Journal of Frailty, Sarcopenia and Falls

Original Article

Assessment of Sarcopenia and Metabolic Abnormalities in HIV Patients Stable on Antiretroviral Therapy: A Cross-Sectional Analysis of an Indian Cohort

Amitkumar Chavan[1], Prayas Sethi[1], Pratheek Choppala[1], Lakshmi Kattamuri[1], Naval K. Vikram[1], Neeraj Nischal[1], Naveet Wig[1]

[1]Department of Medicine, All India Institute of Medical Sciences, New Delhi, India

Abstract

Objectives: Successful ART prolongs PLHIV survival, but metabolic complications like dyslipidemia and sarcopenia are rising. Research on these issues, particularly with newer integrase inhibitor-based regimens, remains limited. **Methods**: We evaluated 84 PLHIV on stable ART (> 2 years) for sarcopenia and metabolic abnormalities using functional assessments (HGS, SPPB), BIA, and detailed biochemical screening for dyslipidemia and insulin resistance. **Results**: Of 84 participants (71.4% male, mean age 38.97 ± 9.77 years), probable sarcopenia prevalence was 8.33% (using AWGS (Asian Working Group for Sarcopenia) criteria), while none had confirmed sarcopenia using BIA for measurement of muscle mass. Dysglycemia affected 33.0%, with 8.33% having diabetes. Dyslipidemia was observed in 76.19%. Metabolic syndrome prevalence was 16.6%. Compared to non-sarcopenic participants, those with probable sarcopenia had significantly lower median MUAC (23 vs. 26 cm, p=0.02 for both sides) and mid-thigh circumferences (Right: 41.5 vs. 45.5 cm, p=0.04; Left: 41 vs. 45 cm, p=0.05). Physical performance, measured by the SPPB score, was also significantly reduced (median 10 vs. 11; p=0.02). **Conclusion**: We identified probable sarcopenia and its correlates in stable PLHIV. Findings suggest current AWGS cutoffs require regional validation. High metabolic morbidity underscores significant cardiovascular risks, necessitating early intervention to optimize quality of life.

Keywords: AntiRetroviral Therapy, Dysglycemia, Dyslipidemia, Metabolic syndrome, Sarcopenia

Introduction

In 2021, the National AIDS Control Organization (NACO) reported 2.4 million people living with Human Immunodeficiency Virus (PLHIV) in India[1]. Advances in HIV management have increased life expectancy nearing that of the general population[2] yet the widespread use of antiretroviral therapy (ART) regimens has brought about non-communicable comorbidities and geriatric syndromes associated with aging (e.g., sarcopenia, impaired glucose tolerance, insulin resistance, metabolic syndrome, lipodystrophy, osteopenia, and dyslipidemia). PLHIV face prolonged exposure to persistent HIV and ART toxicity, which are significant contributors to metabolic disturbances characterized by persistent inflammation and immune activation[3]. These disturbances, coupled with prevalent lifestyle and social risk factors in low-resource settings such as sedentary lifestyle, smoking, lower socio-economic status, and poor nutritional status (low protein intake), result in PLHIV being diagnosed with major comorbidities and geriatric syndromes up to 16 years earlier than individuals without HIV[2].

Sarcopenia is characterized by the progressive loss of

The authors have no conflict of interest.

Corresponding author: *Dr Prayas Sethi, Dept. of Medicine, Third floor, teaching block. AIIMS Delhi, Ansari Nagar, 110049, India*

E-mail: *prayassethi82@gmail.com*

Edited by: *George Lyritis*

Accepted *19 February 2026*

skeletal muscle mass and function, associated with declines in physical function and higher mortality rates in the general population[4]. Despite evidence linking older ART regimens to decreased lean body mass, data on the relationship between newer drugs, particularly integrase inhibitors, and sarcopenia remain sparse[5]. Sarcopenia may impose a substantial health and socioeconomic burden on people with HIV in the future, attributed to both increasing life expectancy (primary sarcopenia) and HIV- and treatment-related factors (secondary sarcopenia)[6].

This study aims to assess the sarco-metabolic profile in stable PLHIV on ART, identifying the prevalence of sarcopenia, dysglycemia, dyslipidemia, insulin resistance, metabolic syndrome, and obesity. Correlations between clinical, anthropometric, and metabolic parameters with sarcopenia were explored, which can aid in diagnosis on an outpatient basis to identify the probable high-risk individuals.

Patients and Methods

The study was conducted at the ART Center, AIIMS, New Delhi, utilizing a cross-sectional observational design. Data collection spanned from January 2021 to November 2022. A sample size of 84 patients was selected through convenience sampling. Inclusion criteria encompassed PLHIV patients who had maintained clinical stability on ART for more than two years, possessed a latest CD4 count exceeding 350 cells/mm^3, maintained a viral load of fewer than 1000 copies/mL, and were aged between 18 and 65 years.

Exclusion criteria were defined to ensure a stable metabolic and inflammatory baseline; specifically, we excluded participants meeting any of the following criteria: (i) current or recent corticosteroid therapy; (ii) known diabetes mellitus or dyslipidemia on treatment; (iii) known cardiac, pulmonary, or renal disease.

After obtaining ethical approval, recruited patients underwent a comprehensive clinical assessment, including the collection of demographic data, review of medical history, physical examinations, anthropometric measurements, and muscle function assessments, including Hand Grip Strength (HGS) and Short Physical Performance Battery (SPPB) tests. Blood investigations included tests such as Fasting Blood Sugar (FBS), Postprandial Blood Sugar (PPBS), Lipid Profile, and HbA1C. Special tests involved assessing serum insulin levels (Reporting follows STROBE guidelines. See Table S1 for the checklist).

Sarcopenia Assessment

The diagnosis of sarcopenia followed the recommendations of the Asian Working Group on Sarcopenia (AWGS). This assessment involved three key components: evaluating low muscle strength using a pneumatic hand dynamometer to assess HGS, determining low muscle quantity by skeletal muscle index (SMI) through Bioimpedance Analysis (BIA), and assessing physical performance with the SPPB scoring developed by National Institute of ageing[7–9].

As per AWGS 2019[7] cut-offs for low HGS were < 18 kg for women and < 28 kg for men and SMI cut-offs were < 7.0 kg/m^2 in men and 5.7 kg/m^2 in women. (Refer to supplementary material for protocol for HGS and body composition analysis)

A SPPB score of 9 or less out of a maximum of 12 was considered poor performance[9]. Patients underwent an initial HGS test, and those with low HGS were identified as having probable sarcopenia. Subsequently, individuals with low SMI on BIA were diagnosed with sarcopenia. Severe sarcopenia was determined in patients exhibiting low muscle strength, diminished muscle mass, and impaired physical performance measured by the SPPB.

Insulin Resistance Measurement: Serum insulin and plasma glucose levels were measured in fasting blood samples obtained after a minimum of 12 hours of fasting. Insulin resistance was quantified using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR), with values below 2.60 considered normal and values equal to or exceeding 3.80 indicating high insulin resistance[10]. Intermediate values falling between 2.60 and 3.79 were treated as increasing metabolic risk but did not meet the threshold for the "high" category in the primary analysis.

Dyslipidemia Evaluation

Patients were required to fast for at least 12 hours before venous blood sample collection. Dyslipidemia diagnosis was made in accordance with the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) guidelines[11]. Specifically, hypercholesterolemia was defined as Total Cholesterol (TC) levels equal to or greater than 200 mg/dl, high LDL-C as levels of 130 mg/dl or higher, hypertriglyceridemia as levels equal to or greater than 150 mg/dl, and low HDL-C as levels below 40 mg/dl for men and below 50 mg/dl for women.

Anthropometry and Other Measurements

Anthropometric measurements encompassed height, weight, Body Mass Index (BMI), hip circumference, waist circumference, bilateral arm, mid-thigh, and mid-calf circumferences. Obesity (B.M.I ≥25 kg/m^2) and overweight (B.M.I 23–24.9 kg/m^2) status were determined using the WHO Asia-Pacific guidelines designed for South Asians[12]. Body mass index (BMI) was classified according to Asia-Pacific criteria as follows: underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), obesity class I (25.0–29.9 kg/m^2), and obesity class II (≥30.0 kg/m^2).

Dysglycemia evaluation and metabolic syndrome

Prediabetes and Diabetes Criteria: Diabetes mellitus was diagnosed according to the American Diabetes

Baseline parameters	Number of patients, n= 84 (%)
Male sex	60 (71.4%)
Age (years)	
18-30	21(25.0%)
31-50	53 (63.1%)
51-65	10 (11.9%)
BMI Category*	
Underweight	3 (3.57%)
Normal Weight	35 (41.66%)
Overweight	11 (13.09%)
Obesity I	28 (33.33%)
Obesity II	7 (8.33%)
CD4 Count Range (cells/mm^3)	
Median CD4 Count: 522 (393-648.5)	
350-499	39 (46.42%)
500-999	42 (50%)
>999	3 (3.57%)
Median CD4 Count	522 (393-648.5)
Median duration of ART (months)	64.5 (48-120)
Participants currently receiving TLD Regimen	82 (97.6 %)
Participants currently receiving INSTI+PI Regimen	2 (2.38 %)

**BMI categories were defined using Asia-Pacific criteria: underweight (< 18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), obesity class I (25.0–29.9 kg/m^2), and obesity class II (≥ 30.0 kg/m^2).*

Table 1. Baseline demographics.

Variable	Prevalence - n (%)
Probable Sarcopenia	7 (8.33%)
Sarcopenia	0 (0%)
Dysglycemia (Prediabetes + Diabetes)	28 (33%)
Diabetes Mellitus	7 (8.33%)
High Insulin Resistance	27 (32.14%)
Dyslipidemia	64 (76.19%)
High LDL	24 (28.57%)
Hypercholesterolemia	10 (11.90%)
Low HDL	54 (64.28%)
Hypertriglyceridemia	20 (23.8%)
Metabolic Syndrome	12 (16.6%)
High Waist to Hip ratio	69 (82.14%)
Abdominal Obesity	48 (57.14%)

Table 2. Prevalence of sarcopenia and metabolic parameters.

Association (ADA) criteria[13]. This included a FBS ≥ 126 mg/dL, a PPBS ≥ 200 mg/dL, or an HbA1C ≥ 6.5 %. Prediabetes was defined by an HbA1C of 5.7 % – 6.4 % or an FBS of 100 – 125 mg/dL. As per the study's exclusion criteria, these diagnoses were limited to individuals who were not previously known to have diabetes and were not on glucose-lowering therapy.

"Dysglycemia" was constructed as a composite endpoint representing any abnormality in glucose metabolism, including both prediabetes and newly diagnosed diabetes mellitus.

Hypertension was diagnosed in alignment with the International Society of Hypertension Global Hypertension Practice Guidelines criteria, respectively[14]. The diagnosis of metabolic syndrome adhered to the Joint Interim Statement criteria, requiring the presence of at least three out of five specific components, including increased waist circumference, hypertriglyceridemia, low HDL levels, elevated blood pressure, and elevated blood sugar[15]. To suit the South Asian study population, the waist circumference cut-off was defined as 90 cm for men and 80 cm for women. Given the exclusion of patients already on treatment for diabetes, dyslipidemia, or serious comorbidities, the blood pressure and glucose components represented treatment-naïve measurements taken during the clinical assessment.

Statistical Analysis

Data were meticulously recorded using a predefined proforma and subsequently organized within an Excel spreadsheet. The normality of variable distributions underwent assessment using the D'Agostino & Pearson test. Variables found to exhibit a normal distribution were presented as mean values accompanied by their respective standard deviations. Conversely, non-normally distributed variables were expressed as medians with the 25th to 75th percentile range. To analyze normally distributed variables, independent t-tests were applied, while skewed variables underwent evaluation using the Wilcoxon rank sum test. Categorical variables were analyzed with Fisher's exact test. In this study, a significance level of $p<0.05$ was deemed statistically significant.

Results

Out of the total 220 individuals screened, 104 patients met the inclusion criteria, and a further 20 patients were excluded due to incomplete investigations. Demographic

Variable, Median (IQR)	Total (n=84)	No Sarcopenia (n=77)	Probable Sarcopenia (n=7)	p-value
Age (years)	38 (30-47)	37 (30-47)	47 (37.5-53)	0.12
Height (cm)	161 (151.5-168.5)	162 (152-170)	155 (149-161)	0.13
Weight (kg)	62.5 (54-70)	63 (54-70.25)	58 (49.9-66.25)	0.26
BMI (kg/m^2)	24 (21.49-27.17)	24.2 (21.8-27.3)	23.4 (20.87-26.25)	0.59
CD4 (cells/mm^3)	522 (393-648.5)	510 (390-647)	482 (402-658)	0.52
Duration of ART (months)	64.5 (48-120)	64 (48-105)	150 (44.25-183)	0.21
Hip circumference (cm)	90 (86-96)	91 (86-97)	85 (83.25-92.75)	0.11
Waist circumference (cm)	86.5 (80-94)	88 (80.75-94)	81 (75 – 90.75)	0.69
Right arm circumference (cm)	26 (24-26)	26 (24-27)	23 (22-24)	0.02
Left arm circumference (cm)	26 (24-27)	26 (24-27)	23 (22-24)	0.02
Right mid-thigh circumference (cm)	45 (42-48)	45.5 (42-49)	41.5 (39-43)	0.04
Left mid-thigh circumference (cm)	44 (41-48)	45 (42-48)	41 (39-42.5)	0.05
Right calf circumference (cm)	33 (30-35)	32 (30-34)	30.5 (28.5-31)	0.10
Left calf circumference (cm)	32 (30-34)	32 (30-34)	30.5 (28.5-31)	0.11
Body Fat Percentage	26.4 (17.9-29.5)	25.2 (18.25-31.1)	21.2 (16.22-22.5)	0.20
Waist-to-hip ratio	0.94 (0.88-0.98)	0.94 (0.89-0.98)	0.97 (0.86-1.03)	0.69
ASM (kg), n, Median (IQR)	n=84, 25.25 (20.8-29.2)	n=77, 25.4 (20.8-29.4)	n=7, 21.9 (20-24.95)	0.10
ASM (Male) (kg), n, Median (IQR)	n=60, 26.40 (24.63-29.75)	n=54, 26.80 (24.8-30.05)	n=6, 22.90 (21.53-25.48)	0.014
ASM (Female) (kg), n, Median (IQR)	n=24, 19.35 (16.88-21.25)	n=23, 19.5 (17.40-21.30)	n=1, 16.5*	-
SMI (kg/m^2), n, Median (IQR)	n=84, 9.55 (8.7-10.49)	n=77, 9.7 (8.9-10.65)	n=7, 9.3 (8.32-9.57)	0.17
SMI (Male) (kg/m^2), n, Median (IQR)	n=60, 9.86 (9.11-10.73)	n=54, 9.91 (9.14-10.88)	n=6, 9.38 (8.55-9.63)	0.082
SMI (Female) (kg/m^2), n, Median (IQR)	n=24, 8.86 (8.14-9.44)	n=23, 8.9 (8.11–9.47)	n=1, 8.33*	-
SPPB	11 (10-12)	11 (10-12)	10 (10-10)	0.02

**Only one female participant was identified with probable sarcopenia; therefore, dispersion values and p-values could not be calculated for this subgroup.*

Table 3. Demographic, clinical and anthropometrical characteristics of the patients.

and clinical characteristics of the 84 participants are presented in Table 1. The study group included 60 (71.4%) male participants. The mean (SD) age of participants was 38.97±9.77 years, with 88% of the population under 50 years of age. The mean (SD) BMI was 24.55 (4.57) kg/m^2, with more than half of the study population (54.8 %) belonging to the overweight and obese category according to the BMI classification in Asian adults. All the participants had clinically stable disease, and the median duration of ART was 64.5 (48-120) months. 98% of the participants were currently receiving first-line ART i.e., TLD regimen, which includes an integrase inhibitor, with all the patients having received TLE regimen (Tenofovir, Lamivudine, and Efavirenz) – previous first-line ART - up to 2018. The disease was well controlled, with the median CD4 count being 522 cells/mm3 (393-648.5), and the plasma viral load was undetectable in all patients. Although eligibility allowed viral load <1000 copies/mL, all included participants had undetectable viral load at enrollment/ testing (Table-1).

The prevalence of probable sarcopenia in the study population was 8.33% (7/84), while none of the participants

had sarcopenia. 6 out of 7 probable sarcopenics were men (Table 2). 28 (33.0%) participants had dysglycemia, out of which 7 (8.33%) participants had newly diagnosed diabetes mellitus. High insulin resistance using HOMA-IR cut-offs was seen in 27 patients (32.14%). Dyslipidemia was found in 64 (76.19%) participants. High LDL, Low HDL, hypercholesterolemia, and hypertriglyceridemia were found in 24 (28.57%), 54 (64.28%), 10 (11.90%), and 20 (23.8%) participants, respectively. All glycemic and lipid abnormalities reported in the results represent newly identified findings detected at the time of study assessment. The prevalence of metabolic syndrome was 16.6% (12/84) while the prevalence of a high waist- to-hip ratio and abdominal obesity were 82.14% (69/84) and 57.14% (48/84) respectively.

Probable sarcopenia and its correlates

Overall, patients who had probable sarcopenia had higher age, lower weight, height, CD4 count, and a longer duration of ART compared to patients without sarcopenia (Table 3). Although none of the parameters reached statistical significance. Participants with probable sarcopenia exhibited significantly reduced right MUAC [median (IQR): 23 (22 - 24) cm vs. 26 (24 - 27) cm; p= 0.02], left MUAC [23 (22 - 24) cm vs. 26 (24 - 27) cm; p= 0.02], right mid-thigh circumference [41.5 (39 - 43) vs. 45.5 (42 - 49) cm; p= 0.04], and left mid-thigh circumference [41 (39 - 42.5) vs. 45 (42 - 48) cm; p= 0.05] compared to those without sarcopenia. Patients with probable sarcopenia had lower ASM, SMI, and SPPB scores in comparison to patients without probable sarcopenia; however, only SPPB scores were significantly lower [median (IQR): 10 (10 - 10) vs. 11 (10 - 12); p= 0.02]. None of the patients had SMI values that were below the cut-offs prescribed by AWGS for the diagnosis of sarcopenia.

Of the seven participants identified with probable sarcopenia, six (85.7 %) were male, and one (14.3 %) was female. Among males, ASM was significantly lower for patients with probable sarcopenia [median (IQR): 22.9 (21.53 - 25.4) vs. 26.8 (24.8 - 30.05) kg; p = 0.014] while SMI was comparable between the two groups. Due to the single occurrence in the female subgroup, comparative statistical analysis and measures of dispersion for female-specific muscle mass parameters could not be performed.

Discussion

Our cross-sectional observational study conducted over 22 months at a tertiary care center in North India (ART center, AIIMS New Delhi) includes 84 stable PLHIV out of which nearly ninety-eight percent of patients received the TLD regimen.

The high prevalence of overweight and obesity (54.8 %) observed in our study population is a significant finding. While the cross-sectional nature of this study precludes the determination of a temporal or causal relationship, this observation is consistent with a growing body of external literature suggesting an association between newer integrase strand transfer inhibitors (INSTIs), such as dolutegravir, and weight gain.

In a study, it was demonstrated that there was an increase in BMI at a rate of 0.3 kg/m^2 per year before dolutegravir transition and at a rate of 1.2 kg/m^2 per year after dolutegravir transition[16]. A cohort from Brazil showed that PLHIV on Ralutegravir-based regimens were 7-fold more likely to become obese (BMI ≥ 30 kg/m^2) when compared to patients receiving other regimens, i.e. NNRTI- or PI-based regimens[17].

The prevalence of probable sarcopenia was low in our study, i.e. 8.33 % compared to previous studies. The majority of individuals identified as probable sarcopenic patients were male participants, aligning with previous studies that also reported a 10.7-fold higher likelihood of detecting presarcopenia in males compared to females[18,19]. Multiple studies that have investigated the prevalence of sarcopenia in PLHIV patients on ART have noted a higher prevalence ranging from 8.5% to 40%, depending on the definition used for sarcopenia[6]. In a meta-analysis of 13 studies involving 2267 participants, the pooled prevalence of sarcopenia among People Living with HIV (PLHIV) was 24.1% (95%CI = 17.8–31.0%; I2 = 91%; LFK = -0.44). Sarcopenia prevalence was higher with the use of low muscle mass only (28.8%; 95% CI= 24.0–34.1%; I2= 78%) compared to studies incorporating both low muscle mass and function (13.2%; 95% CI= 5.2–22.9%; I2= 79%)[6]. Two studies – Wasserman et al. and Pinto Neto et al.[24], which have used SMI cut-offs ≤10.75 kg/m^2 for men and ≤6.75 for women based on BIA reference values obtained from a study by Janssen et al.[25] have reported the prevalence of sarcopenia in PLHIV as 5% and 24.2% respectively. However, the equation for SMI developed for estimating skeletal mass using BIA by Janssen et al. was found to do not apply to the Asian population, and therefore, could not be employed in our study[25]. Two studies conducted in India by Dutta et al.[20,21] assessed muscle mass using DXA and diagnosed sarcopenia following the EWGSOP guidelines, defining it as <= 2 standard deviations from a matched control group. The prevalence of sarcopenia in women[20] and men[21] was reported as 17.5% and 40.0%, respectively.

The observed low prevalence in our study may be attributed to several factors. Firstly, the studies that evaluated sarcopenia in PLHIV included a largely elderly population; in contrast, most of our study population (88%) was less than 50 years of age. Older age has been demonstrated to be positively correlated with sarcopenia[18,22]. Secondly, the studies conducted in the western population mainly used the DXA scan, which is considered to be the gold standard for the diagnosis of low skeletal muscle mass[23]. We used multifrequency BIA to evaluate skeletal muscle mass as it is cheap and easily

available, which may have led to slightly higher SMI values, and there is no matched control group to normalize the SMI values. The gap between BIA and DXA in Asian ethnic groups seems to be greater than that in Europeans or Africans[23]. Also, there is no consensus on cut-offs for low muscle strength and muscle mass in the PLHIV population. We have used the cut-off points (< 7.0 kg/m^2 in men and 5.7 kg/m^2 in women) described in AWGS guidelines, which were primarily validated in the general elderly Asian population. These cut-off points may not apply to the study population. Lastly, our study recruited only clinically asymptomatic individuals who physically visited a healthcare facility to acquire their regular medications. Hence, the observations tend to underestimate the true prevalence of sarcopenia in the PLHIV population in the study population.

In cross sectional study done by Wasserman et al higher body mass index (OR 0.80; P < 0.0007), MUAC (OR 0.83; P < 0.024), and large skeletal frame (OR 0.09; P < 0.003) were negatively associated with presarcopenia. Finding that a participant did not have a MUAC <25th percentile on physical examination had a 90.4% negative predictive value for presarcopenia[18]. MUAC measurement is a straightforward and accessible procedure for clinicians, necessitating minimal patient disrobing and only an inelastic tape measure. Unlike lower extremity circumferences, MUAC is less prone to distortion by fluid retention and remains largely independent of height[26]. Therefore, these body circumferences could be utilized to screen patients for sarcopenia in outpatient basis. SPPB values were also lower in patients with probable sarcopenia with a trend towards significance, implying that sarcopenia affects functional capacity and impairs the quality of life[27].

The observed musculoskeletal changes also have critical implications for the "muscle-bone unit." Although bone mineral density was not measured in this study, the mechanical and endocrine interplay between muscle and bone suggests that patients with reduced muscle strength may be at a heightened risk for osteopenia and fractures. Persistent inflammation and the potential metabolic side effects of long-term ART further exacerbate this risk by disrupting the balance of bone remodeling.

Furthermore, the significant reductions in MUAC and physical performance scores (SPPB) in the probable sarcopenia group suggest early functional impairment. Even in a clinically stable cohort, these subtle declines in physical performance may predict a higher future incidence of falls and fractures. Early screening for low muscle strength and metabolic derangements is therefore essential to mitigate these risks and preserve the quality of life as this population ages. Large-scale population-based studies are required to identify optimal anthropometric cut-offs for screening of sarcopenia.

In our study, 76.19% of patients exhibited dyslipidemia, aligning closely with another North Indian study reporting a prevalence of 79.0%[28]. The most prevalent type was low HDL (64.28%), followed by high LDL (28.57%). Notably, a study of 168 patients demonstrated that ART significantly impacted lipid profiles, with LDL-C (>130 mg/dL) prevalence rising from 3% to 23% post-treatment[29]. A parallel high incidence of low HDL-C (43%) has been documented in African countries[30]. In our study, 33% of participants exhibited dysglycemia, with 8.33% diagnosed with diabetes mellitus and 32.14% showing insulin resistance. Comparable findings were observed in another Indian study, which demonstrated diabetes, prediabetes, and insulin resistance (IR) prevalence of 9%, 16%, and 38%, respectively[32]. These results align with estimates of dysglycemia and its predictors from studies conducted in African and South American populations[33,34]. Hence, patients on ART should be screened for these metabolic abnormalities and should be promptly treated upon identification, which will help mitigate the risk of adverse cardiovascular outcomes.

This is one of the few cross-sectional studies involving an Indian cohort to identify the prevalence of sarcopenia and metabolic derangements in a stable HIV population receiving TLD regimens. It is limited by the single-center, cross-sectional design, convenient sample size, and the use of BIA instead of DXA scan. We identified associations but could not infer temporal relationships or causation.

Conclusions

We identified probable sarcopenia and its correlates in this relatively stable PLHIV population. AWGS cutoffs for SMI may not apply, warranting further population studies using DXA over BIA. MUAC and mid-thigh circumferences were significantly lower in patients with probable sarcopenia, which needs to be further studied as a screening tool for low muscle strength. Dyslipidemia and dysglycemia prevalence highlight cardiovascular risks, emphasizing the need for timely intervention to enhance PLHIV's quality of life.

Ethics approval

Ethics approval was obtained from Institute Ethics Committee, AIIMS New Delhi: Ref. No. IECPG-151/24.02.2021

Consent to participate

Written informed consent was obtained from all participants before enrollment in the study.

Authors' contributions

Study was designed by AC, PS. AC was involved in data collection. AC, PS, PC, KA, LK were involved in drafting manuscript. NV, NW and NN supervised the study and reviewed the manuscript. All authors read and approved the final version of the manuscript.

References

1. India HIV Estimates 2021; National AIDS Control Organization. (2021). HIV Estimations 2021: Technical Report. Government of India, Ministry of Health & Family Welfare. https://naco.gov.in/sites/default/files/India%20HIV%20Estimates.pdf. Accessed 15 October 2025.
2. Marcus JL, Leyden WA, Alexeeff SE, et al. Comparison of Overall and Comorbidity-Free Life Expectancy Between Insured Adults with and Without HIV Infection, 2000-2016. JAMA Netw Open. 2020;3(6):e207954.
3. Nasi M, De Biasi S, Gibellini L, et al. Ageing and inflammation in patients with HIV infection. Clin Exp Immunol. 2017;187(1):44-52
4. Chang SF, Lin PL. Systematic Literature Review and Meta-Analysis of the Association of Sarcopenia with Mortality. Worldviews Evid Based Nurs. 2016;13(2):153-162.
5. Konishi K, Nakagawa H, Asaoka T, Kasamatsu Y, Goto T, Shirano M. Sarcopenia among people living with HIV and the effect of antiretroviral therapy on body composition. Medicine (Baltimore). 2022;101(42):e31349.
6. Oliveira VHF, Borsari AL, Webel AR, Erlandson KM, Deminice R. Sarcopenia in people living with the Human Immunodeficiency Virus: a systematic review and meta-analysis. Eur J Clin Nutr. 2020;74(7):1009-1021.
7. Chen LK, Woo J, Assantachai P, et al. Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. J Am Med Dir Assoc. 2020;21(3):300-307.e2.
8. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31.
9. National Institute on Aging. Short Physical Performance Battery (SPPB). https://www.nia.nih.gov/research/labs/leps/short-physical-performance-battery-sppb. Accessed November 22, 2023.
10. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28(7):412-419.
11. Lipsy RJ. The National Cholesterol Education Program Adult Treatment Panel III guidelines. J Manag Care Pharm. 2003;9(1 Suppl):2-5.
12. Tham KW, Abdul Ghani R, Cua SC, et al. Obesity in South and Southeast Asia—A new consensus on care and management. Obes Rev. 2023;24(2):e13520.
13. American Diabetes Association Professional Practice Committee. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2022. Diabetes Care. 2022;45(Suppl 1):S17-S38.
14. Unger T, Borghi C, Charchar F, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. Hypertens Dallas Tex 1979. 2020;75(6):1334-1357.
15. Alberti KGMM, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):1640-1645.
16. Thivalapill N, Simelane T, Mthethwa N, et al. Transition to Dolutegravir Is Associated with an Increase in the Rate of Body Mass Index Change in a Cohort of Virally Suppressed Adolescents. Clin Infect Dis Off Publ Infect Dis Soc Am. 2021;73(3):e580-e586.
17. Bakal DR, Coelho LE, Luz PM, et al. Obesity following ART initiation is common and influenced by both traditional and HIV-/ART-specific risk factors. J Antimicrob Chemother. 2018;73(8):2177-2185.
18. Wasserman P, Segal-Maurer S, Rubin DS. High prevalence of low skeletal muscle mass associated with male gender in midlife and older HIV-infected persons despite CD4 cell reconstitution and viral suppression. J Int Assoc Provid AIDS Care. 2014;13(2):145-152.
19. Yarasheski KE, Scherzer R, Kotler DP, et al. Age-related skeletal muscle decline is similar in HIV-infected and uninfected individuals. J Gerontol A Biol Sci Med Sci. 2011 Mar;66(3):332-340.
20. Dutta D, Garga UC, Gadpayle AK, et al. Occurrence & predictors of osteoporosis & impact of body composition alterations on bone mineral health in asymptomatic pre-menopausal women with HIV infection. Indian J Med Res. 2018;147(5):484-495.
21. Dutta D, Sharma M, Bansal R, et al. Low skeletal mass is an important predictor of osteoporosis in HIV-infected men in India. Endokrynol Pol. 2017;68(6):642-651.
22. Abdul Aziz SA, Mcstea M, Ahmad Bashah NS, et al. Assessment of sarcopenia in virally suppressed HIV-infected Asians receiving treatment. AIDS Lond Engl. 2018;32(8):1025-1034.
23. Bosy-Westphal A, Jensen B, Braun W, Pourhassan M, Gallagher D, Müller MJ. Quantification of whole-body and segmental skeletal muscle mass using phase-sensitive 8-electrode medical bioelectrical impedance devices. Eur J Clin Nutr. 2017;71(9):1061-1067.
24. Pinto Neto LF da S, Sales MC, Scaramussa ES, da Paz CJC, Morelato RL. Human immunodeficiency virus infection and its association with sarcopenia. Braz J Infect Dis. 2015;20(1):99-102.
25. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol Bethesda Md 1985. 2000;89(2):465-471.
26. Olukoya AA. Identification of underweight women by measurement of the arm circumference. Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet. 1990;31(3):231-235.
27. Cabrera DM, Cornejo MP, Pinedo Y, Garcia PJ, Hsieh E. Assessment of regional body composition, physical function and sarcopenia among peruvian women aging with HIV: A cross-sectional study. PLOS Glob Public Health. 2023;3(8):e0000814.
28. Dutta D, Sharma M, Anand A, Garga UC, Bansal R, Sharma N. Increased trunk fat along with decreased peripheral fat as an important predictor of hypertriglyceridaemia & hypercholesterolaemia in Indians with HIV infection. Indian J Med Res. 2018;148(4):411-421.
29. Padmapriyadarsini C, Ramesh Kumar S, Terrin N, et al. Dyslipidemia among HIV-infected Patients with tuberculosis taking once-daily nonnucleoside reverse-transcriptase inhibitor-based antiretroviral therapy in India. Clin Infect Dis Off Publ Infect Dis Soc Am. 2011;52(4):540-546.
30. Dave JA, Levitt NS, Ross IL, Lacerda M, Maartens G, Blom D. Anti-Retroviral Therapy Increases the Prevalence of Dyslipidemia in South African HIV-Infected Patients. PloS One. 2016;11(3):e0151911.
31. Jain N, Tripathi A, Vaish A, Verma S, Himanshu D, Gutch M. Can Metabolic Factors be used Prognostically for Short-Term Mortality in HIV-Infected Patients? Ann Med Health Sci Res. 2012;2(2):124-128.
32. Marbaniang I, Sangle S, Salvi S, et al. High prevalence of insulin resistance and occurrence prior to hyperinsulinemia threshold among people living with HIV in Pune, India. Diabetes Metab Syndr. 2019;13(3):1813-1819.
33. Tadesse WT, Adankie BT, Shibeshi W, Amogne W, Aklillu E, Engidawork E. Prevalence and predictors of glucose metabolism disorders among People Living with HIV on combination antiretroviral therapy. PloS One. 2022;17(1):e0262604.
34. Njuguna B, Kiplagat J, Bloomfield GS, Pastakia SD, Vedanthan R, Koethe JR. Prevalence, Risk Factors, and Pathophysiology of Dysglycemia among People Living with HIV in Sub-Saharan Africa. J Diabetes Res. 2018;2018:6916497.

Supplementary Material: Method of assessment of body composition and hand grip strength

Measurement of muscle strength and body composition: Body composition was evaluated using the ACCUNIQ multi-frequency bioelectrical impedance analysis (BIA) analyzer. To ensure technical accuracy and minimize measurement variability, the following standardized protocol was implemented:

- Preparation: Participants underwent a 12-hour fast and were instructed to avoid strenuous exercise (24 hours) and alcohol (48 hours) before assessment.
- Protocol: Measurements were taken in a standardized standing position with hands and feet in contact with the base and handle electrodes.
- Calculation: The Skeletal Muscle Index (SMI) was calculated as SMI = Appendicular Skeletal Muscle Mass (ASM) (kg) / height^2 (m^2)

Hand Grip Strength (HGS) was measured using a pneumatic hand dynamometer to identify low muscle strength. The standardized clinical protocol was executed as follows:

- Positioning: Participants were positioned comfortably, in a seated position, with the elbow flexed at 90 degrees. Feet were flat on the floor, and participants were instructed not to support their arms against their bodies or the chair during testing.
- Maximum Effort: Measurements were performed first on the dominant hand, followed by the non-dominant hand. For each hand, three maximal voluntary contractions were recorded. Each contraction lasted approximately 3 seconds, with a rest interval of at least 60 seconds between trials to minimize fatigue.
- Repetitions: Measurements were performed three times for each hand to ensure reliability and account for variability in effort.
- Data Recording: The best value (measured in kilograms) obtained from the successful trials was recorded as the final HGS for each participant.

Supplementary Table S1. STROBE Checklist.

Item No.	Item	Recommendation	Reported in Manuscript (Section/Paragraph)
TITLE & ABSTRACT			
Title	1	(a) Indicate the study's design with a commonly used term in the title or the abstract.	Title: Assessment of Sarcopenia and Metabolic Abnormalities... A Cross-Sectional Analysis of an Indian Cohort.
Abstract		(b) Provide in the abstract an informative and balanced summary of what was done and what was found.	Abstract: Summarizes the study of 84 PLHIV, prevalence of probable sarcopenia (8.33%), and metabolic results.
INTRODUCTION			
Background/ Rationale	2	Explain the scientific background and rationale for the investigation being reported.	Introduction: Discusses the emergence of metabolic complications and sarcopenia in PLHIV on ART.
Objectives	3	State specific objectives, including any prespecified hypotheses.	Introduction: Aims to assess sarco-metabolic profile and identify correlates for outpatient screening.
METHODS			
Study Design	4	Present key elements of study design early in the paper.	Methods: Cross-sectional observational design.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.	Methods: ART Center, AIIMS, New Delhi; January 2021 to November 2022.
Eligibility Criteria	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants.	Methods: Inclusion: PLHIV stable on ART ≥2 years, CD4 >350 cells/mm^3, viral load <1000. Exclusion: Steroid use, known DM/dyslipidemia.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria.	Methods: Sarcopenia (AWGS 2019), Insulin resistance (HOMA-IR), Dyslipidemia (NCEP ATP III), and Metabolic Syndrome (JIS).
Data Sources/ Measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement).	Methods & Supp Material: ACCUNIQ multi-frequency BIA, pneumatic dynamometer for HGS, and fasting biochemical assays.
Study Size	10	Explain how the study size was arrived at.	Methods: Convenience sampling resulted in 84 patients.
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses.	Methods: Normality tested via D'Agostino & Pearson; HOMA-IR categorized as normal, increasing risk, or high.
Statistical Methods	12	(a) Describe all statistical methods. (c) Explain how missing data were addressed.	Methods: Independent t-tests, Wilcoxon rank sum, Fischer's exact test. **Missing data addressed by complete-case analysis (20 excluded).**
RESULTS			
Participants	13*	(a) Report numbers of individuals at each stage (eligible, analyzed). (b) Give reasons for non-participation.	Results: 220 screened → 104 eligible → 84 analyzed. 20 excluded due to incomplete investigations.
Descriptive Data	14*	(a) Give characteristics of study participants.	Results: Baseline demographics provided in Table 1.
Outcome Data	15*	Report numbers of outcome events or summary measures.	Results: Prevalence data provided in Table 2.
Main Results	16	(a) Give unadjusted estimates and precision (e.g., p-values).	Results: Comparative clinical/anthropometric data provided in Table 3.
DISCUSSION			
Key Results	18	Summarise key results with reference to study objectives.	Conclusion: Summarizes identification of probable sarcopenia and metabolic cardiovascular risks.

Supplementary Table S1. *(Cont from previous page).*

Item No.	Item	Recommendation	Reported in Manuscript (Section/Paragraph)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias.	Discussion: Addresses single-center design, convenience sample, BIA usage, and lack of temporal relationship.
Interpretation	20	Give a cautious overall interpretation considering objectives and similar studies.	Discussion: Integrates findings with global DTG-associated obesity literature and AWGS criteria applicability.
OTHER INFO			
Funding	22	Give the source of funding and the role of the funders.	Competing Interests: Authors reported no affiliations or financial involvement with entities related to the manuscript.