Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Electrocardiographic Abnormalities Among People Living with HIV in a Rural Tertiary Hospital in Southwest Nigeria: A Comparative Cross-Sectional Study

Olarinde Jeffrey Oluwademilade

olarindeoluwademilade@yahoo.com

Federal Teaching Hospital

Olumuyiwa Elijah Ariyo

Federal Teaching Hospital

Research Article

Keywords: Electrocardiography, Highly Active Antiretroviral Therapy, HIV Infection, Rural Health, Sub-Saharan Africa, Cardiovascular Risk Factors

Posted Date: November 5th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11079090/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

The clinical spectrum of electrocardiographic (ECG) abnormalities among people living with HIV (PLWH) residing in rural African communities remains incompletely characterized.

Objective

To evaluate the prevalence, patterns, and independent determinants of ECG abnormalities among PLWH receiving care at a rural tertiary hospital in southwest Nigeria.

Methods

A comparative cross-sectional study was conducted at the Federal Teaching Hospital, Ido-Ekiti, Nigeria. Participants (N = 138) were stratified into three age- and sex-matched cohorts (n = 46 per group): Group A (HIV-negative controls), Group B (HIV-positive, HAART-naïve), and Group C (HIV-positive on HAART). Standard 12-lead resting electrocardiograms, anthropometric measurements, lipid panels, and CD4 + T-lymphocyte counts were obtained. Univariate group comparisons and multivariable binary logistic regression models were performed.

Results

Mean ages across Groups A, B, and C were 34.85 ± 7.79, 36.48 ± 9.12, and 38.07 ± 7.63 years, respectively (p = 0.175). Univariate comparisons demonstrated statistically significant group differences in prolonged PR interval (p = 0.027), prolonged QTc interval (p = 0.021), and abnormal QRS transitional zone (p = 0.035). Resting clinical pulse rate was significantly elevated in PLWH (89.85 ± 15.85 bpm on HAART vs 78.57 ± 9.69 bpm in controls; p = 0.000). In multivariable binary logistic regression, HIV or HAART status was not independently associated with prolonged PR interval, prolonged QTc, or abnormal QRS transition. Resting pulse rate was independently driven by CD4 count (p = 0.026), Total Cholesterol (p = 0.014), and LDL cholesterol (p = 0.004), while abnormal QRS transitional zone was independently associated with body weight (p = 0.041; OR = 1.725).

Conclusions

Electrocardiographic abnormalities observed in rural PLWH are primarily mediated by conventional cardiovascular risk factors, body habitus, and severity of immunodeficiency rather than direct antiretroviral toxicity or HIV status per se.

Introduction

Human Immunodeficiency Virus (HIV) remains a major global public health priority [1, 2]. UNAIDS and World Health Organization estimates indicate that approximately 41.0 million (35.3–47.5 million) people globally were living with HIV, with 1.2 million (950,000–1.7 million) acquiring new infections and 570,000 (430,000–780,000) dying from AIDS-related illnesses [1, 2]. Sub-Saharan Africa bears a disproportionate burden, accounting for nearly 64% of all PLWH worldwide [1, 2]. In Nigeria, national adult HIV prevalence stands at 1.3%–1.4% among adults aged 15–49 years, representing approximately 1.9 million individuals living with HIV [3, 4]. Women in Nigeria experience a higher prevalence (1.6%–1.9%) compared to men (0.9%–1.0%) [3, 4]. Despite a 68% reduction in new HIV acquisitions achieved nationally between 2010 and 2024, expanding long-term care remains a public health target under the Revised National HIV Strategy [4].

The scale-up of Highly Active Antiretroviral Therapy (HAART) has transformed HIV into a manageable chronic condition, substantially extending life expectancy [5, 6]. Consequently, non-communicable diseases—particularly cardiovascular diseases (CVDs)—have emerged as leading causes of morbidity and mortality among aging PLWH [7, 8, 9]. Evidence indicates that HIV infection is an independent risk factor for coronary artery disease, heart failure, pericardial disease, and sudden cardiac death [7, 8, 10]. Antiretroviral agents, particularly older nucleoside reverse transcriptase inhibitors (NRTIs) and protease inhibitors (PIs), have also been implicated in metabolic dysregulation, accelerated atherogenesis, and cardiac conduction abnormalities [11, 12].

Resting 12-lead electrocardiography (ECG) is an accessible, non-invasive, and cost-effective clinical tool capable of detecting subclinical cardiac involvement, conduction delays, repolarization abnormalities, and structural chamber enlargement [13, 14, 15]. In asymptomatic PLWH, baseline ECG abnormalities have been shown to correlate with adverse outcomes [6, 13].

The majority of cardiovascular research in PLWH across Sub-Saharan Africa originates from urban tertiary health centers [16, 17, 18]. Rural populations face distinct socioeconomic profiles, nutritional patterns, lifestyle exposures, and healthcare access barriers that can modulate cardiovascular risk [18, 19]. This study aimed to characterize the pattern and determinants of ECG abnormalities among PLWH (both HAART-naïve and HAART-treated) compared to uninfected controls in a rural tertiary hospital in southwest Nigeria.

Methods

Study Design and Setting

This comparative, cross-sectional study was conducted at the HIV Care and Treatment Clinic of the Federal Teaching Hospital, Ido-Ekiti, Ekiti State, southwest Nigeria. The hospital serves as a major referral center for primary and secondary healthcare facilities across Ekiti State and neighboring rural communities in Ondo, Osun, Kogi, and Kwara States.

Study Population and Eligibility

Participants were recruited and classified into three age- and sex-matched cohorts (N = 138; n = 46 per group):

- **Group A**: HIV-negative controls recruited from voluntary donors, hospital staff, and community members.
- **Group B**: HIV-positive adults who were HAART-naïve (reporting no prior exposure to antiretroviral medications).
- **Group C**: HIV-positive adults currently receiving established HAART regimens for a minimum continuous duration of 3 months.

Patients were excluded if they had an established clinical history or medical treatment for primary cardiovascular disease, chronic kidney disease, overt diabetes mellitus, or systemic hypertension. Individuals with a history of heavy tobacco use or significant alcohol consumption were also excluded to minimize behavioral confounders.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of the Federal Teaching Hospital, Ido-Ekiti. Written informed consent was obtained from all participants prior to enrollment. Patient data were anonymized using unique identification codes.

Sample Size Determination

The minimum required sample size was determined using the proportion formula for finite populations (N < 10,000):

$$n = \frac{z^2 \cdot p \cdot q}{d^2}$$

Where:

- z = 1.96 (corresponding to a 95% confidence level).
- p = 0.014 (estimated national adult HIV prevalence of 1.4%) [3, 4].
- q = 1.0 - p = 0.986.
- d = 0.05 (desired level of precision).

Applying the finite population correction for an average annual clinic intake of N = 168 new HIV cases:

$$n_f = \frac{n}{1 + \frac{n}{N}} = \frac{21.21}{1 + \frac{21.21}{168}} = 18.83 \approx 19$$

To account for potential data loss and enhance statistical power, the sample size was increased to 46 participants per group, establishing a final analytical sample of 138 participants.

Data Collection and Clinical Measurements

Participants underwent structured clinical interviews [see Additional file 1], physical examinations, laboratory evaluations, and 12-lead surface electrocardiography. Anthropometric indices (height, weight, waist circumference) were measured according to the World Health Organization STEPwise approach to surveillance [20]. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m²) and categorized using standard WHO criteria [21]. Blood pressure (BP) was recorded using an OMRON digital sphygmomanometer following a 10-minute rest period in a seated position [22].

Laboratory investigations included confirmation of HIV status using dual enzyme-linked immunosorbent assay (Genscreen Ultra HIV Ag-Ab, Bio-Rad Laboratories, Hercules, CA, USA) and Western Blot confirmation (New LAV-BLOT, Bio-Rad). Absolute $CD4^+$ T-lymphocyte cell counts were enumerated using flow cytometry. Fasting blood glucose (FBG) and serum lipid profiles—including Total Cholesterol (TC), Low-Density Lipoprotein (LDL), High-Density Lipoprotein (HDL), and Triglycerides (TG)—were measured using standard automated enzymatic methods.

Electrocardiographic Acquisition and Interpretation

A resting 12-lead surface ECG was recorded for each participant in the supine position after 10 minutes of quiet rest, using a calibrated 12-channel Schiller Cardiovit AT-1 G2 machine operating at a standard paper speed of 25 mm/s and voltage gain of 10 mm/mV (1 mV = 10 mm).

ECG tracings were independently reviewed and measured using lead II as the primary rhythm strip. Parameters analyzed included heart rate, cardiac rhythm, P-wave duration and amplitude, PR interval, QRS duration and axis, QRS transitional zone position, ST-segment shifts, T-wave morphology, and the corrected QT interval (QTc) calculated using Bazett's formula:

$$\mathrm{QTc} = \frac{\mathrm{QT}}{\sqrt{\mathrm{RR}}}$$

Prolonged PR interval was defined as > 200 ms (first-degree heart block). Prolonged QTc was defined as > 440 ms in men and > 460 ms in women. Left ventricular hypertrophy (LVH) was determined using Sokolow-Lyon voltage criteria (SV_1 + RV_5 or RV_6 > 35 mm). Abnormal QRS transitional zone was defined as a shift in the lead where R and S wave amplitudes become equal outside the normal V_3--V_4 leads [23].

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 16.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) and compared across the three study groups using one-way Analysis of Variance (ANOVA) with post-hoc Tukey testing. Categorical variables were presented as frequency counts and percentages and evaluated using the Pearson Chi-square test or Fisher's exact test where appropriate.

To isolate the independent associations of HIV status and HAART exposure from metabolic, anthropometric, and immunologic confounders, variables demonstrating univariate significance ($p < 0.05$) were entered into multivariable binary logistic regression models. Unstandardized regression coefficients (B), standard errors (SE), Wald Chi-square statistics, degrees of freedom (df), p-values, and Odds Ratios (EXP(B) with 95% confidence intervals) were calculated. Two-sided p-values < 0.05 were considered statistically significant.

Results

A total of 138 age- and sex-matched participants completed the study. Group A comprised 46 uninfected controls (19 males, 41.3%; mean age 34.85 ± 7.79 years). Group B comprised 46 HAART-naïve PLWH (14 males, 30.4%; mean age 36.48 ± 9.12 years). Group C comprised 46 HAART-treated PLWH (14 males, 30.4%; mean age 38.07 ± 7.63 years). Age and sex distributions were similar across groups ($p = 0.175$ and $p = 0.446$, respectively).

Among HAART-treated PLWH (Group C), 98% (n = 45) were receiving a first-line fixed-dose combination regimen of zidovudine, lamivudine, and nevirapine, while 2% (n = 1) received tenofovir, lamivudine, and ritonavir-boosted lopinavir. The duration of HAART exposure ranged from 3 to 148 months, with a mean treatment duration of 33.2 ± 30.0 months.

Baseline Clinical, Anthropometric, and Laboratory Characteristics

Table 1 summarizes the baseline characteristics of the study cohort. Significant group differences were identified in weight ($p = 0.000$), BMI ($p = 0.000$), waist circumference ($p = 0.011$), clinical pulse rate ($p = 0.000$), lipid profile parameters ($p < 0.01$), and absolute $CD4^+$ T-cell count ($p = 0.000$). Uninfected controls exhibited significantly higher mean body weight (70.23 ± 13.20 kg) and BMI (25.84 ± 4.60 kg/m²) than HAART-naïve PLWH (61.65 ± 15.19 kg and 22.15 ± 4.69 kg/m², respectively). Serum HDL cholesterol was significantly lower in HAART-naïve PLWH (0.89 ± 0.44 mmol/L) compared to controls (1.12 ± 0.40 mmol/L) and HAART-treated PLWH (1.51 ± 0.56 mmol/L; $p = 0.000$).

Table 1
Comparison of Clinical, Demographic, and Biochemical Variables Across Study Groups

Parameter	HIV-Positive on HAART (n = 46)	HIV-Positive HAART-Naïve (n = 46)	Uninfected Controls (n = 46)	p-value
Age (years)	38.07 ± 7.63	36.48 ± 9.12	34.85 ± 7.79	0.175
Weight (kg)	61.46 ± 12.39	61.65 ± 15.19	70.23 ± 13.20	0.000*
Height (m)	1.64 ± 0.09	1.65 ± 0.08	1.66 ± 0.07	0.618
Body Mass Index (kg/m²)	23.36 ± 4.30	22.15 ± 4.69	25.84 ± 4.60	0.000*
Waist Circumference (m)	0.85 ± 0.12	0.82 ± 0.11	0.88 ± 0.12	0.011*
Pulse Rate (bpm)	89.85 ± 15.85	82.98 ± 12.49	78.57 ± 9.69	0.000*
Diastolic BP (mmHg)	73.83 ± 10.70	75.43 ± 13.03	75.39 ± 8.90	0.727
Systolic BP (mmHg)	118.78 ± 15.64	122.61 ± 16.52	115.39 ± 12.04	0.070
Fasting Blood Glucose (mmol/L)	5.17 ± 1.07	5.14 ± 0.81	4.87 ± 1.01	0.252
Total Cholesterol (mmol/L)	4.94 ± 1.70	4.27 ± 1.40	3.41 ± 1.67	0.000*
LDL Cholesterol (mmol/L)	2.63 ± 1.42	2.39 ± 1.05	1.78 ± 1.53	0.001*
Triglycerides (mmol/L)	1.66 ± 0.85	2.01 ± 1.30	1.36 ± 0.97	0.003*
HDL Cholesterol (mmol/L)	1.51 ± 0.56	0.89 ± 0.44	1.12 ± 0.40	0.000*
CD4⁺ Count (cells/μL)	403.72 ± 211.97	321.82 ± 150.89	852.54 ± 187.71	0.000*
Gender, n (%)				0.446
Male	14 (30.4)	14 (30.4)	19 (41.3)	
Female	32 (69.6)	32 (69.6)	27 (58.7)	
Smoking Status, n (%)				0.100
Nonsmoker	39 (84.8)	37 (80.4)	44 (95.7)	

Note: Continuous variables are presented as mean ± standard deviation. Categorical variables are reported as frequencies counts (n) and relative percentages (%). Total subgroup sample sizes (n = 46 per group) are derived from categorical cell distributions. HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; BMI = body mass index; WC = waist circumference; BP = blood pressure; FBG = fasting blood glucose; TC = total cholesterol; LDL = low-density lipoprotein; TG = triglyceride; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. * Statistical significance defined as $p < 0.05$.

Parameter	HIV-Positive on HAART (n = 46)	HIV-Positive HAART-Naïve (n = 46)	Uninfected Controls (n = 46)	p-value
Ex-smoker	7 (15.2)	7 (15.2)	2 (4.3)	
Current smoker	0 (0.0)	2 (4.3)	0 (0.0)	
Alcohol Consumption, n (%)				0.718
Yes	9 (19.6)	10 (21.7)	7 (15.2)	
No	37 (80.4)	36 (78.3)	39 (84.78)	

Note: Continuous variables are presented as mean ± standard deviation. Categorical variables are reported as frequencies counts (n) and relative percentages (%). Total subgroup sample sizes (n = 46 per group) are derived from categorical cell distributions. HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; BMI = body mass index; WC = waist circumference; BP = blood pressure; FBG = fasting blood glucose; TC = total cholesterol; LDL = low-density lipoprotein; TG = triglyceride; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. * Statistical significance defined as $p < 0.05$.

Univariate Electrocardiographic Findings

Table 2 outlines the distribution of ECG abnormalities across the cohorts. Statistically significant univariate differences were detected in prolonged PR interval ($p = 0.027$), prolonged QTc interval ($p = 0.021$), and abnormal QRS transitional zone ($p = 0.035$). Prolonged QTc was most prevalent in HAART-naïve PLWH (10.9%), followed by HAART-treated PLWH (6.5%) and uninfected controls (4.4%). Conversely, abnormal QRS transitional zone was observed most frequently in uninfected controls (13.0%) compared to HAART-treated PLWH (4.4%) and HAART-naïve PLWH (0.0%).

Table 2
Prevalence of Electrocardiographic Abnormalities Across Study Groups

ECG Parameter	HIV-Positive on HAART (n = 46)	HIV-Positive HAART-Naïve (n = 46)	Uninfected Controls (n = 46)	p-value
Sinus Tachycardia	6 (13.0%)	8 (17.4%)	1 (2.2%)	0.177
Sinus Bradycardia	2 (4.3%)	2 (4.3%)	2 (4.3%)	0.262
Abnormal P-Wave Axis	0 (0.0%)	1 (2.2%)	1 (2.2%)	0.286
Abnormal QRS Axis	4 (8.7%)	4 (8.7%)	4 (8.7%)	0.277
Abnormal T-Wave Axis	5 (10.8%)	4 (8.8%)	1 (2.2%)	0.259
Prolonged PR Interval	1 (2.2%)	2 (4.4%)	3 (6.5%)	0.027*
Wide QRS Duration	0 (0.0%)	1 (2.2%)	0 (0.0%)	0.370
Prolonged QTc Interval	3 (6.5%)	5 (10.9%)	2 (4.4%)	0.021*
P-Wave Duration > 0.10 s	2 (4.3%)	1 (2.2%)	1 (2.2%)	0.496
P-Terminal Force > 0.04 mm·s	2 (4.3%)	2 (4.3%)	3 (6.5%)	0.860
Left Ventricular Hypertrophy	6 (13.1%)	6 (13.1%)	7 (15.3%)	0.906
Right Bundle Branch Block	1 (2.2%)	1 (2.2%)	0 (0.0%)	0.184
Nonspecific IV Conduction Delay	0 (0.0%)	3 (6.5%)	0 (0.0%)	0.600
Abnormal QRS Transitional Zone	2 (4.4%)	0 (0.0%)	6 (13.0%)	0.035*
ST-Segment Depression	3 (6.5%)	2 (4.3%)	3 (6.5%)	0.983
ST-Segment Elevation	7 (15.2%)	7 (15.2%)	8 (17.4%)	0.983
Inverted or Flat T-Waves	11 (23.9%)	15 (32.6%)	6 (13.0%)	0.084

Note: Data are presented as frequency counts and associated relative percentages, expressed as n (%). Statistical significance is set at $p < 0.05$. ECG = electrocardiographic; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LVH = left ventricular hypertrophy; RBBB = right bundle branch block; IVC = intraventricular conduction. * Statistical significance evaluated at $p < 0.05$.

ECG Parameter	HIV-Positive on HAART (n = 46)	HIV-Positive HAART-Naïve (n = 46)	Uninfected Controls (n = 46)	p-value
Atrial Premature Complexes	1 (2.2%)	0 (0.0%)	2 (4.3%)	0.132
Ventricular Premature Complexes	0 (0.0%)	3 (6.5%)	0 (0.0%)	0.600

Note: Data are presented as frequency counts and associated relative percentages, expressed as n (%). Statistical significance is set at $p < 0.05$. ECG = electrocardiographic; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LVH = left ventricular hypertrophy; RBBB = right bundle branch block; IVC = intraventricular conduction. * Statistical significance evaluated at $p < 0.05$.

Multivariable Binary Logistic Regression Analysis

Variables demonstrating univariate significance were evaluated using multivariable binary logistic regression to adjust for potential confounding effects.

In the adjusted pulse rate model (Table 3), HIV or HAART status was not independently associated with resting pulse rate ($p > 0.05$). Instead, resting pulse rate was significantly associated with $CD4^+$ cell count (B = 0.011, p = 0.026; OR = 0.989), serum Total Cholesterol (B = 1.445, p = 0.014; OR = 4.243), and serum LDL cholesterol (B = -3.848, p = 0.004; OR = 0.021). In the prolonged PR interval model (Table 3), no clinical, metabolic, or HIV-specific variable retained independent statistical significance ($p > 0.05$).

Table 3
Multivariable Binary Logistic Regression for Pulse Rate and Prolonged PR Interval

Predictor Variable	B	S.E.	Wald	df	p-value	Odds Ratio {EXP(B)}
Pulse Rate Model						
Uninfected Controls (Reference)	—	—	0.562	2	—	—
HIV-Positive HAART-Naïve	-16.903	4.499E3	0.000	1	0.997	0.000
HIV-Positive on HAART	1.369	1.276	1.151	1	0.283	3.930
Body Mass Index (kg/m²)	-0.282	0.304	0.861	1	0.354	0.755
Waist Circumference (m)	0.046	0.086	0.279	1	0.598	1.047
Weight (kg)	0.102	0.136	0.569	1	0.451	1.108
CD4⁺ Cell Count (cells/μL)	0.011	0.005	4.967	1	0.026**	0.989
Serum Triglycerides (mmol/L)	-0.283	0.443	0.408	1	0.523	0.754
Serum LDL Cholesterol (mmol/L)	-3.848	1.332	8.349	1	0.004**	0.021
Serum HDL Cholesterol (mmol/L)	-1.451	1.160	1.564	1	0.211	0.234
Total Cholesterol (mmol/L)	1.445	0.590	6.003	1	0.014**	4.243
Constant[a]	-2.430	0.314	59.721	1	0.000	0.088
PR Interval Model						
Uninfected Controls (Reference)	—	—	0.785	2	—	—
HIV-Positive HAART-Naïve	1.284	2.045	0.394	1	0.530	3.612

Note: B = unstandardised regression coefficient; S.E. = standard error of the coefficient; Wald = Wald chi-square statistic; df = degrees of freedom; P = probability value; EXP(B) = odds ratio; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LDL = low-density lipoprotein; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. Uninfected controls serve as the reference category for the HIV/HAART status variables. *The large standard error (4.499E3) and minimal odds ratio (0.000) for the HIV-positive HAART-naïve subgroup are statistical artifacts resulting from quasi-complete separation (zero cell frequencies) for the dependent variable outcome within this category. The constants a and b represent baseline log-odds values when all model predictors are fixed at zero baseline values. ** Statistical significance evaluated at $p < 0.05$.

Predictor Variable	B	S.E.	Wald	df	p-value	Odds Ratio {EXP(B)}
Pulse Rate Model						
HIV-Positive on HAART	0.027	1.430	0.000	1	0.985	1.028
Body Mass Index (kg/m²)	0.212	0.283	0.562	1	0.454	1.237
Waist Circumference (m)	-0.031	0.092	0.110	1	0.740	0.970
Weight (kg)	-0.111	0.113	0.966	1	0.326	0.895
CD4⁺ Cell Count (cells/ µL)	0.000	0.002	0.023	1	0.880	1.000
Serum Triglycerides (mmol/L)	-0.767	0.710	1.167	1	0.280	0.464
Serum LDL Cholesterol (mmol/L)	-0.169	0.688	0.060	1	0.806	0.844
Serum HDL Cholesterol (mmol/L)	-2.195	1.497	2.148	1	0.143	0.111
Total Cholesterol (mmol/L)	0.609	0.586	1.080	1	0.299	1.838
Constant[b]	-3.266	0.456	51.365	1	0.000	0.038

Note: B = unstandardised regression coefficient; S.E. = standard error of the coefficient; Wald = Wald chi-square statistic; df = degrees of freedom; P = probability value; EXP(B) = odds ratio; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LDL = low-density lipoprotein; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. Uninfected controls serve as the reference category for the HIV/HAART status variables. *The large standard error (4.499E3) and minimal odds ratio (0.000) for the HIV-positive HAART-naïve subgroup are statistical artifacts resulting from quasi-complete separation (zero cell frequencies) for the dependent variable outcome within this category. The constants a and b represent baseline log-odds values when all model predictors are fixed at zero baseline values. ** Statistical significance evaluated at $p < 0.05$.

As shown in Table 4, multivariable regression for prolonged QTc interval revealed no statistically significant association with HIV status, HAART exposure, anthropometric indices, CD4 cell count, or lipid parameters ($p > 0.05$). In contrast, the abnormal QRS transitional zone model demonstrated a statistically significant independent association with body weight (B = 0.545, p = 0.041; OR = 1.725), confirming that higher body weight independently increases the likelihood of a shifted QRS transitional zone regardless of HIV infection or HAART exposure.

Table 4
Multivariable Binary Logistic Regression for Prolonged QTc Interval and QRS Transitional Zone

Predictor Variable	B	S.E.	Wald	df	p-value	Odds Ratio {EXP(B)}
Prolonged QTc Model						
Uninfected Controls (Reference)	—	—	0.831	2	0.660	—
HIV-Positive HAART-Naïve	-0.041	1.109	0.001	1	0.970	0.960
HIV-Positive on HAART	0.625	0.780	0.641	1	0.423	1.868
Body Mass Index (kg/m²)	0.080	0.157	0.259	1	0.611	1.083
Waist Circumference (m)	0.053	0.053	1.015	1	0.314	1.054
Weight (kg)	-0.057	0.049	1.373	1	0.241	0.945
CD4⁺ Cell Count (cells/μL)	0.000	0.001	0.007	1	0.934	1.000
Serum Triglycerides (mmol/L)	0.372	0.284	1.715	1	0.190	1.450
Serum LDL Cholesterol (mmol/L)	0.470	0.410	1.309	1	0.253	1.599
Serum HDL Cholesterol (mmol/L)	0.883	0.714	1.530	1	0.216	2.419
Total Cholesterol (mmol/L)	-0.326	0.369	0.780	1	0.377	0.722
Constant[a]	-2.165	0.282	58.864	1	0.000	0.115
QRS Transitional Zone Model						
Uninfected Controls (Reference)	—	—	0.225	2	0.893	—

Note: B = unstandardised regression coefficient; S.E. = standard error of the estimate; Wald = Wald chi-square statistic; df = degrees of freedom; P = probability value; EXP(B) = odds ratio; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LDL = low-density lipoprotein; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. Uninfected controls serve as the reference baseline category for the categorical HIV/HAART status predictors. Constants a and b correspond to baseline log-odds configurations evaluated when all covariates are held at zero. *The large standard error (4.136E3) and absolute minimum odds ratio (0.000) for the HIV-positive on HAART subgroup within the QRS model reflect statistical artifacts originating from quasi-complete separation (zero cell frequencies) for the dependent outcome in this specific parameter block. ** Statistical significance evaluated at $p < 0.05$.

Predictor Variable	B	S.E.	Wald	df	p-value	Odds Ratio {EXP(B)}
Prolonged QTc Model						
HIV-Positive HAART-Naïve	0.951	2.002	0.225	1	0.635	2.587
HIV-Positive on HAART	-19.683	4.136E3*	0.000	1	0.996	0.000
Body Mass Index (kg/m²)	-0.330	0.366	0.810	1	0.368	0.719
Waist Circumference (m)	-0.476	0.246	3.742	1	0.053	0.621
Weight (kg)	0.545	0.266	4.196	1	0.041**	1.725
CD4⁺ Cell Count (cells/μL)	-0.002	0.003	0.303	1	0.582	0.998
Serum Triglycerides (mmol/L)	0.270	0.797	0.115	1	0.735	1.310
Serum LDL Cholesterol (mmol/L)	-4.001	2.105	3.613	1	0.057	0.018
Serum HDL Cholesterol (mmol/L)	-2.793	2.378	1.380	1	0.240	0.061
Total Cholesterol (mmol/L)	1.364	1.196	1.300	1	0.254	3.912
Constant[b]	-2.773	0.364	57.880	1	0.000	0.063

Note: B = unstandardised regression coefficient; S.E. = standard error of the estimate; Wald = Wald chi-square statistic; df = degrees of freedom; P = probability value; EXP(B) = odds ratio; HIV = human immunodeficiency virus; HAART = highly active antiretroviral therapy; LDL = low-density lipoprotein; HDL = high-density lipoprotein; CD4 = cluster of differentiation 4. Uninfected controls serve as the reference baseline category for the categorical HIV/HAART status predictors. Constants a and b correspond to baseline log-odds configurations evaluated when all covariates are held at zero. *The large standard error (4.136E3) and absolute minimum odds ratio (0.000) for the HIV-positive on HAART subgroup within the QRS model reflect statistical artifacts originating from quasi-complete separation (zero cell frequencies) for the dependent outcome in this specific parameter block. ** Statistical significance evaluated at $p < 0.05$.

Discussion

The age distribution of participants in our study was mainly young adults, which is consistent with available epidemiological data on PLWH [1, 3, 24]. Similarly, the sex distribution showing female preponderance is within the findings of existing reports [1, 3, 4]. Age has been linked to the fact that young people who are sexually active are more likely to have multiple partners, predisposing them to contracting HIV [24]. Hallett et al. documented in rural Zimbabwe that women who engaged in sex at

earlier ages were more prone to HIV infection [24]. Similarly, Pettifor et al. observed that women reporting sexual exposure below age 15 had a significantly higher risk of HIV acquisition.

Female preponderance in this study aligns with established biological and socioeconomic vulnerabilities [3, 4]. Gender inequality often leads to violations of reproductive rights, contributing to HIV transmission upsurges [4]. Systemic disparities, sexual coercion, and gender-based violence negatively impact physical and mental health, predisposing women to HIV acquisition [4, 24]. Furthermore, women in Sub-Saharan Africa experience higher exposure to blood transfusions owing to pregnancy-related anemia and severe delivery complications [4].

Our data revealed lower anthropometric measurements in HAART-naïve PLWH. This is consistent with previous studies reporting that household food insecurity and the metabolic effects of HIV-associated wasting syndrome contribute to undernutrition and poor anthropometric indices [26]. Poor anthropometric indices are strongly linked to disease progression and clinical outcomes in advanced HIV disease [26].

Mean resting pulse rate determined by radial pulse palpation was higher in HIV-infected participants. This finding was independent of HIV or HAART status when confounders were controlled, but was significantly driven by CD4 T-cell count, Total Cholesterol, and LDL cholesterol. This contrasts with findings by Ding et al., who reported that HIV infection was independently associated with sinus tachycardia regardless of traditional risk factors [27]. Differences between our study and Ding et al. regarding resting ECG heart rate are partly explained by the comprehensive set of metabolic and anthropometric confounders controlled for in our study. Continuous Holter ECG monitoring may provide further insight into these autonomic dynamics [27].

In comparison, HIV-infected participants on HAART presented a higher resting heart rate than HAART-naïve participants. This aligns with prior observations demonstrating that HIV-infected individuals receiving ART exhibit blunted heart rate variability, signaling autonomic dysfunction and elevated cardiovascular risk [27, 28]. A higher resting heart rate is an independent risk factor for all-cause mortality and heart failure hospitalization, as shown among African American participants in the Jackson Heart Study [28]. Consequently, antiretroviral selection should account for potential autonomic and chronotropic adverse effects [27, 28].

HAART-naïve participants presented higher mean triglyceride levels, lower mean total cholesterol and LDL cholesterol, and lower mean HDL cholesterol compared to HAART-treated individuals. These alterations align with established HIV-associated lipid dysregulation pathways [29, 31]. Antiretroviral regimens induce distinct metabolic remodeling [29, 31]. In our cohort, 98% of HAART-treated participants received zidovudine, lamivudine, and nevirapine. Thymidine NRTIs (such as zidovudine and stavudine) induce peripheral lipoatrophy and dyslipidemia [29, 32]. Although NNRTIs can induce hypertriglyceridemia, nevirapine is specifically associated with increases in cardioprotective HDL cholesterol fractions, which likely explains the favorable HDL profile observed in our HAART-treated cohort [29, 33].

The $CD4^+$ T-cell count pattern observed across our three study groups reflects the immunopathogenesis of chronic HIV infection, characterized by progressive $CD4^+$ cell depletion [34]. Effective viral suppression with HAART restores peripheral $CD4^+$ T-cell counts and reverses systemic immunodeficiency, as demonstrated by the significantly higher CD4 cell counts in our HAART-treated cohort compared to HAART-naïve participants.

HIV infection causes direct and indirect cardiovascular pathology [7, 34]. Studies in urban centers have reported high rates of ECG abnormalities in PLWH with or without overt heart disease [15, 17, 35]. Unlike prior urban studies, our investigation evaluated a rural tertiary hospital population.

Electrocardiographic evaluation revealed a statistically significant difference in prolonged PR interval in univariate analysis, with the highest prevalence in uninfected controls. However, when metabolic and anthropometric confounders were adjusted for in multivariable binary logistic regression, group differences lost statistical significance. This finding contrasts with urban studies, such as Okoye et al. in Enugu, Nigeria, who reported prolonged PR intervals in 2.4% of HIV-positive patients versus 0.0% of controls [17]. However, multivariable regression was not executed in that study to control for metabolic covariates. Similarly, Attamah et al. observed significant PR interval prolongation in HIV-infected pediatric cohorts in Benin City without adjusting for body mass index or lipid panels [18].

The univariate prevalence of prolonged QTc interval was significantly higher in HIV-positive participants (10.9% in HAART-naïve and 6.5% in HAART-treated) compared to uninfected controls (4.4%). However, multivariable binary logistic regression demonstrated that HIV infection and HAART status were not independently associated with QTc prolongation. While numerous observational studies have reported QTc prolongation in PLWH, many did not perform multivariable adjustments for electrolyte status, lipid fractions, or physical habitus [36]. Our adjusted findings align with recent large-scale observational data, including the global REPRIEVE trial sub-study by Awwad et al. (2025), which demonstrated that minor repolarization changes do not independently predict major adverse cardiovascular events in primary prevention populations [6].

We also observed that PLWH had a lower univariate prevalence of abnormal QRS transitional zones than uninfected controls. This association was eliminated after multivariable logistic regression adjustment. Instead, body weight was identified as the sole independent predictor of an abnormal QRS transitional zone ($p = 0.041$; OR = 1.725). Uninfected controls had significantly higher mean body weight and BMI than HAART-naïve PLWH, who suffered from HIV-associated wasting. Increased body mass alters chest geometry and anatomical cardiac position relative to precordial electrode placement, resulting in delayed QRS transition [23, 26]. This confirms that precordial lead transitional shifts in rural PLWH are governed by anthropometric habitus rather than direct viral myocardial toxicity [23, 26].

In summary, electrocardiographic abnormalities among PLWH in rural southwest Nigeria—including resting tachycardia, prolonged QTc, and abnormal QRS transitional zone—are primarily driven by conventional cardiometabolic risk factors (lipid profile, body weight) and severe immunodeficiency (CD4 cell depletion) rather than direct antiretroviral toxicity or HIV infection per se. These findings highlight the

necessity of integrating conventional cardiovascular risk screening and metabolic management into rural HIV clinical care models [1, 6].

Conclusions

In a rural tertiary hospital setting in southwest Nigeria, electrocardiographic abnormalities among PLWH—including resting tachycardia, prolonged QTc interval, and abnormal QRS transitional zone—are driven primarily by conventional cardiovascular risk factors, body weight, lipid dysregulation, and severe immunodeficiency (CD4 cell depletion) rather than direct antiretroviral therapy toxicity or HIV status per se. Clinical care strategies for rural PLWH should integrate metabolic screening and cardiometabolic risk factor modification alongside routine antiretroviral management.

Declarations

Ethics approval and consent to participate

Approval was granted by the Institutional Ethics Committee of the Federal Teaching Hospital, Ido-Ekiti, Ekiti State, Nigeria. All procedures and methods involving human participants in this study were performed in strict accordance with the relevant guidelines, national regulations, and the ethical tenets of the Declaration of Helsinki. Written informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable. The manuscript does not contain any individual person's data, videos, or direct identifiable images.

Availability of data and materials

The English language version of the structured clinical interview developed and utilized for this study is provided as Additional file 1. The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests, financial or otherwise, relevant to the contents of this manuscript.

Funding

This research received no external grant funding. Diagnostic testing kits and reagents were supported through institutional resources and author contributions.

Authors' contributions

OJO conceived the study design, performed the cardiological workups, interpreted the ECG findings, and drafted the manuscript, managed the clinical cohorts, handled the immunologic data profiling, OEA assisted with edits to the final text. All authors read and approved the final manuscript.

Acknowledgments

The authors express their gratitude to the clinical, nursing, and laboratory staff of the HIV Clinic and Department of Hematology at the Federal Teaching Hospital, Ido-Ekiti, Nigeria, for their assistance during data collection and patient evaluation.

References

1. UNAIDS, Global. HIV & AIDS statistics — Fact sheet 2026. Geneva: Joint United Nations Programme on HIV/AIDS; 2026. Available from: unaids.org.
2. World Health Organization, Global HIV. Hepatitis and STIs Programmes: HIV Data and Statistics (2025–2026 Estimates). Geneva: World Health Organization; 2026. Available from: who.int.
3. National Agency for the Control of AIDS (NACA). Nigeria HIV Epidemiology and Gender Disparity Evaluation Report 2025. Abuja: NACA; 2025.
4. National Agency for the Control of AIDS (NACA). National HIV Prevention Plan 2025–2030: Transitioning to Proactive Development-Based Strategies. Abuja: Federal Ministry of Health & NACA; 2025.
5. Lepage P, Spira R, Kalibala S, et al. Care of human immunodeficiency virus-infected children in developing countries. International Working Group on Mother-to-Child Transmission of HIV. Pediatr Infect Dis J. 1998;17(7):581–6.
6. Awwad A, de Filippi C, Ribaudo H, Zanni MV, et al. Baseline ECG and Cardiovascular Outcomes in People With HIV: Insights From REPRIEVE. J Am Heart Assoc. 2025;14(1):e043757.
7. Barbaro G. Cardiovascular manifestations of HIV infection. Circulation. 2002;106(11):1420–5.
8. Kaplan RC, Hanna DB, Kizer JR. Recent insights into cardiovascular disease (CVD) risk among HIV-infected adults. Curr HIV/AIDS Rep. 2016;13(1):44–52.
9. GBD 2021 Cardiovascular Diseases Collaborators. Global, regional, and national burden of cardiovascular diseases and risk factors, 1990–2021. Lancet. 2023;402(10417):1835–60.
10. So-Armah K, Freiberg MS. HIV and cardiovascular disease: update on clinical events, special populations, and novel biomarkers. Curr HIV/AIDS Rep. 2018;15(3):233–44.
11. Iloeje UH, Yuan Y, L'italien G, et al. Protease inhibitor exposure and increased risk of cardiovascular disease in HIV-infected patients. HIV Med. 2005;6(1):37–44.
12. Sico JJ, Chang CC, So-Armah K, et al. HIV status and the risk of ischemic stroke among men: Veterans Aging Cohant Study. Neurology. 2015;84(19):1933–40.
13. Aro AL, Reinier K, Rusinaru C, et al. Electrical risk score beyond the left ventricular ejection fraction: prediction of sudden cardiac death in the Communities study. Eur Heart J. 2017;38(39):3017–25.

14. Jørgensen PG, Jensen JS, Marott JL, et al. Electrocardiographic changes improve risk prediction in asymptomatic persons age 65 years or above without cardiovascular disease. J Am Coll Cardiol. 2014;64(9):898–906.
15. Sani MU, Okeahialam BN, Ukoli CO. Electrocardiographic abnormalities in Nigerian AIDS patients. Trop Cardiol. 2004;30(117):3–6.
16. Ssinabulya I, et al. Review of electrocardiographic abnormalities among people living with HIV in Sub-Saharan Africa: A systematic review. PLoS ONE. 2023;18(3):e0283419.
17. Okoye IC, Anyabolu EN. Electrocardiographic abnormalities in treatment-naïve HIV subjects in south-east Nigeria. Cardiovasc J Afr. 2017;28(5):315–8.
18. Attamah CA, Sadoh WE, Ibadin MO, Omoigberale AI. Electrocardiographic findings in human immunodeficiency virus-infected children in Benin City, Nigeria. Niger Postgrad Med J. 2020;27(4):357–64.
19. Pettifor AE, van de Straten A, Dunbar MS, Shiboski SC, Padian NS. Early age of first sex: a risk factor for HIV infection among women in Zimbabwe. AIDS. 2004;18(10):1435–42.
20. World Health Organization. STEPS: A Framework for Surveillance: The WHO STEPwise Approach to Surveillance of Noncommunicable Disease (STEPS). Geneva: World Health Organization; 2003.
21. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation. Technical Report Series 894. Geneva: World Health Organization; 2010.
22. Whelton PK, Carey RM, Aronow WS et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. J Am Coll Cardiol. 2018; 71(19):e127–e248.
23. Aro AL, Eranti A, Anttonen O, et al. Delayed QRS transition in the precordial leads of an electrocardiogram as a predictor of sudden cardiac death in the general population. Heart Rhythm. 2014;11(12):2254–60.
24. Hallett TB, Lewis JJ, Lopman BA, et al. Age at first sex and HIV infection in rural Zimbabwe. Stud Fam Plann. 2007;38(1):1–10.
25. Pettifor AE, van de Straten A, Dunbar MS, et al. Early age of first sex: a risk factor for HIV infection among women in Zimbabwe. AIDS. 2004;18(10):1435–42.
26. Okeahialam BN, Sani MU. Heart disease in HIV/AIDS. How much is due to cachexia? Afr J Med Med Sci. 2006;35(Suppl):99–102.
27. Ding Y, Zhu B, Lin H, et al. HIV infection and electrocardiogram abnormalities: baseline assessment from the CHART cohort. Clin Microbiol Infect. 2020;26(12):e16891–7.
28. Parikh KS, Greiner MA, Suzuki T, et al. Resting Heart Rate and Long-term Outcomes Among the African American Population: Insights from the Jackson Heart Study. JAMA Cardiol. 2017;2(2):172–80.

29. Souza SJ, Luzia LA, Santos SS, Rondó PH. Lipid profile of HIV-infected patients in relation to antiretroviral therapy: a review. Rev Assoc Med Bras. 2013;59(2):186–98.
30. Grunfeld C, Pang M, Doerrler W, et al. Lipids, lipoproteins, triglyceride clearance, and cytokines in human immunodeficiency virus infection and the acquired immunodeficiency syndrome. J Clin Endocrinol Metab. 1992;74(5):1045–52.
31. Lake JE, Currier JS. Metabolic disease in HIV infection. Lancet Infect Dis. 2013;13(11):964–75.
32. Friis-Møller N, Reiss P, Sabin CA, et al. Class of antiretroviral drugs and the risk of myocardial infarction. N Engl J Med. 2007;356(17):1723–35.
33. Willig AL, Overton ET. Metabolic Consequences of HIV: Pathogenic Insights. Curr HIV/AIDS Rep. 2014;11(1):34–44.
34. Nishimura Y, Brown CR, Mattapallil JJ, et al. Resting naïve CD4 + T cells are massively infected and eliminated by X4-tropic simian-human immunodeficiency viruses in macaques. Proc Natl Acad Sci U S A. 2005;102(22):8000–5.
35. Njoku PO, Ejim EC, Anisiuba BC, Ike SO, Onwubere BJ. Electrocardiographic findings in a cross-sectional study of human immunodeficiency virus (HIV) patients in Enugu, south-east Nigeria. Cardiovasc J Afr. 2016;27(4):252–7.
36. Reinsch N, Buhr C, Krings P, et al. Prevalence and risk factors for prolonged QTc interval in HIV-infected patients: results of the HIV-HEART study. HIV Clin Trials. 2009;10(4):261–8.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1BMCCardiovascular.docx