Electrocardiographic and Echocardiographic Findings in Elite Ghanaian Male Soccer Players

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Abstract

Objective: To analyze the athlete's heart of adult and adolescent elite male soccer players by electrocardiography (ECG) and echocardiography (ECHO) and to describe typical ECG and ECHO findings in this cohort (West African elite soccer players). **Design:** A cross-sectional study of ECGs and ECHOs conducted as part of precompetition medical assessment for national male soccer teams preparing for various Fédération Internationale de Football Association (FIFA) tournaments in 2016 and 2017. **Setting:** Ghana National Football Association. **Participants:** One hundred fifty-nine players playing for the National male soccer teams preparing for tournaments in 2016 and 2017. **Interventions:** Precompetition medical assessment using ECGs and ECHOs. **Main Outcome Measures:** Number of athletes with abnormal ECGs and ECHO findings. **Results:** Twenty-three percent of the players had abnormal ECGs. Nine percent of the participants had T-wave inversions in lateral leads (V_5–V_6). Sokolow–Lyon criteria for left ventricular hypertrophy were present in 64% of participants. Thirty-six (23%) players had left ventricular wall thickness (LVWT) ≥13 mm, with no player exceeding 16 mm. Four percent of players had left ventricular cavity dimension greater than 60 mm. Relative wall thickness >0.42 was present in 44% of the players. **Conclusions:** Uncommon ECG changes seem to be more common in elite Ghanaian soccer players compared with previously reported results for Caucasians and even mixed populations of black athletes. Although ST elevation, T-wave inversions, and LVWT up to 15 mm are common, ST depression, deep T-waves in lateral leads, and LVWT ≥16 mm always warrant further clinical and scientific investigations.

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

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INTRODUCTION

Precompetition cardiovascular screening using electrocardiography (ECG) and echocardiography (ECHO) to identify cardiac pathology before sports (professional or recreational) participation has become common in recent years due to the increasing numbers of sudden cardiac death (SCD) in sports.[1–6] Black Africans, males and soccer players, are all documented groups among which the incidence of SCD is highest.[5–7]

Data from various studies involving athletes of African/Afro-Caribbean descent reveal a higher prevalence of ECG and ECHO abnormalities due to their exaggerated physiological response to sport participation causing electrophysiological and structural cardiac changes.[8–14] Differentiating these exaggerated physiological responses from phenotypic expression of mild hypertrophic cardiomyopathy (HCM) in this group is a challenge.[8–10,15–17] To help solve this diagnostic challenge, modern research in the field of sports cardiology has focused on the influence of ethnicity, sex, and type of sport on the ECG and ECHO patterns in athletes.[11,12,16–23]

Data on ECG and ECHO patterns in a homogenous group of African soccer players are however scarce,[24,25] although soccer is the leading sports played in Africa. Precompetition medical assessment (PCMA) before any major soccer tournament or the football league season is mandatory in Ghana, but compliance to this rule has not always been strictly followed, hence the lack of availability of reliable data on soccer players' PCMA. This study therefore aims to examine the electrocardiographic and echocardiographic tracings in Ghanaian (West Africans) male soccer players playing for the various National and premier soccer teams and to provide data on precompetition medical assessment for Ghanaian national team players in the absence of currently available information. We believe data from this study will contribute to the development of a race-sensitive ECG and ECHO interpretation criteria, hence minimizing the need for further investigations and unfair disqualification of this ethnic group.

METHODS

Study Population

In this cross-sectional study; subjects were current players of Ghanaian male national soccer teams preparing for various international football tournaments. Subjects were aged between 14 and 27 years, as presented in (Table 1). Players with any cardiovascular disease were excluded from the study.

The players had been involved in competitive soccer playing averagely 6 and 10 years for the adolescents and

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TABLE 1. Anthropometrics of Ghanaian Male Soccer Players

Variable	Total (n = 159)	Adolescent (n = 66)	Adult (n = 93)	P
Age	19.28 ± 2.90	16.62 ± 1.16	21.16 ± 2.21	<0.0001*
Weight (kg)	68.42 ± 7.96	65.59 ± 7.48	70.42 ± 7.72	<0.0001*
Height (cm)	175.19 ± 7.69	173.98 ± 6.65	176.04 ± 8.27	0.096
BSA (m^2)	1.83 ± 0.14	1.79 ± 0.13	1.86 ± 0.14	0.001*

**Significant difference at* P *< 0.05.*

adults, respectively. They usually train 6 days every week, with each session lasting averagely 2 hours. As part of preparations for tournaments, all players had to go through a mandatory precompetition medical assessment, which included cardiac screening (12-lead ECG and 2-dimensional ECHO). A total of 159 male soccer players who are all Ghanaians (black West Africans) were screened. All the players signed a written consent and also consented that data from the cardiac screening could be used for research purposes.

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

Preparticipation Cardiovascular Screening

Players completed a questionnaire regarding family history and personal symptoms with the help of a team doctor. There were no positive responses to either family history or personal history of cardiovascular disease. Measurement of weight, height, and blood pressure (BP) and assessment of physical characteristics for diseases such as Marfan syndrome were undertaken. None of the players has ever been tested positive for the use of doping substances.

Resting 12-Lead Electrocardiography

Standard 12-lead ECGs were performed using a commercially available ECG machine (Welch Allyn, United Kingdom). The subject was positioned in the supine position, and ECGs were recorded 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 intervals were corrected for the heart rate by use of the Bazett[26] formula.

ST segment shift was considered significant if ≥0.1 mV in ≥2 contiguous leads. An early reporlarization 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.[27] 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.[28]

Electrocardiographies were analyzed independently by experienced investigators (M.A.-A. and P.P.) using the most recent criteria published.[29]

Transthoracic Echocardiography

A 2-dimensional echocardiography 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 Echocardiography protocol.[30]

Left ventricular wall thickness (LVWT) and left ventricular 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 left ventricular mass was calculated with the Devereux formula[31] and indexed for body surface area (BSA). Left ventricular wall thickness (either interventricular wall or posterior wall greater than 12 mm) is defined as maximal LVWT.[15,20,21] Left ventricular (LV) cavity dimension was described as enlarged when left ventricular end-diastolic dimension (LVEDd) was greater than 60 mm.[15,22,23]

Left ventricular ejection fraction (EF) was calculated from LV volumes by Simpson's rule.[32] Assessment of diastolic function included traditional pulsed-wave Doppler across the mitral valve[33] and tissue Doppler velocity imaging[27] of the septal and lateral mitral valve annulus.

Echocardiographic images were saved to compact discs. Measurements were repeated independently by an experienced cardiologist (M.A.-A.) blinded to the identity of the athlete, and unclear cases were discussed by the study group.

Statistical Analysis

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

RESULTS

Demographic Characteristics

Our study cohort of 159 male soccer players were all Ghanaians (black West Africans), comprising 66 adolescents (14-18 years) and 93 adults (19-27 years). Weight (kg), height (cm), and BSA (m^2) were all lower in adolescent players (Table 1). No player recorded a BP greater than 130/85 mm

TABLE 2. Electrocardiographic Characteristics of Ghanaian Male Soccer Players			
ECG Parameter	Adolescents	Adults	*P*
Heart rate (beats/min)	60.18 ± 10.14 (41-90)	58.68 ± 9.63 (37-90)	0.344
PR interval (ms)	171.27 ± 25.77 (120-234)	184.73 ± 27.37 (132-265)	0.002*
QRS duration (ms)	89.62 ± 11.06 (70-122)	95.44 ± 12.13 (70-137)	0.002*
R/S voltage (S1 + R5) (mm)	45.20 ± 13.55 (20-94)	42.16 ± 11.19 (27-69)	0.124
QTc interval (ms)	402.83 ± 21.13 (338-464)	410.34 ± 28.08 (338-493)	0.068

**Significant difference at P < 0.05.*

Hg. The various ECG and ECHO patterns are reported in (Tables 2–6).

Electrocardiography Patterns

First-degree atrioventricular (AV) block was significantly more prevalent in adults compared with adolescent players (29% vs 12% $P < 0.01$). One adult player had Mobitz type I (Wenckebach) AV block, whereas almost half of our study population had heart rates lower than 60 beats/min; Sokolow Lyon voltage criteria for LVH was present in almost two-third of the players.

QRS duration ranged from 70 to 137 ms, with 23% and 3.8% of the players having incomplete right bundle branch block and complete right bundle branch blocks, respectively. QT interval was prolonged (QTc ≥470 ms) in 3 adult players with times 475 ms, 478 ms, and 493 ms. Right-axis deviation (RAD) and left-axis deviation (LAD) were present in 3 and 1 player, respectively. A total of 74 (47%) players had ST segment elevation, with the convex (domed) pattern being more prevalent compared with the concave pattern (30% vs 16%). ST segment depression was rare (0.6%) regardless of age. Sixty-three (40%) players had inverted T waves with some 10 players having T waves deeply inverted. Prevalence of T-wave inversion was higher in anterior (V_1–V_4) than lateral (V_5–V_6) leads (18.7% vs 8.81%) and mostly preceded by convex ST segment elevation. As per the international consensus standards for ECG interpretation in athletes,[29] 23.3% and 6.2% of the players had abnormal and borderline ECGs, respectively. Although T-wave inversions in lateral leads, deep T-wave inversions, ST depression, and long QT intervals accounted for the abnormal ECGs, cRBB, RAD, and LAD accounted for the borderline ECGs. In addition to the players with abnormal ECGs who needed further investigation, 1 adolescent player had both cRBB and RAD and needed a follow-up.

Echocardiography Patterns

Adult players exhibited a greater LV wall thickness and LV mass compared with adolescent players (11.5 ± 1.89 mm vs 10.7 ± 2.07 mm, $P < 0.010$ and 213.9 ± 62.5 g vs 190.4 ± 63.8 g $P < 0.013$, respectively). LV mass index was greater than 115 g/m^2 in 36% of the players. Thirty-six (23%) players

TABLE 3. Electrocardiographic Characteristics of Ghanaian Male Soccer Players				
ECG Findings	Total (n = 159)	Adolescent (n = 66)	Adult (n = 93)	*P*
First-degree AV block (PR interval >200 ms)	35 (22.0)	8 (12.1)	27 (29.0)	0.011*
Second-degree AV block, type I	1 (0.6)	0 (0.0)	1 (1.1)	0.398
Sinus bradycardia (HR <60 beats/min)	79 (49.7)	30 (45.5)	49 (52.7)	0.369
Sokolow–Lyon criteria for LVH	101 (63.5)	48 (72.7)	53 (57.0)	0.042
Incomplete RBBB (100 ms < QRS <120 ms)	36 (22.6)	12 (18.2)	24 (25.8)	0.258
Complete RBBB (QRS ≥120 ms)	6 (3.8)	1 (1.5)	5 (5.4)	0.208
Long QT (QTc ≥470 ms)	3 (1.9)	0 (0.00)	3 (3.23)	0.267
RAD	3 (1.9)	1 (1.5)	2 (2.2)	0.772
LAD	1 (0.6)	1 (1.5)	0 (0.0)	0.234
ST elevation	74 (46.5)	27 (40.9)	47 (50.5)	0.230
Convex ST elevation	48 (30.2)	22 (33.3)	26 (28.0)	0.467
Concave ST elevation	26 (16.4)	5 (7.6)	21 (22.6)	0.012*
ST depression	1 (0.6)	0 (0.0)	1 (1.1)	0.398
T-wave inversion (total)	63 (39.6)	24 (36.4)	39 (41.9)	0.189
Deep T-wave inversion	10 (6.3)	5 (7.6)	5 (5.4)	0.574
T-wave inversions leads				
V_1–V_4	30 (18.7)	11 (16.7)	19 (20.4)	0.682
V_5–V_6	14 (8.81)	8 (12.1)	6 (6.45)	0.261

**Significant at P < 0.05.*
AV, atrioventricular; HR, heart rate; RBBB, right bundle branch block.

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

Variable	Total (n = 159)	Adolescent (n = 66)	Adult (n = 93)	*P*
Normal ECGs	112 (70.4)	45 (68.2)	68 (73.1)	0.595
Borderline ECGs	10 (6.29)	4 (6.06)	5 (5.38)	1.000
Abnormal ECGs	37 (23.3)	17 (25.8)	20 (21.5)	0.571

had LVWT ≥ 13 mm, 21 (13%) players had LVWT ≥ 14 mm, and 7 (4%) players had LV wall thickness ≥15 mm, with no player exceeding 16 mm (3 players had LVWT of 16 mm). Left ventricular cavity size ranged from 42 mm to 69 mm, with 6 players having LVEDd >60 mm. Seventy (44%) players exhibited relative wall thickness (RWT) greater than 0.42, and 19 (12%) players had RWT >0.50. Left ventricular EF was >55% in all players. Visual assessment revealed no segmental wall motion abnormalities. Transmitral flow and diastolic mitral annulus velocities (both early and late) were normal in all athletes.

Comparison Between Electrocardiography and Echocardiography Findings

Seventeen (11%) players had both T-wave inversions (including deep T-wave inversion) and LV wall thickness ≥13 mm, but morphological assessment and physical examination did not reveal any signs of any type of cardiomyopathy including HCM in any player. Although a cardiac magnetic resonance imaging (cMRI) may have given a more accurate conclusion in these players, cMRI unfortunately was not been available in Ghana at the time of the study. One 19-year-old adult player, weighing 65 kg, 176-cm tall with a BSA of 1.80 m^2 with ST depression, LVH ($S_1 + R_5 = 69$ mm) and T-wave inversions had a normal echocardiography, further confirming the poor correlation between ECG findings (LVH) and cardiac dimensions on echocardiography. Considering the fact that these players were all free of any cardiac symptoms or diseases, they were considered eligible with yearly screening with ECG and ECHO recommended.

DISCUSSION

The influence of black ethnicity on the cardiovascular adaptation to sports, which is normally manifested on athletes' ECG and ECHO, and collectively described as the "athlete's heart," has attracted significant attention in recent years.[8–10]

Most of the studies involving athletes of black African descent have confirmed that black male athletes compared with their Caucasian counterparts exhibit a higher prevalence of morphological changes.[11,14,18,19] Such exaggerated

TABLE 5. Echocardiographic Characteristics of Ghanaian Male Soccer Players

ECHO Findings	Total (n = 159)	Adolescent (n = 66)	Adult (n = 93)	*P*
IVS (mm)	10.9 ± 1.93 (7-16)	10.5 ± 1.86 (7-16)	11.1 ± 1.93 (7.7-16)	0.030*
PWT (mm)	10.3 ± 1.80 (6.9-16)	9.87 ± 1.75 (6.9-16)	10.7 ± 1.78 (7-15)	0.006*
mLVWT (mm)	11.2 ± 1.99 (7.5-16)	10.7 ± 2.07 (7.5-16)	11.5 ± 1.89 (8-16)	0.010*
LV end-diastolic dimensions (mm)	50.6 ± 4.53 (42-69)	50.1 ± 4.17 (43-64)	51.0 ± 4.76 (42-69)	0.208
LV end-systolic dimensions (mm)	31.2 ± 4.34 (20-47)	30.6 ± 3.47 (22-37.5)	31.6 ± 4.83 (20-47)	0.143
Left ventricular mass (g)	204.2 ± 63.9 (97.2-485.7)	190.4 ± 63.8 (118.5-485.7)	213.9 ± 62.5 (97.2-386.9)	0.013*
Relative left ventricular mass	3.00 ± 0.88 (1.57-7.14)	2.90 ± 0.87 (1.72-7.14)	3.05 ± 0.89 (1.57-6.14)	0.225
Left ventricular mass index (g/m^2)	111.2 ± 32.4 (56.3-261.7)	106.1 ± 32.5 (67.4-261.7)	114.9 ± 31.0 (56.3-205.5)	0.063
RWT (%)	41.9 ± 6.80 (26.3-60.9)	40.8 ± 6.47 (26.3-60.3)	42.7 ± 6.93 (27.1-60.9)	0.075
FS (%)	38.3 ± 7.09	38.9 ± 5.77	37.9 ± 7.89	0.411
EF (%)	62.5 ± 6.07	62.6 ± 6.27	62.3 ± 5.95	0.749
E-wave (cm/s)	82.8 ± 14.9	89.6 ± 12.8	78.0 ± 14.4	<0.0001*
A-wave (cm/s)	48.3 ± 11.8	46.2 ± 10.0	49.8 ± 12.8	0.063
E/A ratio	1.80 ± 0.50	2.01 ± 0.51	1.66 ± 0.46	<0.0001*
E′ wave S (cm/s)	13.1 ± 2.79	13.38 ± 2.63	12.9 ± 2.90	0.317
A′ wave S (cm/s)	8.68 ± 1.52	8.47 ± 1.62	8.97 ± 1.33	0.112
E′/A′ S	0.96 ± 0.85	1.46 ± 0.72	0.60 ± 0.75	<0.0001*
E′ wave L (cm/s)	16.0 ± 4.14	16.3 ± 3.69	15.9 ± 4.44	0.561
A′ wave L (cm/s)	9.50 ± 2.65	8.85 ± 2.61	10.5 ± 2.44	0.003*
E′/A′ L	1.10 ± 1.05	1.75 ± 0.92	0.88 ± 0.64	<0.0001*
E/E′	6.02 ± 1.90	6.33 ± 1.70	5.80 ± 2.00	0.079

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

TABLE 6. Echocardiographic Abnormalities Among Ghanaian Male Soccer Players

ECHO Findings	Total (n = 159)	Adolescent (n = 66)	Adult (n = 93)	*P*
Normal	85 (53.5)	39 (59.1)	46 (49.5)	0.230
LVH	72 (45.3)	25 (37.9)	47 (50.5)	0.114
mLVWT (≥12 mm)	61 (38.4)	18 (27.3)	43 (46.2)	0.015*
mLVWT (13 mm up to 15 mm)	33 (20.8)	6 (9.1)	27 (29.0)	0.003*
mLVWT (≥16 mm)	3 (1.9)	2 (3.0)	1 (1.1)	0.571
LV end-diastolic dimensions (>60 mm)	6 (3.8)	2 (3.0)	4 (4.3)	0.679
RWT (>42%)	70 (44.0)	24 (36.4)	46 (49.5)	0.857
Pulmonary regurgitation	2 (1.3)	2 (3.0)	0 (0.0)	0.091

**Significant difference at $P < 0.05$.*
mLVWT, maximum left ventricular wall thickness.

responses to exercise are believed to be a result of a combination of genetic, endocrine, and hemodynamic factors.[15] The heterogeneous nature of the black Africans/Afro-Caribbeans forming these study cohorts is a limitation to these studies considering the possibility of a genetic drift in black Europeans and black Americans resulting from ancestral migration.[9]

This study presents findings in a homogenous group of 159 Ghanaian (black West African) male soccer players made up of both adults and adolescents competing at the highest level. Conclusions drawn from the study can therefore be said to be truly representative of the black West African male player and can serve as a useful guide for interpreting ECGs and ECHOs of athletes from this region and, to an extent, black African athletes in general.

Electrocardiography Patterns

The prevalence of common/training-related ECG changes (Table 3) in our study cohort was high and similar to the prevalence in other black African and Caucasian athletes, as reported in other studies.[11,14] This implies athletic training may be responsible for common/training-related ECG changes. The higher prevalence of uncommon ECG changes in Ghanaian male soccer players compared with their Caucasian and West-Asian counterparts suggests a combination of black ethnicity and exercise training may be predisposing factors.[7]

Almost half of our study population ECGs had ST segment elevation with the convex-shaped (domed) pattern more prevalent than the concave pattern (30% vs 16%). The high prevalence of convex ST segment elevation pattern in black African players, which has no clinical significance, is strongly linked to a combination of black ethnicity and training load.[11,24] ST depression, which is a common finding in black African HCM patients,[11] was rare (1 adult player) among our players. Therefore, irrespective of one's ethnicity, age, or type of sport, the presence of ST depression should always be investigated further to rule out HCM.

Our study population exhibited a higher prevalence (40%) of T-wave inversion compared with prevalence among other black African athletes in other studies.[11,13,14,34] The difference between our study population and that of the Europe and American-based studies is the fact that black ethnicity is normally self-assigned in the Europe and American-based studies.

Thirty players demonstrated T-wave inversion in anterior leads (V_1–V_4), with about 9% of players having T-wave inversions in lateral leads (V_5–V_6). This confirms the overall higher prevalence of T-wave inversion in these leads in black African athletes compared with their Caucasian counterparts.[11,13,14,24] A recent study by Calor et al[35] also revealed 90% and 9% prevalence rates of T-wave inversions in lateral leads in HCM and healthy athletes (most of whom were of black African descent), respectively, suggesting the need to completely exclude HCM in any athlete with T-wave inversions in lateral leads. Although further investigation using ECHO did not confirm our suspicion of HCM in the players with T-wave inversions in lateral leads, we still recommend close monitoring of such players and yearly cardiovascular screening with ECG and ECHO.

From our findings, it is obvious that uncommon ECG changes unrelated to training are more prevalent among black African athletes compared with their Caucasian counterparts.[13–15,24,34] It also seems that our study cohort (West Africans) had exaggerated cardiac adaptation to physical activity compared with other black African cohorts living in Europe and the Americas.[11,13,14]

Echocardiography Patterns

Our findings revealed that the increase in LV wall thickness was accompanied by a similar increase in LV mass and RWT, but LV cavity dimension remained the same, hence confirming the high prevalence of concentric pattern of LV remodeling in black African athletes.[11,13,34,36] Although RWT was greater than 0.42 in 44% of the players, 36 players had LVWT ≥13 mm. Although concentric LV hypertrophy has been confirmed to be more prevalent in athletes of black African descent compared with their Caucasian counterparts,[11,13] we recommend yearly cardiovascular screening with ECG and ECHO for the players who had RWT >0.42 and LVWT ≥13 mm, and free of symptoms of any cardiovascular disease, to detect early or exclude any sinister cardiovascular disease. Our data also revealed a significant number of adults compared with adolescents had LVWT >12 mm (46.2% vs 27.3% $P < 0.015$). Sixteen of the 21 players who had LVWT ≥14 mm were adults (Figure 1). This may be attributed to the transition from adolescence to adulthood, which is associated with body maturation and a longer exposure to continued exercise training.

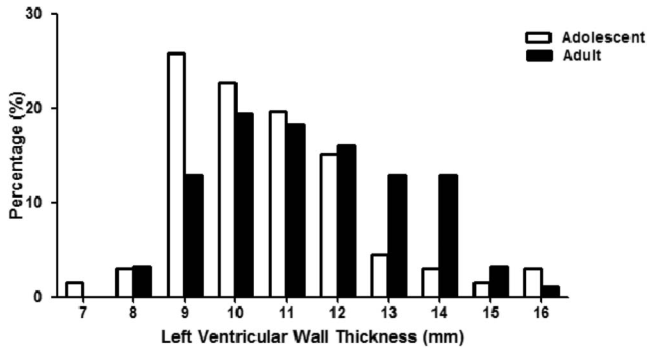

Figure 1. Distribution of LVWT in male adolescents and adult soccer players.

Consistent with findings in other studies,[11,13,24] none of the players in our study had wall thickness exceeding 16 mm. Therefore, any athlete with findings in the grey zone between 13 and 15 mm (or even up to 16 mm in black West African athletes), regardless his ethnicity, should always be further investigated to exclude HCM.

Clinical Implications

It is evident from our data, in agreement with other studies,[15,24] that regional differences do exist when it comes to cardiac (LV) remodeling in response to chronic exercise training. The West African soccer player is more likely to have an exaggerated LV remodeling compared with the east African long-distance runner.[15] It is therefore clinically important for the practicing sports physician or cardiologist to take into consideration the ancestral origin of black athletes when interpreting ECG and ECHO reports to ascertain their eligibility to participate in sports.

T-wave inversions in anterior leads preceded by convex ST segment elevation represent a physiological response to exercise training in black African players. Our investigation suggests that, regardless of ethnicity, deeply inverted T-waves and ST depression should always be further investigated to rule out any cardiomyopathy. The application of race-sensitive ECG and ECHO interpretation criteria will reduce the need for further investigations and also the number of disqualified black African sports men and women.

LIMITATION

The limitations of our study are inherent in the study design; this is a cross-sectional study without a control group, hence our inability to perform long-term follow-up or use other screening tools such as cMRI and genetic testing, which were not part of this initial study. The absence of long-term follow-up and the lack of cMRI in Ghana during the study period make it difficult to completely rule out the presence of cardiomyopathies among this cohort of athletes.

The study population was made up of only Ghanaians (West Africans) who participated in only 1 sporting discipline (soccer), and hence, we cannot consider our results to be representative of the entire African population. In addition, the effect of other sporting disciplines on the type of cardiac adaptation cannot be fully explained using our findings.

The investigators also consider the absence of data regarding previous precompetition medical assessment a limitation.

CONCLUSIONS

Ghanaian (black West African) elite football players demonstrate both common training-related and even uncommon training-unrelated ECG and ECHO findings to a high degree. Although ST elevation, T-wave inversions, and LVWT up to 15 or even 16 mm are more common in this ethnic group, these findings and especially ST depression, deep T-waves in lateral leads, and LVWT ≥13 to 16 mm warrant further clinical and scientific investigation.

Future studies (including the use of cMRI and genetic testing) involving other sporting disciplines and participants from other regions in Africa are required to further elucidate clinically relevant findings.

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