Electrocardiographic and Echocardiographic Findings in Ghanaian Female Soccer Players

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Abstract

Objective: To examine the heart of Ghanaian adult and adolescent female soccer players using electrocardiography (ECG) and echocardiography (ECHO), and to describe typical ECG and ECHO findings in a cohort of west African female soccer players. **Design:** Cross-sectional study of ECG and ECHO performed as part of precompetition medical assessment for 3 national female football teams preparing for various Fédération Internationale de Football Association (FIFA) tournaments in 2016. **Setting:** Ghana National Football Association. **Participants:** Seventy-five female players playing for the National female football teams preparing for FIFA tournaments in 2016. **Interventions:** Precompetition medical assessment using ECGs and ECHOs. **Main Outcome Measure:** Number of athletes with abnormal ECG and ECHO findings using the International ECG Interpretation criteria. **Results:** Eight percent of the participants had T-wave inversions in lateral leads (V_5–V_6). Voltage criteria for left ventricular hypertrophy (LVH) were present in 35% of participants. A total of 2.7% of the players had LV wall thickness (LVWT) ≥12 mm with no player exceeding 13 mm. No player had LV cavity dimension greater than 60 mm. **Conclusion:** Ghanaian female soccer players seem to have a high prevalence of LVH and repolarization change. Although LVWT up to 12 mm might be normal in this cohort, deep T-wave inversions and LVWT ≥13 mm should always be further investigated and/or undergo a long-term follow.

Key Words: black athlete, athlete's heart, electrocardiogram, echocardiogram, hypertrophic cardiomyopathy

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INTRODUCTION

Participation in regular sports elicits various electrophysiological and structural cardiac changes, which can be seen on athletes' electrocardiogram (ECG) and echocardiography (ECHO) and collectively known as "athlete's heart."[1–3] Although commonly falling within the defined limits of physiological normality, these cardiac adaptations may sometimes lead to a diagnostic dilemma for the practicing sports physician where they may overlap with the phenotypic expression of pathology, especially in endurance athletes.[4–6] These physiological adaptations complicate the differentiation of sinister cardiac disorders implicated in sudden cardiac death (SCD), which is more prevalent among black athletes than whites.[1]

Researchers in the field of sports medicine and cardiology in recent years have particularly focused on the influence of ethnicity and gender/sex on cardiovascular adaptation to sports in the context of an increased number of both male and female athletes of African descent excelling at elite competitive levels in western countries.[7–10]

Results from a study by Rawlins et al[10] involving a heterogeneous group of black female (African/Afro-Caribbean, black British, and black French) athletes revealed exaggerated cardiac morphological changes when compared with their white counterparts.

There are, however, very little data concerning the cardiovascular adaptations to exercise among black female athletes. There are no current data on ECG and ECHO patterns among west African female athletes.

Given that these athletes present comparable changes with those seen among the athletes studied by Rawlins et al, our aim in this study was to characterize ECG and ECHO patterns among Ghanaian (west African) female athletes to prevent over investigation and unnecessary exemptions.

This study will also form the basis for future longitudinal follow-up studies.

METHODS

Study Population

In this cross-sectional study, subjects were drawn from female national soccer teams preparing for various Fédération Internationale de Football Association (FIFA) tournaments. Subjects were aged between 15 and 27 years, as presented in Table 1.

These athletes usually had 6-day training sessions every week, with each session lasting 2 hours, on average. Sessions consisted of general football technique and conditioning activities.

As part of preparations for FIFA tournaments, all players underwent mandatory precompetition medical assessment, including cardiac screening (12-lead ECG and a 2-dimensional ECHO). A total of 75 female Ghanaian soccer players (black west Africans) underwent screening. Written

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TABLE 1. Anthropometrics of Female Adolescent and Adult Footballers

Variable	Total (n = 75)	Adolescent (n = 43)	Adult (n = 32)	P
Age	19.1 ± 3.7	16.6 ± 1.1	22.6 ± 3.0	<0.0001
Weight (Kg)	57.0 ± 6.9	56.4 ± 6.8	57.8 ± 7.0	0.421
Height (cm)	163.1 ± 5.7	162.9 ± 5.9	163.4 ± 5.5	0.683
BSA (m^2)	1.6 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	0.488

Significant difference at P < 0.05.

consent for screening was given by all players, who also consented to the use of their cardiac screening data for research purposes.

Ethics approval for the PhD study was obtained from the Ghana Health Service Ethics Review Committee.

Preparticipation Cardiovascular Screening

Players completed a questionnaire with nurse assistance, recording family history and personal symptoms. Measurements of weight, height, blood pressure, and assessments of physical characteristics for diseases such as Marfan's syndrome were undertaken by a female team physician. There was no history of positive doping test results for restricted substances among players.

Resting 12-Lead ECG

Standard 12-lead ECGs were performed using commercially available ECG machine (Welch Allyn, United Kingdom). The subject was positioned in the supine position and recording performed after 5 minutes of rest, at a standard speed of 25 mm/s. The heart rate, P wave duration, PR intervals, and QRS axis were calculated. P-, Q-, R-, S-, and T-wave voltages; ST segments; QRS duration; PR interval; and QT interval were measured in each lead with calipers. QT interval was corrected for the heart rate by use of the Bazett[11] formula.

ST segment shift was considered significant if ≥0.1 mV in ≥2 contiguous leads. Early repolarization pattern was defined as ST segment elevation with J-point elevation ≥0.1 mV in ≥2 contiguous nonanterior leads. T-wave inversion of ≥ −0.1 mV in ≥2 leads was considered significant, (excluding aVR, V1 and III in isolation). T-wave inversions of ≥0.2 mV in any lead were defined as deep T-wave inversions.[12] T-wave inversions were classified as anterior (V2–V4), inferior (II, III, and aVF), and lateral (I, aVL, V5, and V6). ST segment depression was defined as ≥0.5 mm in depth in 2 or more contiguous leads. Electrocardiographic left ventricular hypertrophy (LVH) was defined with the Sokolow–Lyon voltage criterion.[13]

ECGs were analyzed independently by experienced investigators (M.A.A., P.T.A., and P.P.) using the most recent published criteria.[14]

Transthoracic Echocardiography

Two-dimensional ECHO was performed using cardiac ultrasound machines (GE Vivid E by General Electric, China and CX50 by Philips, The Netherlands). For optimal image acquisition, standard views were obtained with the subjects placed in the left lateral position as per the European Society of ECHO protocol.[15]

Left ventricular wall thickness (LVWT) and LV end diastolic dimensions (LVEDd) were measured using the 2-dimensional guided M-Mode method between the tip of the mitral valve leaflets and papillary muscles, and LV mass calculated with the Devereux formula[16] and was indexed for body surface area (BSA). Maximum LVWT was defined as either interventricular wall or posterior wall greater than 11 mm.[10] Left ventricular cavity dimension was described as enlarged when LVEDd (LV end-diastolic diameter) was greater than 54 mm.[10]

Left ventricular ejection fraction (EF) was calculated from LV volumes by Simpson's rule.[17] Assessment of diastolic function included traditional pulsed-wave Doppler across the mitral valve[18] and tissue Doppler velocity imaging[12] of the septal and lateral mitral valve annulus.

Echocardiographic studies were saved to compact discs, and cardiac measurements were repeated independently by an experienced cardiologist (M.A.A.), blinded to the identity of the athlete, and diagnostic uncertainty was discussed by the study group.

Statistical Analysis

Statistical analyses were performed using SPSS software (Chicago, IL; V.21). Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Results are expressed as mean values and SDs and percentages as appropriate. ECG and ECHO findings of adolescent and adult female footballers were compared to evaluate differences between mean values using the unpaired *t* test for continuous variables. The χ^2 test was used to evaluate differences between proportions for categorical ECG and ECHO findings of adolescent and adult female soccer players. An alpha error <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

All 75 female football players were Ghanaians (black west Africans). Forty-three percent (32) of the players were adults aged from 19 to 27 years with adolescents (14-18 years) constituting 57% (43) of the study population. Weight (kg), height (cm), and BSA (m^2) were all slightly higher in the adult players compared with the adolescent players as reported in (Table 1).

TABLE 2. Electrocardiographic Parameters in Female Adolescent and Adult Footballers

ECG Parameter	Adolescents	Adults	P
Heart rate (beats/min)	61.5 ± 11.1 (44-95)	60.1 ± 10.1 (40-81)	0.585
PR interval (ms)	168.4 ± 20.8 (130-237)	169.8 ± 29.4 (130-260)	0.811
QRS duration (ms)	78.3 ± 7.8 (60-105)	80.9 ± 7.7 (66-100)	0.157
R/S voltage (S1 + R5) (mm)	33.5 ± 9.3 (17-59)	30.3 ± 8.3 (19-56)	0.128
QTc interval (ms)	408.6 ± 21.1 (333-443)	430.5 ± 19.5 (391-467)	0.001*

Significant difference at P < 0.05.

TABLE 3. Electrocardiographic Findings in Female Adolescent and Adult Footballers

ECG Findings	Total (n = 75)	Adolescent (n = 43)	Adult (n = 32)	*P*
First-degree AV block (PR interval >200 ms)	7 (9.3)	3 (7.0)	4 (12.5)	0.416
Sinus bradycardia (HR < 60 beats/min)	36 (48.0)	21 (48.8)	15 (46.9)	0.870
Sokolow–Lyon criteria for LVH (T-R)	26 (34.7)	18 (41.9)	8 (25.0)	0.129
Incomplete RBBB (QRS >100 ms, <120 ms)	1 (1.3)	1 (2.3)	0 (0.0)	0.385
ST elevation	34 (45.3)	21 (48.8)	13 (40.6)	0.480
Total T-wave inversion	24 (32.0)	14 (32.6)	10 (31.2)	0.904
Deep T-wave inversion (T-uR)	1 (1.3)	1 (2.3)	0 (0.0)	0.385
TWI in leads				
V_1-V_4	8 (10.7)	4 (9.3)	4 (12.5)	0.657
V_5-V_6	6 (8.0)	4 (9.3)	2 (6.3)	0.630

AV, atrioventricular; ERP, early repolarization; RAD, right axis deviation; T-R, training-related; T-uR, training-unrelated.

Characteristics of the ECG and ECHO patterns among the 75 Ghanaian female football players are presented in (Tables 2-7).

ECG Patterns

A total of 36 (48%) of the players had heart rates lower than 60 beats/min. First degree atrio-ventricular block was observed in 7 (9.3%) players. QRS duration ranged from 60 to 105 ms. Only one adolescent player demonstrated incomplete right bundle branch block morphology. Voltage criteria for LVH and Sokolow–Lyon criteria were more prevalent in adolescent players compared with the adult players (42% vs 25%). No female player had QTc interval greater than 470 ms.

Forty-five percent (45.3%) of players had ST segment elevation with associated slurring and/or J-wave, with both concave and convex (dome) patterns present (27% vs 18.3%, respectively). No player had ST segment depression.

Inverted T waves were seen in 24 (32%) of the players, with similar proportions in both adolescents and adults (33% vs 31%). Eight players had T-wave inversions in anterior leads (V_1-V_4), and extended to lateral leads (V_5-V_6) in 6 players. T waves were deeply inverted in leads V_2-V_6 in one adolescent player. As per the most recent international criteria for ECG interpretation,[14] 91%, 1.3%, and 8% of the players had normal, borderline, and abnormal ECGs, respectively.

Echocardiography Patterns

Echocardiographic findings are presented in (Tables 5-7 and Figure 1). Left ventricular wall thickness ranged from 7 mm to 13 mm. Three adolescent players had LVWT >11 mm, with only one female player having wall thickness of 13 mm and none >13 mm. Diastolic LV cavity dimensions ranged from 40 mm to 57 mm. No female player had LVEDd >60 mm.

Left ventricular mass index was similar in both adolescent and adult female players (89 ± 13.7 vs 86 ± 11.0). Relative wall thickness (RWT) was higher in adolescents compared with adult players (38 ± 6.1 vs 35 ± 4.4 $P < 0.02$). Thirteen adolescent and 2 adult players had RWT >0.42 with the highest being 0.49. Regarding LV geometry, 10.7%, 17.3%, and 9.3% of the players had concentric remodeling, eccentric hypertrophy, and concentric hypertrophy, respectively (Table 7).[19]

Left atrial diameter ranged from 26 mm to 39 mm in adolescents, and 24 mm to 40 mm in adult players. Left ventricular EF was 68 ± 5.5 in adolescent players and 69 ± 5.0 in adult players, with no player having EF <55%. No segmental wall motion abnormalities were seen on visual assessment. Early and late transmitral flow velocities and early and late diastolic mitral annulus velocities were all normal.

Comparison Between Electrocardiogram and Echocardiography Findings

Three of the 24 players with inverted T-waves had increased LVWT (LVWT >11 mm but less than 13 mm). A total of 5 players (4 adolescents and 1 adult) with T-wave inversions in lateral leads also had RWT >0.42, but physical examination and morphological assessment failed to reveal evidence of structural heart disease such as hypertrophic cardiomyopathy (HCM), dilated cardiomyopathy, and arrhythmogenic right ventricular cardiomyopathy (ARVC). The investigators acknowledge that cardiac magnetic resonance imaging is the gold standard for diagnosis of these conditions. However, this was not available in Ghana during the study period.

Critical examination of the data revealed that ECG derived voltage criteria for LVH, Sokolow–Lyon criteria ($S_1 + R_5 >$ 35 mm) correlated poorly with cardiac dimensions (LV wall thickness, cavity size, or RWT) on ECHO.

DISCUSSION

Several studies have confirmed exaggerated cardiovascular adaptation to sports/physical training in black athletes compared with their white counterparts.[9,10,20,21] A relatively large female athletes' study by Rawlins et al also confirmed black female athletes exhibited higher prevalence of cardiac morphological changes on ECG and ECHO than white female

TABLE 4. ECG Classification According to the International Criteria[14]

Variable	Total (n = 75)	Adolescent (n = 43)	Adult (n = 32)	*P*
Normal ECGs	68 (90.7)	39 (90.7)	29 (90.6)	0.881
Borderline ECGs	1 (1.3)	0 (0.0)	1 (3.1)	0.506
Abnormal ECGs	6 (8.0)	4 (9.3)	2 (6.3)	0.890

TABLE 5. Echocardiographic Findings in Female Adolescent and Adult Footballers

ECHO Findings	Total (n = 75)	Adolescent (n = 43)	Adult (n = 32)	*P*
IVS (mm)	9.1 ± 1.2	9.3 ± 1.4	8.9 ± 1.3	0.207
PWT (mm)	8.2 ± 1.1	8.4 ± 1.2	7.9 ± 0.9	0.040*
mLVWT (mm)	9.2 ± 1.2	9.5 ± 1.2	9.0 ± 1.1	0.067
LV end-diastolic dimensions (mm)	48.1 ± 3.6	47.5 ± 3.9	48.9 ± 2.9	0.092
LV end-systolic dimensions (mm)	29.9 ± 3.9	29.4 ± 3.7	30.5 ± 4.0	0.242
Left ventricular mass (g)	141.1 ± 22.8	142.2 ± 25.0	139.5 ± 19.8	0.615
Relative LV mass	2.5 ± 0.4	2.5 ± 0.4	2.4 ± 0.4	0.284
LV mass index (g/m^2)	87.7 ± 12.6	88.8 ± 13.7	86.2 ± 10.9	0.384
RWT (%)	36.3 ± 5.6	37.6 ± 6.1	34.6 ± 4.4	0.020*
FS (%)	38.5 ± 4.4	38.1 ± 5.1	38.88 ± 3.4	0.482
EF (%)	68.5 ± 5.0	68.0 ± 5.5	69.0 ± 5.0	0.662
E-wave (cm/s)	93.0 ± 13.4	92.14 ± 13.6	94.2 ± 13.4	0.511
A-wave (cm/s)	50.8 ± 10.4	49.4 ± 9.4	52.9 ± 11.4	0.152
E/A ratio	1.9 ± 0.4	1.9 ± 0.4	1.8 ± 0.4	0.395
E′ wave S (cm/s)	13.0 ± 1.9	13.0 ± 2.0	12.9 ± 1.7	0.681
A′ wave S (cm/s)	7.9 ± 1.31	7.6 ± 1.2	8.3 ± 1.38	0.020
E′/A′ S	1.7 ± 0.4	1.8 ± 0.4	1.6 ± 0.3	0.171
E′ wave L (cm/s)	17.5 ± 2.8	17.4 ± 2.7	17.7 ± 2.9	0.621
A′ wave L (cm/s)	7.8 ± 1.8	7.8 ± 1.9	7.7 ± 1.7	0.743
E′/A′ L	2.4 ± 0.5	2.3 ± 0.5	2.4 ± 0.6	0.576
E/E′	6.1 ± 1.0	6.1 ± 1.0	6.2 ± 1.1	0.622

** Significant at* $P < 0.05$.
FS, fractional shortening; IVS, interventricular septal wall thickness; mLVWT, Maximum left ventricular wall thickness; PWT, posterior wall thickness.

athletes. These morphological changes sometimes make it difficult for practicing sports physicians and cardiologist to distinguish between normal physiological adaptation and cardiac disorders like the various cardiomyopathies, which are mostly implicated in most SCDs, more commonly seen among black athletes than among white athletes.[1,4–6]

The relevance of this study stems from the increasing number of females participating and excelling at international competitions. This study is the first to be conducted among a homogenous group of Ghanaian (black west African) female soccer players comprising both adults and adolescents involved in elite competitions at both national and international levels. Inferences drawn from the study therefore provide a clinically significant data, which could serve as a guide in the analysis and interpretation of ECGs and ECHOs of black African females during precompetition cardiovascular screening, in a multiethnic setting.

ECG Patterns

ECG voltage criteria for LV hypertrophy were found in about 35% of our study population. An adolescent player aged 17 years had a very high R/S-wave voltage ($S_1 + R_5 = 52$ mm). Although all the players with high R/S-voltage criteria for LVH had normal ECHOs, we still recommended yearly cardiovascular screening with ECG and ECHO. QRS duration among our population was relatively short (mean 80 ms). This prevalence (35%) of high R/S-wave voltage is lower than the prevalence (90%) in adolescent black African male football players,[22] and higher when compared with prevalence among black (black British and black French) and white female athletes (8% and 12%, respectively).[10] It can be inferred that male gender could be a strong determinant of high R/S-wave voltage. These high R/S voltage criteria for LV hypertrophy, however, correlated poorly with cardiac dimensions on ECHO. The 2 players who had wall thickness greater

TABLE 6. Echocardiographic Abnormalities Among Female Footballers

ECHO Findings	Total (n = 75)	Adolescent (n = 43)	Adult (n = 32)	*P*
Normal	47 (62.7)	24 (55.8)	23 (71.9)	0.155
LVH	21 (28.0)	15 (34.9)	6 (18.8)	0.124
mLVWT (≥12 mm)	2 (2.7)	2 (4.7)	0 (0.0)	0.216
LV end-diastolic dimensions (>54 mm)	5 (6.7)	4 (9.3)	1 (3.1)	0.289
RWT (>42%)	15 (20.0)	13 (30.1)	2 (6.2)	0.010*
Mitral regurgitation	1 (1.3)	0 (0.0)	1 (3.1)	0.243
LV mass index (>95g/m^2)	17 (22.7)	11 (25.6)	6 (18.8)	0.485

TABLE 7. Left Ventricular Geometry in Ghanaian Female Soccer Players

	Total (n = 75)	Adolescents (n = 43)	Adults (n = 32)	*P*
Normal				
RWT≤ 0.42; LVMI ≤ 95g/m^2	47 (62.7)	23 (53.5)	24 (75.0)	0.057
Concentric remodelling				
RWT > 0.42; LVMI ≤ 95g/m^2	8 (10.7)	7 (16.3)	1 (3.13)	0.068
Eccentric hypertrophy				
RWT ≤ 0.42; LVMI > 95g/m^2	13 (17.3)	7 (16.3)	6 (18.8)	0.780
Concentric hypertrophy				
RWT > 0.42; LVMI > 95g/m^2	7 (9.33)	6 (14.0)	1 (3.13)	0.111

than 12 mm on ECHO had normal R/S-wave voltage ($S_1 + R_5 < 35$ mm) on ECG.

ST-segment elevation was observed in about 45% of our study population. This prevalence is similar to the prevalence of ST-segment elevation among male adolescent football players[22] and higher than the prevalence among black and white female athletes.[10] Although the concave-shaped elevation might be strongly linked to African ethnicity,[9] the convex pattern of elevation might be strongly linked to a combination of black ethnicity and training load[22] and therefore warrants no further investigation if present in isolation and without any clinical signs and symptoms. No player exhibited ST-segment depression; hence, the presence of this pattern in any athlete may warrant further investigation. In agreement with data from black male players,[22] the prevalence of ECG criteria for LVH and ST-segment elevation is higher in our female adolescent players than the adults.

T-waves were inverted in 32% of our study population with adults and adolescents having similar prevalence. Only one adolescent player had deep T -wave inversion. The prevalence (32%) of inverted T-waves was higher among our study cohort compared with white female athletes and other black female athletes living outside Africa (black British and black French) (2% and 14%), respectively.[10] T-wave inversions were mostly confined to anterior leads and extended to lateral leads (V_5-V_6) in 8% of the players. This pattern of T-wave inversions might mimic the presence of cardiac disorders such as HCM or ARVC, but further investigation (using ECHO) failed to confirm our suspicion of these cardiomyopathies. Although one could argue that such patterns might be a race-related adaptation to physical activity,[9,10,22,23] our lack of other screening tools such as cardiac MRI and lack of long-term follow-up on these players and family members makes it difficult to completely rule out HCM or ARVC. It is, however, unlikely that 32% of our study population might have HCM or ARVC.

From our findings, the presence of deep T-wave inversions in lateral leads, coupled with LV thickness greater than 12 mm in a black female player, is unlikely to be a normal physiological adaptation and would therefore require further investigation during precompetition medical screening.

Echocardiography Patterns

Our study cohort (Ghanaian female soccer players) demonstrated a LV geometry made up of concentric remodeling, eccentric hypertrophy, and concentric hypertrophy in 10.7%, 17.3%, and 9.3% of the players (Table 7). Relative wall thickness >0.42 was present in 20% of these female players, a pattern similar to what was recorded among black male soccer players,[22] suggesting a strong link between this pattern of remodeling and black African race. The investigators, however, recommended yearly cardiovascular screening with ECG and ECHO for all players with RWT >0.42, lateral T-wave inversion and LVWT >12 mm, and free of signs and symptoms of cardiovascular diseases to enable early detection of any life-threatening cardiovascular disease.

Two players had LVWT ≥12 mm with no player exceeding 13 mm (Figure 1). This finding is consistent with findings in another study involving black and white female athletes where no black female or white female had wall thickness exceeding

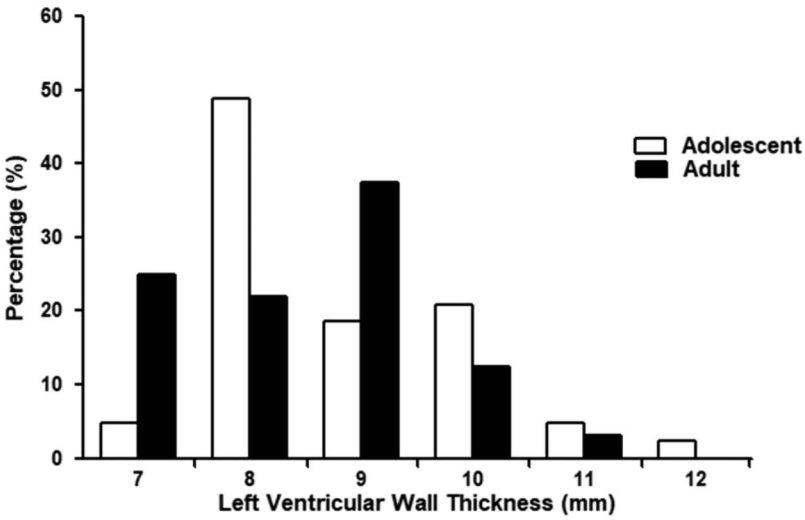

Figure 1. Distribution of LVWT in female adolescent and adult soccer players.

12 mm and 11 mm, respectively,[10] suggesting that wall thickness >12 mm in any female athlete regardless of her race should always be interpreted with caution and possibly investigated further. No player had LV cavity dimension exceeding 60 mm.

There was poor correlation between ECG findings such as voltage criteria for LVH, T-wave inversions, repolarization changes, and ECHO findings such as LV wall thickness, mass, and cavity dimensions.

Clinical Implications

The investigators believe information derived from this study would be of immense clinical relevance during precompetition cardiovascular screening of female black African athletes. The above results highlight the need for race- and gender-sensitive ECG interpretation criteria among athletes to reduce the need for further investigation and to reduce the risk of unfairly disqualifying otherwise healthy athletes. The need to go further than the use of only ECG during precompetition assessment was also evident, considering the fact that none of the players with abnormal ECGs[14] had any abnormality on ECHO and on clinical/physical examination. We also found a difference in the adaptation pattern in our homogenous cohort when compared with patterns observed in a heterogeneous group of female black athletes in other studies.[10] Environmental influence and a possible genetic drift[2] as a result of ancestral migration should always be considered during screenings in a multiethnic population including female black athletes. We believe our findings as reported here will help to improve the general understanding of the peculiar adaptation of the female black footballer's heart to chronic exercise, ultimately leading to a reduction in the amount of subjects wrongly suspected to have true cardiac disorders while continuing to identify those subjects who have significant cardiac disease.

Study Limitation

Participants were all Ghanaians (west Africans), and as such, we cannot consider our results as representative of the entire African continent. Our study population was also restricted to soccer players; hence, the effect of different sporting disciplines on the type of adaptation cannot be wholly explained using our findings. As a cross-sectional study, the absence of long follow-up, cardiac MRI, and genetic testing on athletes with abnormal ECGs is a major limitation since we cannot completely rule out the presence of cardiomyopathies among these players.

CONCLUSION

In conclusion, the prevalence of LVH and repolarization changes is as common in female black football players just as males. There is still a clinical dilemma in distinguishing athlete's heart from HCM in black female athletes but to a lesser extent as compared to their male counterparts. Future studies involving other sporting disciplines and participants from other regions in Africa are required to help develop a race- and gender-specific ECG and ECHO interpretation tool to be used during precompetition medical screening.

References

1. Papadakis M, Whyte G, Sharma S, et al. Preparticipation screening for cardiovascular abnormalities in young competitive athletes. *Br J Sports Med*. 2008;337:806–812.
2. Barry MJ. Structural features of the athlete heart as defined by echocardiography. *J Am Coll Cardiol*. 1986;7:190–203.
3. Riding NR, Sheikh N, Adamuz C, et al. Comparison of three current sets of electrocardiographic interpretation criteria for use in screening athletes. *Heart*. 2015;101:384–390.
4. Scharhag J, Lollgen H, Kindermann W. Competitive sports and the heart: benefit or risk? *Dtsch Arztebl Int*. 2013;110:14–24.
5. Drezner JA, Ashley E, Baggish AL, et al. Abnormal electrocardiographic findings in athletes: recognising changes suggestive of cardiomyopathy. *Br J Sports Med*. 2013;47:137–152.
6. Chandra N, Bastiaenen R, Papadakis M, et al. Sudden cardiac death in young athletes: practical challenges and diagnostic dilemmas. *J Am Coll Cardiol*. 2013;61:1027–1040.
7. Chandra N, Papadakis M, Sharma S, et al. Cardiac adaptation in athletes of black ethnicity: differentiating pathology from physiology. *Heart*. 2012;98:1194–1200.
8. Pelliccia A, Maron MS, Maron BJ, et al. Assessment of left ventricular hypertrophy in a trained athlete: differential diagnosis of physiologic athlete's heart from pathologic hypertrophy. *Prog Cardiovasc Dis*. 2012; 54:387–396.
9. Papadakis M, Carre F, Kervio G, et al. The prevalence, distribution, and clinical outcomes of electrocardiographic repolarization patterns in male athletes of African/Afro-Caribbean origin. *Eur Heart J*. 2011;32: 2304–2313.
10. Rawlins J, Carre F, Kervio G, et al. Ethnic differences in physiological cardiac adaptation to intense physical exercise in highly trained female athletes. *Circulation*. 2010;121:1078–1085.
11. Bazett HC. An analysis of the time relations of electrocardiograms. *Heart*. 1920;7:353–367.
12. Nagueh SF, McFalls J, Meyer D, et al. Tissue Doppler imaging predicts the development of hypertrophic cardiomyopathy in subjects with subclinical disease. *Circulation*. 2003;108:395–398.
13. Sokolow M, Lyon TP. The ventricular complex in left ventricular hypertrophy obtained by unipolar precordial and limb leads. *Am Heart J*. 1949;37:161–186.
14. Drezner JA, Sharma S, Baggish A, et al. International criteria for electrocardiographic interpretation in athletes: consensus statement. *Br J Sports Med*. 2017;51:704–731.
15. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification, *Eur J Echocardiogr*. 2006;7:79–108.
16. Devereux RB. Detection of left ventricular hypertrophy by M-modeechocardiography: anatomic validation, standardization and comparison to other methods. *Hypertension*. 1987;9:19–26.
17. Otterstad JE, Froeland G, St John Sutton M, et al. Accuracy and reproducibility of biplane two-dimensional echocardiographic measurements of left ventricular dimensions and function. *Eur Heart J*. 1997;18:507–513.
18. Lewis JF, Spirito P, Pellicia A, et al. Usefulness of Doppler echocardiographic assessment of diastolic filling in distinguishing "athlete's heart" from hypertrophic cardiomyopathy. *Br Heart J*. 1992; 68:296–300.
19. Lang RM, Badano PL, Mor-Avi V, et al. Recommendation for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and European Association of Cardiovascular Imaging. *J Am Soc Echocardiogr*. 2015;28:1.
20. Sheikh N, Papadakis M, Carre F, et al. Cardiac adaptation to exercise in adolescent athletes of African ethnicity: an emergent elite athletic population. *Br J Sports Med*. 2013;47:585–592.
21. Riding NR, Salah O, Sharma S, et al. ECG and morphological adaptations in Arabic athletes: are the ESC's recommendations for interpretation of the 12-lead ECG appropriate for this ethnicity? *Br J Sports Med*. 2014;48:1138–1143.
22. Di Paolo F, Schmied C, Zerguini YA, et al. The athlete's heart in adolescent Africans. *J Am Coll Cardiol*. 2012;59:1029–1036.
23. Basavarajaiah S, Boraita A, Whyte G, et al. Ethnic differences in left ventricular remodeling in highly-trained athletes. *J Am Coll Cardiol*. 2008;51:2256–2262.