Scientific Research Publishing

World Journal of Cardiovascular Diseases, 2026, 16(8), 542-553
https://www.scirp.org/journal/wjcd
ISSN Online: 2164-5337
ISSN Print: 2164-5329

The Heart of the Black African Female Athlete: Clinical, Electrocardiographic and Echocardiographic Features in a 54-Case Series

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How to cite this paper: Gaye, N.D., Mingou, J.S., Benaammouch, S., Ndiaye, M., Diouf, M.T., Ly, L., Gueye, S.O., Thiam, M.A., Mbaye, A., Kane, A. and Ngaïdé, A.A. (2026) The Heart of the Black African Female Athlete: Clinical, Electrocardiographic and Echocardiographic Features in a 54-Case Series. *World Journal of Cardiovascular Diseases*, **16**, 542-553.
https://doi.org/10.4236/wjcd.2026.168052

Received: June 16, 2026
Accepted: August 23, 2026
Published: August 26, 2026

Abstract

Introduction: Regular sports practice induces cardiovascular adaptations known as athlete's heart. These changes may involve the clinical examination, electrocardiogram and echocardiography, and may sometimes mimic structural or electrical heart disease. In Black African female athletes, reference data remain limited. This study aimed to analyse the clinical, electrocardiographic and echocardiographic features of the hearts of Black African female athletes competing in sports clubs in Senegal. **Methods:** This was a prospective, descriptive and analytical cross-sectional study conducted from 10 May to 30 June 2022 in three sports centres in Dakar. Black African female athletes aged at least 18 years, who had been practising competitive sport for more than one year and trained for at least five hours per week, were included. Anamnestic, clinical, electrocardiographic and echocardiographic data were collected using a standardised form. Resting 12-lead ECGs were interpreted according to international sports cardiology recommendations. Transthoracic echocardiography assessed chamber dimensions, wall thickness, left ventricular systolic function, TAPSE, diastolic parameters and pulmonary artery systolic pressure. Statistical analysis was performed using SPSS version 18, with statistical significance set at $p < 0.05$. **Results:** The study included 54 female athletes: 30 referees (55.6%), 16 volleyball players (29.6%) and 8 track-and-field athletes

(14.8%). Mean age was 26.43 ± 6.06 years. Mean training volume was 6.65 ± 2.69 hours per week. The most frequent symptoms were palpitations (14.8%) and exertional dyspnoea (11.1%). On ECG, the main abnormalities were early repolarisation (35.2%), respiratory sinus arrhythmia (35.18%), sinus bradycardia (20.4%), precordial T-wave inversion (16.7%), atrial enlargement (16.66%) and incomplete right bundle branch block (13%). On echocardiography, left ventricular ejection fraction was preserved in all athletes. Left ventricular end-diastolic diameter was <54 mm in 98.1%, interventricular septal thickness was <11 mm in 94.4%, and pulmonary artery systolic pressure was <25 mmHg in 90.7%. **Conclusion:** The athletes studied had an overall reassuring clinical and echocardiographic profile. Although several ECG findings were compatible with athlete's heart, potentially pathological abnormalities were also observed, and their clinical significance could not be determined because follow-up was not systematically documented.

Keywords

Athlete's Heart, Female Athlete, Electrocardiogram, Echocardiography, Black Africa

1. Introduction

Regular sports practice induces favourable cardiovascular adaptations, but intensive training may modify the clinical examination, resting electrocardiogram and echocardiography. This remodelling, classically referred to as athlete's heart, reflects the interaction between training load, type of sport, duration of practice, sex, age and ancestry. The clinical challenge is to distinguish physiological adaptation from structural or electrical heart disease associated with arrhythmic risk, particularly when abnormalities involve repolarisation, cardiac chamber dimensions or wall hypertrophy [1]-[6].

Available data mainly concern adult male athletes from European or North American populations. Several studies have shown that Black athletes more frequently present with high QRS voltages, early repolarisation, T-wave inversion and, in some cases, more marked left ventricular hypertrophy than Caucasian athletes [7]-[12]. In women, interpretation is even more challenging, as cardiac remodelling is generally less pronounced than in men, while some electrocardiographic features may be overinterpreted in the absence of appropriate reference values [13]-[16].

In African countries, this issue is important for at least three reasons. First, the number of high-level female athletes is increasing, yet local data remain scarce. Second, cardiovascular screening programmes must be realistic, low-cost and applicable in settings where access to advanced imaging or genetic testing is limited. Third, the absence of African reference values may lead to two opposite errors: falsely reassuring athletes with truly pathological abnormalities, or unjustifiably

excluding athletes with benign adaptations.

This study aimed to analyse the clinical, electrocardiographic and echocardiographic features of the hearts of Black African female athletes competing in sports clubs in Senegal, in order to contribute to the development of local data relevant to sports medicine.

2. Methods

This was a prospective, descriptive and analytical cross-sectional study conducted from 10 May to 30 June 2022 in three sports centres in Dakar: Dakar Université Club, Alassane Djigo Stadium and Iba Mar Diop Stadium. The target population consisted of Black African female athletes competing in sports clubs. Female athletes aged at least 18 years, who had been practising competitive sport for more than one year and trained for at least five hours per week, were included. Pregnant athletes, those who refused to participate, and those whose weekly sports practice was below the predefined threshold were not included. Participants were recruited through the coaches and managers of the three sports centres using a non-probability sampling method. The total number of potentially eligible athletes approached and the number of non-inclusions according to reason were not systematically recorded.

Data were collected using a pre-established survey form comprising an anamnestic section and a clinical, electrocardiographic and echocardiographic section. The interview collected information on age, place of residence, occupation, socioeconomic status, personal and family history, symptoms related or unrelated to exercise, alcohol and tobacco consumption, duration of sports practice and weekly training volume. The clinical examination included vital signs, anthropometric measurements, body mass index calculation and systematic cardiovascular auscultation.

All ECGs were recorded at rest, in the supine position, using standard 12-lead acquisition with a portable six-channel Schiller electrocardiograph. The tracings were subsequently reviewed by a single operator, blinded to the clinical data, and interpreted according to international sports cardiology recommendations. The parameters analysed included rhythm, heart rate, P wave, PR interval, bundle branch blocks, extrasystoles, corrected QT interval, repolarisation, T waves and hypertrophy criteria.

T-wave inversion was defined as a negative T-wave amplitude ≥ 0.1 mV in at least two contiguous leads among V2-V6, II-aVF, or I-aVL, excluding aVR, III, and V1; its precordial distribution was classified as anterior, anteroseptal, or lateral. The Black athlete anterior repolarisation pattern was defined as T-wave inversion in V1-V4 preceded by J-point elevation and convex ST-segment elevation. Early repolarisation was defined as J-point elevation ≥ 0.1 mV associated with a concave or ascending ST segment and/or terminal QRS notching in the inferior or lateral leads. Left atrial enlargement was defined by a P-wave duration > 120 ms in lead I or II, with a negative terminal component of the P wave in V1 meas-

uring ≥ 0.1 mV in depth and ≥ 40 ms in duration; right atrial enlargement was defined by a P-wave amplitude ≥ 0.25 mV in lead II, III, or aVF. Ventricular pre-excitation was defined by a PR interval < 120 ms associated with a delta wave. Low atrial rhythm was defined as a regular narrow-QRS rhythm with negative P waves in the inferior leads, consistent with atrial activation originating from a region below the sinus node.

Transthoracic echocardiography was performed using a portable Mindray ultrasound system equipped with pulsed-wave, continuous-wave, colour and tissue Doppler. Measurements included ventricular and atrial dimensions, wall thickness, left ventricular ejection fraction, TAPSE, diastolic parameters, possible valvular heart disease and pulmonary artery systolic pressure. Data were analysed using SPSS version 18. Qualitative variables were expressed as numbers and percentages, and quantitative variables as means and standard deviations. The distribution of quantitative variables was assessed by graphical inspection and the Shapiro-Wilk test. Homogeneity of variances was evaluated using Levene's test. Comparisons among the three disciplines were performed using one-way analysis of variance when parametric assumptions were satisfied, or the Kruskal-Wallis test otherwise. Qualitative variables were compared using the chi-square test or Fisher's exact test when expected cell counts were small. Comparisons among referees, track-and-field athletes and volleyball players were exploratory and aimed to describe possible differences associated with training profiles; they were not designed to test a prespecified causal hypothesis. Because the groups were small and unbalanced, particularly the athletics group, which included only eight participants, these analyses do not support definitive conclusions regarding differences among disciplines. Statistical significance was set at $p < 0.05$.

The study was conducted with institutional authorisation from the National Higher Institute of Popular Education and Sport (INSEPS) and with the agreement of the managers of the participating sports centres. Each participant received oral and written information about the study and provided written informed consent before enrolment.

3. Results

The study included 54 female athletes: 30 referees (55.6%), 16 volleyball players (29.6%) and 8 track-and-field athletes (14.8%) **(Figure 1)**. Mean age was 26.43 ± 6.06 years and was significantly higher among referees (28.53 ± 6.65 years) than among volleyball players (24.88 ± 4.40 years) and track-and-field athletes (21.63 ± 1.69 years; $p = 0.006$). The 20 - 25-year age group was the most represented (51.9%) **(Figure 2)**. Nearly half of the athletes lived in Dakar (48.1%), 46.3% in the suburbs and 5.6% in other regions. Socioeconomic status was low in 70.4% of participants. Students accounted for 63% of the sample.

The mean duration of sports practice was 6.59 ± 5.14 years and was higher among referees. The mean training volume was 6.65 ± 2.69 hours per week, with a higher value among track-and-field athletes (11.38 hours/week; $p = 0.0001$). To-

bacco use was reported by 11.1% of the athletes and alcohol consumption by 13%. No family history of sudden death was reported. Family histories of hypertension and diabetes were reported by 24.1% and 18.5% of participants, respectively. The most frequent symptoms were palpitations (14.8%) and exertional dyspnoea (11.1%). Mean height was 1.66 ± 0.09 m, mean weight was 56.52 ± 10.02 kg and mean body mass index was 20.59 ± 3.43 kg/m^2 (Table 1).

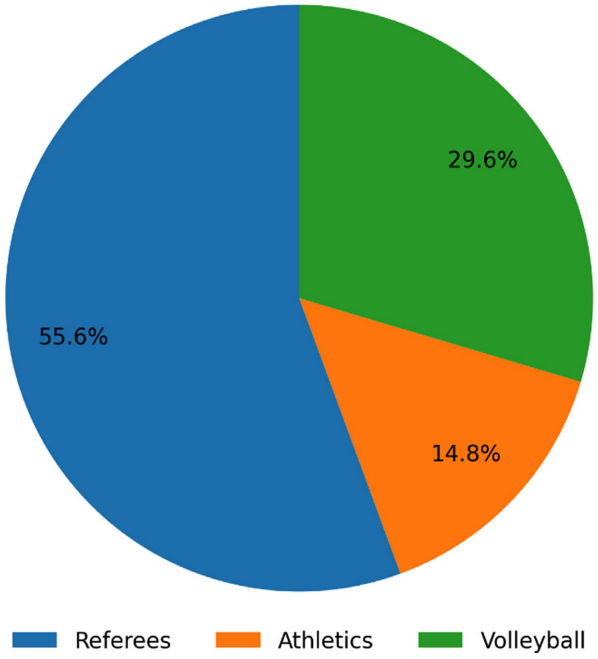

Figure 1. Distribution of participants according to sports discipline (n = 54).

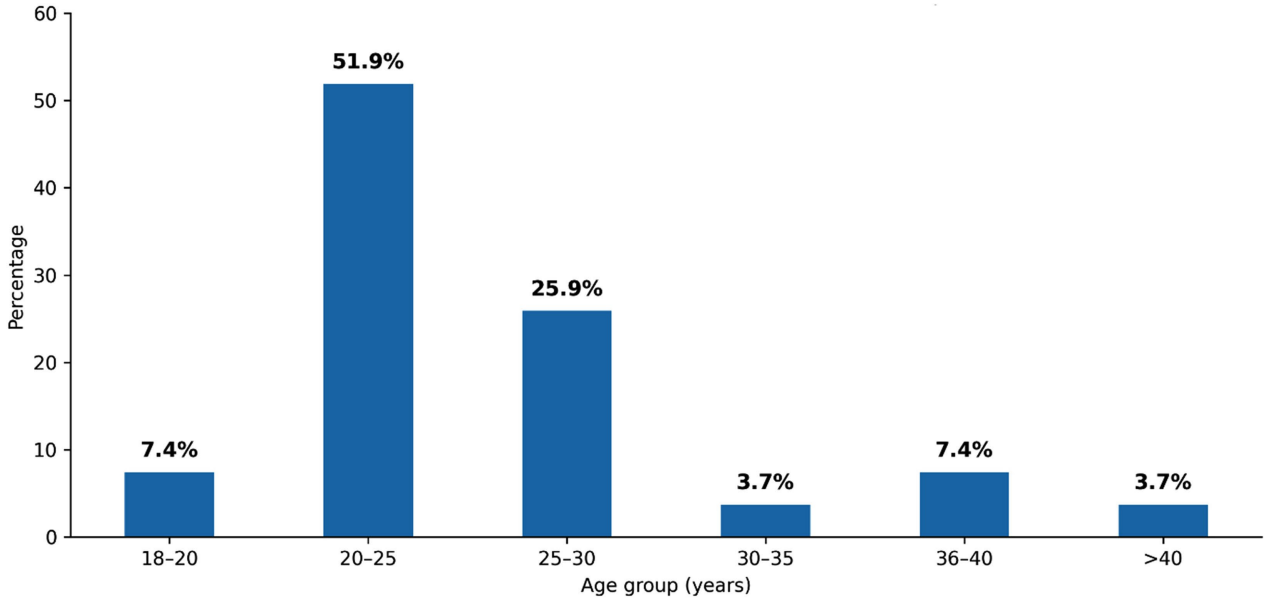

Figure 2. Distribution of participants by age group (n = 54).

Table 1. Sociodemographic, sports-related and clinical characteristics of participants according to discipline.

Variable	Total n = 54	Referees n = 30	Athletics n = 8	Volleyball n = 16	p-value
Age, years	26.43 ± 6.06	28.53 ± 6.65	21.63 ± 1.69	24.88 ± 4.40	0.006
Age group, n (%)					**0.227**
18 - 20 years	4 (7.4)	1 (3.3)	1 (12.5)	2 (12.5)	
20 - 25 years	28 (51.9)	14 (46.7)	7 (87.5)	7 (43.8)	
25 - 30 years	14 (25.9)	8 (26.7)	0 (0.0)	6 (37.5)	
30 - 35 years	2 (3.7)	1 (3.3)	0 (0.0)	1 (6.3)	
36 - 40 years	4 (7.4)	4 (13.3)	0 (0.0)	0 (0.0)	
>40 years	2 (3.7)	2 (6.7)	0 (0.0)	0 (0.0)	
Place of residence, n (%)					**0.086**
Dakar	26 (48.1)	10 (33.3)	4 (50.0)	12 (75.0)	
Suburbs	25 (46.3)	18 (60.0)	4 (50.0)	3 (18.8)	
Regions	3 (5.6)	2 (6.7)	0 (0.0)	1 (6.3)	
Socioeconomic status, n (%)					**0.180**
Low	38 (70.4)	18 (60.0)	8 (100.0)	12 (75.0)	
Middle	13 (24.1)	9 (30.0)	0 (0.0)	4 (25.0)	
High	3 (5.6)	3 (10.0)	0 (0.0)	0 (0.0)	
Student, n (%)	34 (63.0)	15 (50.0)	7 (87.5)	12 (75.0)	0.136
Years of sports practice	6.59 ± 5.14	7.60 ± 5.64	6.00 ± 2.73	4.50 ± 1.41	0.016
Training hours/week	6.65 ± 2.69	5.80 ± 2.01	11.38 ± 1.77	5.88 ± 1.54	0.0001
Current smoking, n (%)	6 (11.1)	0 (0.0)	1 (12.5)	5 (31.3)	0.006
Alcohol consumption (%)	7 (13.0)	0 (0.0)	3 (37.5)	4 (25.0)	0.005
Family history of hypertension (%)	13 (24.1)	7 (23.3)	3 (37.5)	3 (18.8)	0.593
Family history of diabetes, n (%)	10 (18.5)	5 (16.7)	1 (12.5)	4 (25.0)	0.703
Palpitations, n (%)	8 (14.8)	5 (16.7)	0 (0.0)	3 (18.8)	0.434
Exertional dyspnoea, n (%)	6 (11.1)	0 (0.0)	3 (37.5)	3 (18.8)	0.006
BMI, kg/m^2	20.59 ± 3.43	20.17 ± 2.95	20.00 ± 2.20	21.69 ± 4.54	0.483

On ECG, the mean heart rate was 70.72 ± 13.08 bpm. Sinus bradycardia was observed in 20.4% of athletes, respiratory sinus arrhythmia in 35.2%, atrial enlargement in 16.66%, first-degree atrioventricular block in 1.9%, incomplete right bundle branch block in 13%, early repolarisation in 35.2%, precordial T-wave inversion in 16.7%, inferior T-wave inversion in 1.9% and electrical left ventricular hypertrophy in 3.7%. Two cases of ventricular pre-excitation and two low atrial rhythms were observed among referees (**Figure 3**) (**Table 2**).

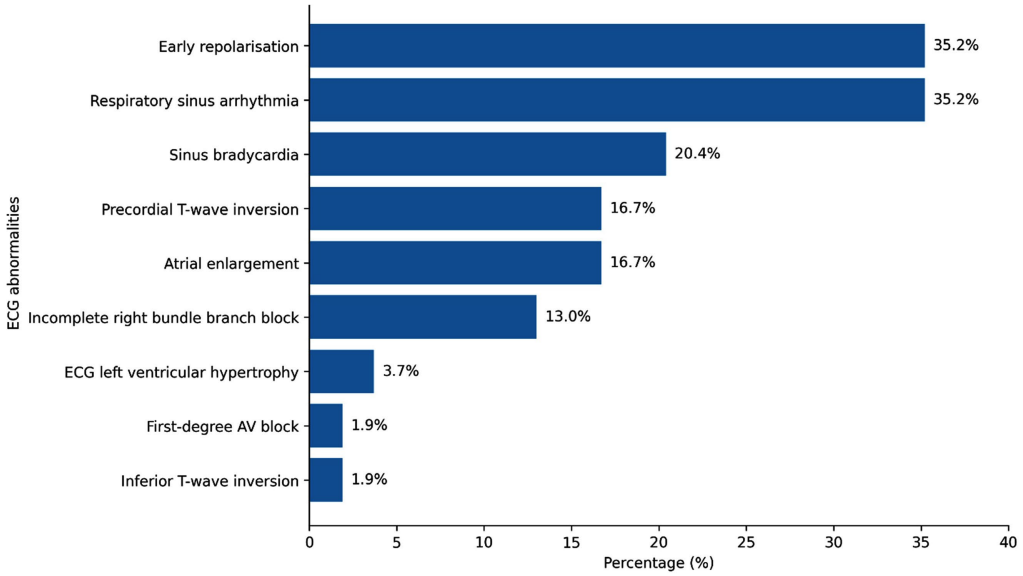

Figure 3. Distribution of the main electrocardiographic abnormalities observed (n = 54).

Table 2. Electrocardiographic parameters and ECG abnormalities according to discipline.

Variable	Referees n = 30	Athletics n = 8	Volleyball n = 16	Total n = 54	p-value
Quantitative ECG parameters					
Heart rate, bpm	68.73 ± 11.59	70.75 ± 18.50	74.44 ± 12.77	70.72 ± 13.08	0.173
PR interval, ms	141.33 ± 20.30	142.50 ± 12.82	153.75 ± 26.05	145.19 ± 21.70	—
QTc interval, Bazett, ms	416.47 ± 27.11	409.00 ± 25.38	416.56 ± 42.83	415.39 ± 31.84	0.833
QTc interval, Hodges, ms	408.80 ± 27.18	407.25 ± 29.64	396.19 ± 40.73	404.83 ± 31.97	0.440
Sokolow-Lyon index, mm	21.02 ± 6.63	17.69 ± 4.04	21.63 ± 5.15	20.69 ± 5.92	—
ECG findings					
Respiratory sinus arrhythmia, n (%)	12 (40.0)	4 (50.0)	3 (18.8)	19 (35.2)	0.227
Sinus bradycardia < 60 bpm, n (%)	6 (20.0)	3 (37.5)	2 (12.5)	11 (20.4)	—
Left atrial enlargement, n (%)	3 (10.0)	2 (25.0)	3 (18.8)	8 (14.8)	0.495
Right atrial enlargement, n (%)	0 (0.0)	0 (0.0)	1 (6.3)	1 (1.9)	0.298
ECG left ventricular hypertrophy, n (%)	2 (6.7)	0 (0.0)	0 (0.0)	2 (3.7)	0.436
Pre-excitation, n (%)	2 (6.7)	0 (0.0)	0 (0.0)	2 (3.7)	—
Low atrial rhythm, n (%)	2 (6.7)	0 (0.0)	0 (0.0)	2 (3.7)	—
First-degree AV block, n (%)	1 (3.3)	0 (0.0)	0 (0.0)	1 (1.9)	—
Incomplete right bundle branch block, n (%)	4 (13.3)	2 (25.0)	1 (6.3)	7 (13.0)	0.434
Ventricular extrasystole, n (%)	1 (3.3)	0 (0.0)	0 (0.0)	1 (1.9)	0.665
ST-segment depression, n (%)	1 (3.3)	0 (0.0)	0 (0.0)	1 (1.9)	—
Precordial T-wave inversion, n (%)	9 (30.0)	0 (0.0)	0 (0.0)	9 (16.7)	0.013
Inferior T-wave inversion, n (%)	1 (3.3)	0 (0.0)	0 (0.0)	1 (1.9)	0.665
Early repolarisation, n (%)	12 (40.0)	4 (50.0)	3 (18.8)	19 (35.2)	0.227
Strictly normal ECG, n (%)	3 (10.0)	2 (25.0)	8 (50.0)	13 (24.1)	0.010

On echocardiography, left ventricular end-diastolic diameter was <54 mm in 98.1% of athletes, interventricular septal thickness was <11 mm in 94.4%, and all participants had a posterior wall thickness <11 mm. Left ventricular ejection fraction was preserved in all athletes, with a mean value of 70.83% ± 6.70%. Mean TAPSE was 24.83 ± 4.59 mm. The mean transmitral E/A ratio was 2.02 ± 0.81. The mean E/e' ratio was 6.33 ± 1.53, with values of 6.25 ± 1.77 in referees, 7.27 ± 1.06 in track-and-field athletes, and 6.02 ± 1.03 in volleyball players. Because the full set of variables required for guideline-based assessment of diastolic function was unavailable, no classification as a pseudonormal or restrictive pattern was made. Pulmonary artery systolic pressure was normal, <25 mmHg, in 90.7% of participants (Table 3).

Table 3. Echocardiographic parameters according to discipline.

Variable	Referees n = 30	Athletics n = 8	Volleyball n = 16	Total n = 54	p-value
Left ventricular structure					
LV end-diastolic diameter, mm	44.33 ± 3.13	44.75 ± 6.48	43.94 ± 4.15	44.28 ± 3.98	0.053
LVEDD < 54 mm, n (%)	30 (100.0)	7 (87.5)	16 (100.0)	53 (98.1)	0.053
Interventricular septum in diastole, mm	8.30 ± 1.60	7.50 ± 1.20	8.50 ± 1.26	8.24 ± 1.47	0.757
IVS < 11 mm, n (%)	28 (93.3)	8 (100.0)	15 (93.8)	51 (94.4)	0.757
Posterior wall in diastole, mm	6.97 ± 0.81	7.75 ± 1.49	7.06 ± 1.00	7.11 ± 1.00	—
LVPW < 11 mm, n (%)	30 (100.0)	8 (100.0)	16 (100.0)	54 (100.0)	—
Systolic function					
LVEF (Teichholz), %	71.00 ± 6.84	70.50 ± 6.72	70.69 ± 6.84	70.83 ± 6.70	0.978
Preserved LVEF, n (%)	30 (100.0)	8 (100.0)	16 (100.0)	54 (100.0)	—
Right heart parameters					
TAPSE, mm	25.60 ± 4.95	26.63 ± 4.21	22.50 ± 3.18	24.83 ± 4.59	—
Right ventricular diameter, mm	21.07 ± 1.26	23.13 ± 2.36	21.94 ± 1.00	21.63 ± 1.56	—
Diastolic and pulmonary parameters					
Left atrial diameter, mm	31.43 ± 3.85	29.88 ± 3.23	30.81 ± 4.07	31.02 ± 3.80	—
Left atrial area, cm^2	13.30 ± 1.53	13.13 ± 1.46	13.31 ± 1.96	13.28 ± 1.63	—
Right atrial area, cm^2	12.03 ± 1.07	12.63 ± 1.30	12.06 ± 1.48	12.13 ± 1.23	—
Aortic diameter, mm	26.53 ± 4.01	23.75 ± 2.87	24.31 ± 2.60	25.46 ± 3.65	—
E/A ratio	2.02 ± 0.94	2.63 ± 0.52	1.71 ± 0.46	2.02 ± 0.81	0.003
E/e' ratio	6.25 ± 1.77	7.27 ± 1.06	6.02 ± 1.03	6.33 ± 1.53	—
PASP, mmHg	13.47 ± 10.29	17.63 ± 12.97	10.00 ± 7.20 mmHg	13.09 ± 11.22	0.073
PASP < 25 mmHg, n (%)	27 (90.0)	6 (75.0)	16 (100.0)	49 (90.7)	—

4. Discussion

This study provides local data on the hearts of Black African female athletes, a population that remains poorly represented in international series. The overall

profile was that of young trained women, with normal body mass index, substantial duration of sports practice and a training volume above the threshold usually required to observe cardiovascular adaptations. The disciplines studied involved different dynamic and static components that may contribute to the heterogeneity observed; however, the discipline-specific comparisons were exploratory and should be interpreted cautiously because the groups were small and unbalanced, particularly the athletics group of eight participants [17]-[19].

The ECG findings were dominated by early repolarisation, sinus bradycardia, respiratory sinus arrhythmia, atrial enlargement criteria, incomplete right bundle branch block and T-wave inversion. Several of these findings are classical training-related adaptations, particularly when isolated and observed in asymptomatic athletes. However, the frequency of precordial T-wave inversion, mainly observed among referees, should be interpreted with caution. Recent recommendations consider some anterior T-wave inversions in Black athletes as potentially physiological when associated with J-point elevation and convex ST-segment elevation. By contrast, lateral T-wave inversion, extensive inferior T-wave inversion, ST-segment depression, pre-excitation, or abnormalities associated with symptoms require further investigation [4] [7] [10]-[12].

The echocardiographic findings were reassuring. Almost all athletes had a left ventricular end-diastolic diameter < 54 mm, wall thickness < 11 mm and preserved left ventricular systolic function. These results suggest an overall normal ventricular geometry, without major hypertrophy or excessive dilatation. Mean TAPSE confirmed preserved right ventricular longitudinal function, and pulmonary artery systolic pressure was normal throughout most of the cohort. Although the transmitral E/A ratio and mean E/e' ratio were measured, E-wave deceleration time, septal and lateral e' velocities, indexed left atrial volume, and peak tricuspid regurgitation velocity were not all available. Accordingly, no integrated classification of diastolic function was made, and the measured E/A and E/e' ratios alone do not demonstrate elevated left ventricular filling pressures [20]-[26].

This study has several limitations: small sample size, absence of a non-athletic female control group, recruitment limited to Dakar, heterogeneity of sports disciplines, and absence of cardiac magnetic resonance imaging, Holter monitoring, exercise testing or longitudinal follow-up. Because data on the total number of eligible athletes approached and the individual reasons for non-participation were unavailable, the participation rate could not be calculated and selection bias cannot be excluded. Potentially pathological electrocardiographic abnormalities were identified during screening; however, specialist referrals, additional investigations, and long-term clinical outcomes were not systematically recorded. Their clinical significance therefore cannot be determined from this study. Nevertheless, the study has practical value. It shows that a protocol combining history-taking, clinical examination, ECG interpreted according to modern criteria and targeted echocardiography may help distinguish physiological adaptation from warning signs in African female athletes.

5. Conclusions

The Black African female athletes studied had an overall reassuring clinical profile, characterised by young age, normal body mass index, regular sports practice and infrequent symptoms. ECG showed several adaptations compatible with athlete's heart, including sinus bradycardia, respiratory sinus arrhythmia, incomplete right bundle branch block and early repolarisation. Nevertheless, the frequency of precordial T-wave inversion, the presence of pre-excitation and some repolarisation abnormalities require specialist interpretation. Because subsequent investigations and clinical outcomes were not systematically recorded, the significance of these potentially pathological findings could not be established.

Echocardiography showed predominantly normal left ventricular geometry, preserved left ventricular systolic function, satisfactory right ventricular function and normal pulmonary artery pressure. These findings support the development of Senegalese and African reference values specific to female athletes. They also support the integration of structured cardiovascular screening, combining ECG and targeted echocardiography, into the follow-up of competitive female athletes. Multicentre studies including non-athletic controls, advanced imaging and longitudinal follow-up are needed to better define the boundary between physiological adaptation and early cardiomyopathy.

Author Contributions

Conceptualisation: AAN and JSM; Formal analysis: SB; Writing - original draft: NDG and AAN; Supervision: AAN and AK; Writing - review and editing: all authors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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