30.7)
University/tertiary completed	34 (19.0)
Marital status	
Never married	32 (17.9)
Currently married	48 (26.8)
Separated/divorced	35 (19.6)
Widowed	64 (35.7)
Employment status	
Employed	90 (50.3)
Unemployed	89 (49.7)
Monthly income	
< 10,000 KES	123 (68.7)
≥ 10,000 KES	56 (31.3)
Clinical Characteristics	
Duration since HIV diagnosis	

≥ 10 years	145 (81.0)
< 10 years	34 (19.0)
ART regimen	
DTG-based regimen	151 (84.4)
Non-DTG-based regimen	28 (15.6)
Viral load[a] (n = 176)	
Suppressed (< 50 copies/mL)	165 (93.8)
Unsuppressed (≥ 50 copies/mL)	11 (6.3)
Duration of ART use	
> 10 years	140 (78.2)
≤ 10 years	39 (21.8)
Blood pressure[a] (n = 174)	
Hypertension, self-reported	75 (41.9)
Hypertension, measured	78 (44.8)
Diabetes, self-reported	18 (10.1)
Diabetes, measured [b] (HbA1c > 6.5%)	15 (8.4)
Cognitive function (MoCA)	
Normal (26–30)	9 (5.0)
Mild cognitive impairment (18–25)	119 (66.5)
Moderate cognitive impairment (10–17)	47 (26.3)
Severe cognitive impairment (< 10)	4 (2.2)
Depression severity (PHQ-9)[a] (n = 175)	
None (0–4)	146 (83.4)
Mild (5–9)	25 (14.3)
Moderate (10–14)	4 (2.3)

Note. Continuous variables are presented as median (interquartile range, IQR); categorical variables are presented as frequency, n (%). CCC = Comprehensive Care Clinic; ART = antiretroviral therapy; DTG = dolutegravir; BP = blood pressure; HbA1c = glycated hemoglobin; MoCA = Montreal Cognitive Assessment; PHQ-9 = Patient Health Questionnaire-9.

[a] Denominator is lower than the total sample (N = 179) because of missing data for that variable (viral load, n = 3 missing; blood pressure, n = 5 missing; PHQ-9, n = 4 missing). [b] Composed of systolic blood pressure BP>140/90 mmHg (78, 43.6%) and Diastolic BP> 90 mmHg (24, 13.4%)

Prevalence of general and central obesity using anthropometric and DEXA measurements

Using DEXA, the majority of participants (97.2%) fell in the overweight/obese categories as per the body fat percentage. A minority (2.8%) fell in the underweight/normal categories according to body fat percentage on DEXA. According to the BMI, the majority fell under the overweight/obese categories (79.5%). Fewer participants fell into the normal (19.9%) and underweight (0.6%) categories.

The majority had central obesity according to waist circumference (66.3%). A higher number had central obesity measured by waist-to-height ratio (86.0%). Cardiometabolic risk stratification by VAT has the majority falling into the low risk category (88.3%) (Table 2).

Table 2. Prevalence of General and Central Obesity Using Anthropometric and DEXA-Derived Measurements

Measure	Classification	Range	n (%), N=179	Cardiometabolic Risk
General Obesity Measure				
Body fat percentage (%) [a]	Underweight/Normal	<20–<30	5 (2.8)	Low Risk
	Overweight/Obese	30–>35	174 (97.2)	High Risk
Body mass index (weight/height^2) [1, b]	Underweight	<18.5	1 (0.6)	Low Risk
	Normal	18.5–24.9	35 (19.9)	Low Risk
	Overweight	25–29.9	78 (44.3)	High Risk
	Obese	>30	62 (35.2)	High Risk
Central Obesity Measure				
Waist circumference (cm) [2, b]	No Obesity	<88	60 (33.7)	Low Risk
	Obesity	>88	118 (66.3)	High Risk
Waist-to-Height Ratio (WHtR) [b]	No Obesity	<0.5	25 (14.0)	Low Risk
	Obesity	>0.5	153 (86.0)	High Risk
Waist-to-Hip Ratio (WHR) [3, b]	No Obesity	<0.85	76 (42.7)	Low Risk
	Obesity	>0.85	102 (57.3)	High Risk
Visceral Adipose Tissue (VAT) Mass (g) [a]		<600.5	158 (88.3)	Low Risk
		>600.5	21 (11.7)	High Risk

[1] n = 2 missing.
[2] n = 1 missing.
[3] n = 1 missing.
[a] Measured by dual-energy X-ray absorptiometry (DEXA).
[b] Anthropometric measure.

Correlates of Central measures of Abnormal Visceral Adipose Tissue (VAT) mass (grams)

In univariate analysis, those with mild or moderate depression using PHQ-9 were three times more likely to have high VAT. The crude odds ratio (COR) = 3.26 (95% CI: 1.15 – 9.18, p = 0.026). The association between high VAT and mild-to- moderate depression remained significant in multivariable analysis after adjusting for age (aOR was 3.24; CI: 1.14- 9.23; p-value 0.028)

In univariate analysis, participants with tertiary education had a lower likelihood of a high VAT, and tertiary education was not included in the multivariable model (Table 3).

Table 3. Correlates of High Visceral Adipose Tissue (VAT) Mass (grams) on DEXA (N=179)

Correlates	Low Risk VAT, n (%) or Median (IQR)	Elevated/High Risk, n (%) or Median (IQR)	OR (95% CI)	P value	aOR (95% CI)	P value
Age	57.5 (53-62)	58 (55-61)	0.98 (0.92, 1.04)	0.48	0.98 (0.94, 1.06)	0.94
Education						
Low (no formal, less than primary and primary)	76 (48.1)	14 (66.7)	ref	—	—	—
Secondary/high school	49 (31)	6 (28.6)	0.66 (0.24, 0.88)	0.44	—	—
Tertiary	33 (20.9)	1 (4.8)	0.16 (0.02, 1.35)	**0.09**	—	—
Employment						
Unemployed	78 (49.4)	11 (52.4)	ref	—	—	—
Employed	80 (50.6)	10 (47.6)	0.89 (0.35, 2.23)	0.80	—	—
Duration of HIV (Since Diagnosis)						
<10 years	32 (20.3)	2 (9.5)	ref	—	—	—
≥10 years	126 (79.7)	19 (90.5)	2.41 (0.52, 11.10)	0.26	—	—
ART Regimen						
Non-DTG Based	27 (17.1)	1 (4.8)	ref	—	—	—
DTG Based	131 (82.9)	20 (95.2)	4.12 (0.52, 32.88)	0.18	—	—
Duration of ART use						
<10 years	34 (21.8)	2 (14.3)	ref	—	—	—
≥10 years	122 (78.2)	18 (85.7)	1.67 (0.46, 6.11)	0.43	—	—

Correlates	Low Risk VAT, n (%) or Median (IQR)	Elevated/High Risk, n (%) or Median (IQR)	OR (95% CI)	P value	aOR (95% CI)	P value
Monthly Income						
<10,000 KSh	108 (71.5)	15 (75)	ref	—	—	—
≥10,000 KSh	43 (28.5)	5 (25)	0.84 (0.28, 2.48)	0.75	—	—
Depression – PHQ-9 Score						
None	133 (85.8)	13 (65)	ref	—	ref	—
Mild/Moderate	22 (14.2)	7 (35)	3.26 (1.15, 9.18)	**0.026**	**3.24 (1.14, 9.23)**	**0.028**
Cognitive Function (MoCA)						
Normal/Mild	112 (70.9)	16 (76.2)	ref	—	—	—
Moderate/Severe	46 (29.1)	5 (23.8)	0.76 (0.26, 2.23)	0.62	—	—

KSh = Kenyan Shillings. — = not applicable/not entered into that model. OR/aOR presented with 95% Wald confidence intervals (robust standard errors). Bold values indicate p<0.10. Total N=179 (158 low-risk VAT, 21 elevated/high-risk VAT); denominators for individual correlates vary slightly due to missing data.
aOR = adjusted odds ratio from multivariable logistic regression of high VAT mass on age and depression (PHQ-9 category; N=175 after exclusion of 4 observations with missing data). Education, ART regimen (DTG-based vs. non-DTG-based), and HIV duration were considered for multivariable adjustment based on univariate screening (p<0.1) but were not included in the final model due to non-significance and unstable estimates given limited sample size in key subgroups (elevated-VAT group n=21).

Correlates of Central measures of Abnormal Waist to Height Ratio (WHtR)

In univariate analysis, those participants who had been diagnosed with HIV more than ten years before the study were three times more likely to have a high waist-to-height ratio. The COR = 2.88 (95% CI: 1.13 – 7.33, p = 0.027). The association between high waist-to-height ratio and duration since HIV remained significant in multivariable analysis adjusting for age; aOR was 2.82 (CI: 1.10 - 7.25) with a p-value of 0.028.

In univariate analysis, participants on ART for a duration greater than ten years were about two times more likely to have a high waist-to-height ratio. The COR= 2.47 (95% CI: 0.98-6.24, p = 0.055), with a borderline p-value and collinearity with duration since HIV diagnosis; this was not included in multivariable analysis.

Other variables considered for multivariable analysis included annual income, with those earning more than 10,000 KSh (Approx. 77 USD) having three times more likelihood of

having a high waist-to-height ratio. The COR = 3.02 (95% CI: 0.84-10.83, p = 0.089). Cognitive function showed a reduced likelihood for a high waist-to-height ratio. COR= 0.45 (95% CI: 0.19-1.09, p= 0.075). Cognitive function was not included in multivariable analysis (Table 4).

Table 4. Correlates of Increased Waist-to-Height Ratio (WHtR) Risk (N=178)

Correlates	Normal WHtR, n (%) or Median (IQR)	Increased Risk, n (%) or Median (IQR)	OR (95% CI)	P value	aOR (95% CI)	P value
Age	58 (53-64)	58 (53-61)	0.97 (0.91, 1.04)	0.459	0.98 (0.92, 1.05)	0.524
Education						
Low (no formal, less than primary and primary)	16 (64.0)	74 (48.4)	ref	—	—	—
Secondary/high school	6 (24.0)	49 (32.0)	1.77 (0.64, 4.90)	0.273	—	—
Tertiary	3 (12.0)	30 (19.6)	2.16 (0.58, 8.13)	0.252	—	—
Marital Status						
Never Married	5 (20.0)	27 (17.6)	ref	—	—	—
Currently Married	5 (20.0)	43 (28.1)	1.59 (0.41, 6.15)	0.497	—	—
Previously Married (Divorced, Widowed, Separated)	15 (60.0)	83 (54.2)	1.03 (0.33, 3.14)	0.966	—	—
Employment						
Unemployed	16 (64.0)	73 (47.7)	ref	—	—	—
Employed	9 (36.0)	80 (52.3)	1.95 (0.80, 4.73)	0.140	—	—
Duration Since HIV Diagnosis						
<10 years	9 (36.0)	25 (16.3)	ref	—	ref	—
≥10 years	16 (64.0)	128 (83.7)	2.88 (1.13, 7.33)	**0.027**	**2.82 (1.10, 7.25)**	**0.031**
ART Regimen						
Non-DTG Based	5 (20.0)	23 (15.0)	ref	—	—	—
DTG Based	20 (80.0)	130 (85.0)	1.41 (0.48, 4.20)	0.532	—	—

Correlates	Normal WHtR, n (%) or Median (IQR)	Increased Risk, n (%) or Median (IQR)	OR (95% CI)	P value	aOR (95% CI)	P value
Duration on ART						
<10 years	9 (36.0)	28 (18.5)	ref	—	—	—
≥10 years	16 (64.0)	123 (81.5)	2.47 (0.98, 6.24)	**0.055**	—	—
Annual Income						
<10,000 KSh	21 (87.5)	102 (69.9)	ref	—	—	—
≥10,000 KSh	3 (12.5)	44 (30.1)	3.02 (0.84, 10.83)	**0.089**	—	—
Depression – PHQ-9 Score						
None	22 (88.0)	123 (82.6)	ref	—	—	—
Mild/Moderate	3 (12.0)	26 (17.4)	1.55 (0.42, 5.66)	0.505	—	—
Cognitive Function (MoCA)						
Normal/Mild	14 (56.0)	113 (73.9)	ref	—	—	—
Moderate/Severe	11 (44.0)	40 (26.1)	0.45 (0.19, 1.09)	**0.075**	—	—

KSh = Kenyan Shillings. — = not applicable/not entered into that model. OR / aOR presented with 95% Wald confidence intervals (robust standard errors). Bold values indicate p<0.10.

Total N=178 (25 normal WHtR, 153 increased-risk WHtR); denominators for individual correlates vary slightly due to missing data.

aOR = adjusted odds ratio from multivariable logistic regression of increased WHtR risk on age and duration since HIV diagnosis (≥10 years vs. <10 years; N=177 after exclusion of 1 observation with missing data). Duration on ART, annual income, cognitive function, and employment were considered for multivariable adjustment based on univariate screening (p<0.1) but were not retained in the final model due to non-significance and limited added explanatory value (high WHtR group n=25). Duration on ART was excluded due to multicollinearity with duration since HIV diagnosis when included in the same model.

Sensitivity and Specificity of Different Anthropometric Measures for high VAT

A two-by-two cross-tabulation of each dichotomized anthropometric measurement against the DEXA-derived VAT mass was done. A cutoff value of 600.5 grams of VAT was used, yielding sensitivity, specificity, a positive predictive value, and a negative predictive value. Waist-to-height ratio had a sensitivity of 100% (95% CI: 0.85-1.00) and a specificity of 16% (95% CI: 0.11–0.22). The positive predictive value was 14%, and the negative predictive value was 100%.

Waist circumference had a sensitivity of 95% (95% CI: 0.77 – 0.99) and a specificity of 38% (95% CI: 0.30 – 0.45). The positive predictive value was 17%, and the negative predictive value was 98%. Waist-to-hip ratio had a sensitivity of 67% (95% CI: 0.45 – 0.83) and a specificity of 44% (95% CI: 0.11 – 0.22). The positive predictive value was 14% with a negative predictive value of 91% (Table 5a).

Table 5a. Diagnostic Performance of Anthropometric Measures Using Visceral Adipose Tissue (VAT) Mass ≥600.5 g on DEXA as the Gold Standard for High-Risk Obesity

Anthropometric Measure	Cardio-metabolic Risk Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV
Waist-to-Height Ratio (WHtR)	≥0.50	1.00 (0.85, 1.00)	0.16 (0.11, 0.22)	0.14	1.00
Waist Circumference	≥88 cm	0.95 (0.77, 0.99)	0.38 (0.30, 0.45)	0.17	0.98
Waist-to-Hip Ratio (WHR)	≥0.85	0.67 (0.45, 0.83)	0.44 (0.36, 0.52)	0.14	0.91

PPV = positive predictive value; NPV = negative predictive value. Sensitivity and specificity 95% confidence intervals calculated using the Wilson score method. Values derived from 2×2 cross-tabulation of each dichotomized anthropometric measure against high-risk VAT mass (≥600.5g) as the reference standard.
N=179 for WHtR; N=178 for waist circumference and WHR due to missing data on one observation.

A two-by-two cross-tabulation of each dichotomized anthropometric measurement was done utilizing the study-derived cut-off values. This was done against the DEXA-derived VAT mass, using 600.5 grams as the cutoff, yielding sensitivity, specificity, a positive predictive value, and a negative predictive value.

Waist-to-height ratio had a sensitivity of 81% (95% CI: 0.60 – 0.92) and a specificity of 75% (95% CI: 0.67 – 0.81). The positive predictive value was 30%, and the negative predictive value was 97%.

Waist circumference had a sensitivity of 71% (95% CI: 0.50 – 0.86) and a specificity of 85% (95% CI: 0.79 – 0.90). The positive predictive value was 39%, and the negative predictive value was 96%. Waist-to-hip ratio had a sensitivity of 52% (95% CI: 0.32 – 0.72) and a specificity of 83% (95% CI: 0.76 – 0.88). The positive predictive value was 29%, and the negative predictive value was 93% (Table 5b).

Table 5b. Diagnostic Performance of Anthropometric Measures at Youden-Optimal Cut-offs Against Visceral Adipose Tissue (VAT) Mass ≥600.5 g on DEXA

Anthropometric Measure	Youden-Optimal Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV
Waist-to-Height Ratio (WHtR)	≥0.60	0.81 (0.60, 0.92)	0.75 (0.67, 0.81)	0.30	0.97
Waist Circumference	≥99.5 cm	0.71 (0.50, 0.86)	0.85 (0.79, 0.90)	0.39	0.96
Waist-to-Hip Ratio (WHR)	≥0.92	0.52 (0.32, 0.72)	0.83 (0.76, 0.88)	0.29	0.93

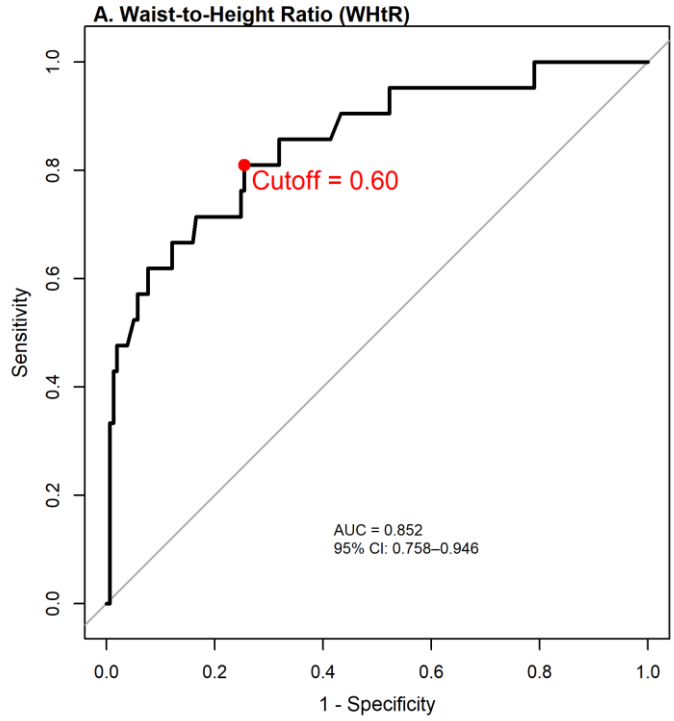
Youden-optimal cutoffs were derived from receiver operating characteristic (ROC) curve analysis as the threshold maximizing the Youden index (sensitivity + specificity − 1) for each measure against high-risk VAT mass.

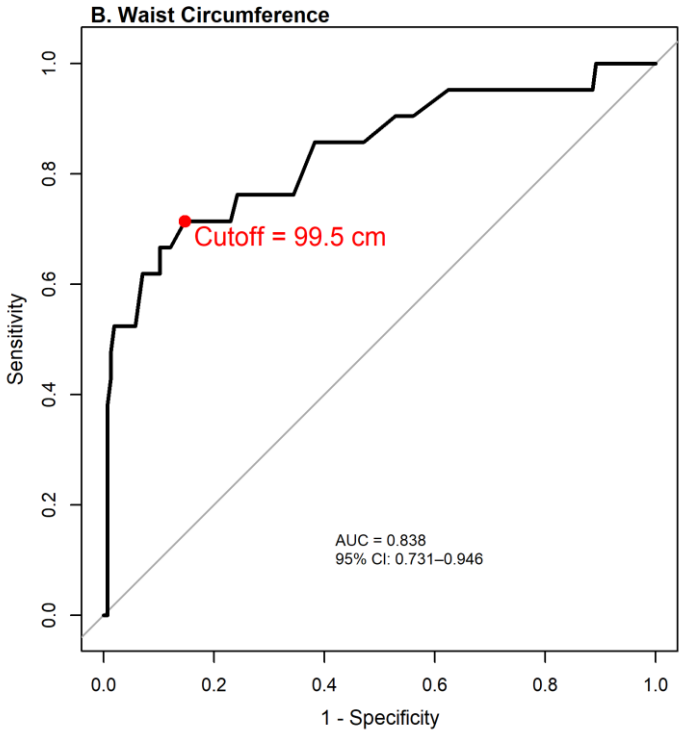
PPV = positive predictive value; NPV = negative predictive value. Sensitivity and specificity 95% confidence intervals calculated using the Wilson score method. Values derived from 2×2 cross-tabulation of each dichotomized anthropometric measure against high-risk VAT mass (≥600.5g) as the reference standard.
N=179 for WHtR; N=178 for waist circumference and WHR due to missing data on one observation.

Receiver Operating Characteristic (ROC) Curves for WC, WHtR, WHR As Predictors of High VAT (≥ 600.5 G) On DEXA

ROC analysis was performed for each anthropometric measurement against a high VAT of 600.5g. WHtR had an AUC of 0.852 (95% CI: 0.758 – 0.946), with an optimal cut-off of 0.60 calculated using Youden's index, and a sensitivity of 81% and specificity of 74.5%. Waist circumference had an AUC of 0.838 (95% CI: 0.731 – 0.946), with an optimal cut-off of 99.5 cm and a sensitivity of 71.4% and specificity of 85.4%. WHR had an AUC of 0.671 (95% CI: 0.542 – 0.800), with an optimal cut-off of 0.92 yielding a sensitivity of 52.4% and a specificity of 82.8% (Figure 1).

Figure 1. Receiver Operating Characteristic (ROC) Curves for Anthropometric Measures vs. Elevated VAT Mass


A. Waist-to-Height Ratio (WHtR)
Cutoff = 0.60
AUC = 0.852
95% CI: 0.758–0.946
Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0


B. Waist Circumference
Cutoff = 99.5 cm
AUC = 0.838
95% CI: 0.731–0.946
Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0

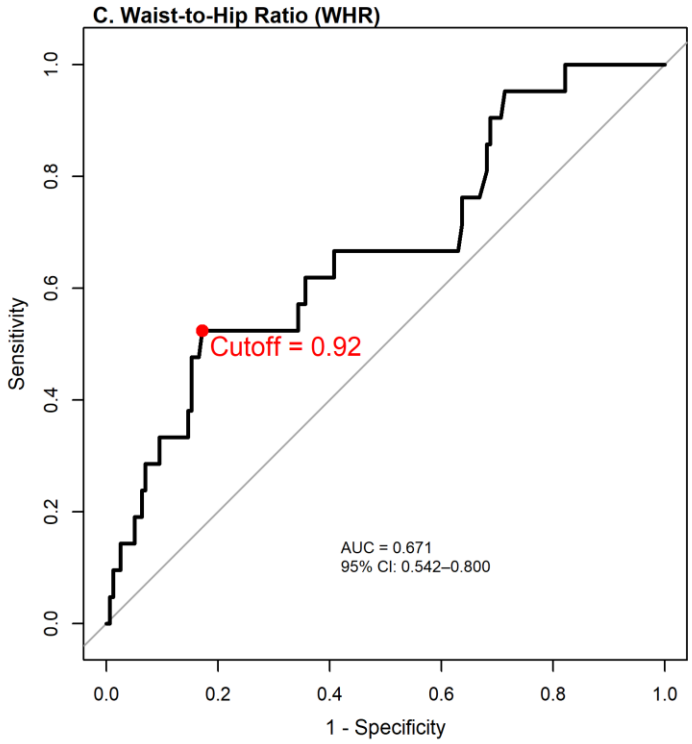


Figure 1. Receiver operating characteristic (ROC) curves for three anthropometric measures as predictors of elevated visceral adipose tissue (VAT) mass (> 600.5 g) on DEXA. (A) Waist-to-height ratio (WHtR), (B) waist circumference (WC), (C) waist-to-hip ratio (WHR). The diagonal grey line represents the line of no discrimination (AUC = 0.5). Red points indicate the optimal cut-off for each measure, identified using Youden's index (sensitivity + specificity − 1). AUC = area under the curve; 95% CI calculated using the DeLong method. N=179 for WHtR; N=178 for waist circumference and WHR due to missing data on one observation.

Discussion

This cross-sectional study of women receiving HIV related care in a large referral hospital found a high prevalence of overweight and obesity measured by total body fat percentage on DEXA and BMI. Using the three anthropometric measures for central obesity, WHtR classified a high percentage of the women as obese, and a moderate percentage were classified as obese by WC and WHR. Women who had been diagnosed as living with HIV for 10 or more years were more likely to be obese according to the waist-to-height ratio measure. In contrast, using VAT mass on DEXA, the majority of the women were classified as having low cardiometabolic risk. Women with mild to moderate depression were more likely to be classified as having high cardiometabolic risk using VAT, consistent with studies that show increased likelihood of non-communicable diseases and mood disorders in HIV.[17] Study-derived cut-off values for predicting elevated VAT using the three anthropometric measurements were higher than the WHO recommended values.

A high percentage of the women in this study were classified as overweight/obese as per the total body percentage measure on DEXA. Studies looking at the risk of cardiometabolic disease in obese and overweight participants in Asians not living with HIV, found that the risk of diabetes was associated with high VAT and not total body fat percentage, independent of BMI.[18] DEXA-derived measurements excluding total body fat percentage were found to be associated with cardiometabolic risk after controlling for age, diabetes, and medication use.[19] Air displacement plethysmography is another technique used for total body composition assessment. Participants classified as non-obese on BMI were reclassified as obese using total body fat percentage by this technique.[20] This suggests the importance of combining body measurements such as BMI and body composition techniques in the assessment of body composition, especially for cardiometabolic risk assessment for obesity, to avoid misclassification. The techniques used for body composition, such as DEXA, are expensive and not feasible for routine care, but can be used to inform an alternative body measure for cardiometabolic assessment in the clinic.

Measuring a WHtR may be useful in clinical settings for cardiometabolic risk assessment. Prior studies have shown that it provides better discrimination of obesity and, thus, cardiometabolic risk compared to BMI.[13,15] However, studies in Nairobi, Kenya, have shown that waist circumference, rather than the weight-to-height ratio, is the better predictor of cardiometabolic risk.[21] The prevalence of central obesity, as defined by WC, WHR, and WHtR, was lower in comparable studies in Cameroon. The prevalence of central obesity by WC, WHR, and WHtR was 33.5%, 44.5%, and 36.5%, respectively.[12] Women with longer duration of living with HIV and exposure to ART were more likely to be obese and to have greater cardiometabolic risk, consistent with prior studies.[3,22] Cut-off values for waist circumference as a predictor of metabolic syndrome are higher than globally acceptable values in studies of people living with HIV in South Africa.[23] That suggests a need for further studies to derive relevant cut-off values for populations of people living with HIV in Africa for assessment of cardiometabolic risk.[24]

There is no universal cut-off value for VAT mass measured on DEXA. The cut-off value of 660.5 grams was derived from the São Paulo Aging and Health (SPAH) study. This study used a population of women living in low-economic settings that differed from the population in this study by advanced age, race, HIV sero-status, and geographical location.[25] VAT was used to predict metabolic syndrome as a major study outcome in the SPAH study. The gold-standard modalities for measuring body composition are MRI or CT. These are comparable to DEXA in estimating general as well as truncal fat, but DEXA overestimates fat in other areas such as in the limbs of people living with HIV.[26] Anthropometric measurements cannot

distinguish between subcutaneous adipose tissue (SAT) and VAT. MRI and CT are best for distinguishing between SAT and VAT, but DEXA is recommended for overall body composition measurements.[11]

As people living with HIV are living longer due to better ART coverage and sustained viral load suppression, being overweight and obese are increasingly becoming a public health concern. There is a need for integration of assessment of obesity and cardiometabolic risk assessment in routine clinic visits to enable a more holistic approach to HIV care that averts complications. Obesity and overweight are seldom given attention during HIV care. Integration of assessment and management pathways for obesity and overweight is needed to avert complications. The use of supplemental drugs such as the GLP-1 agonists to manage obesity and overweight in people living with HIV is an area that requires further studies to inform policy, especially in sub-Saharan Africa. Pharmacologic interventions approved in the West for management of obesity in populations of people living with HIV include glucose-dependent insulinotropic polypeptide receptor agonists (GIP-RA), glucagon-like peptide 1 receptor agonists (GLP1-RA) such as semaglutide, as well as phentermine-topiramate, bupropion-naltrexone, and orlistat.[22] These pharmacologic interventions have shown efficacy in populations living with HIV, although studies are limited and lacking in sub-Saharan Africa.

This study was able to show that obesity is a public health concern that needs further exploration, especially in women living with HIV, who are fifty years and older in age. This age group of women requires tailored care that incorporates their varied needs as they age and live with HIV. Our study results suggest that waist-to-height ratio is the anthropometric measure of choice in clinic settings and could be used as a tool for screening and cardiometabolic risk assessment. However, there is a need for further studies to quantify population-specific anthropometric and VAT mass cut-offs for women older than 50 years living with HIV in sub-Saharan Africa. Management strategies for obesity need to be explored at the public policy level in sub-Saharan Africa as obesity reduction drugs are introduced to this population, as well as the incorporation of lifestyle modifications alongside pharmaceuticals.

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