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Resting electrocardiographic characteristics in male elite and sub-elite football referees from Burkina Faso

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**Posthumous.*

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Abstract

A healthy resting electrocardiogram (ECG) is mandatory for football referees given the rigour of football officiating, but the electrocardiographic profile of those in Burkina Faso is largely unknown. The objective of this study was to determine the resting electrocardiographic characteristics of Burkinabè male elite and sub-elite football referees. Following the 2017 Athlete ECG Interpretation Criteria, a cross-sectional study was conducted in which a 12-lead resting surface ECG was performed in 121 football referees aged 23 to 44 years old. The proportion and χ^2 tests were respectively used to examine any electrocardiographic risk prevalence and to test the probable effects of age categories, officiating categories and level of arbitration. The football referees were grouped into two age (≤ 35 years and > 35 years old) and officiating (central referees and assistant referees) categories. The level of arbitration further included elite and sub-elite referees. Normal ECG changes in repolarization, conduction, morphology, and rhythm were observed in 33.9%, 30.6%, 28.1%, and 57.0% of the referees, respectively. The borderline ECG change in morphology was recorded in 9.1% of the referees and there was no more than one case in the same referee. The abnormal ECG modification of the repolarization was found in 5.8% of the referees. These were negative T waves in: anterior (2.5%), lateral (0.8%), inferolateral (1.7%) and ST segment depression (0.8%). Borderline and abnormal ECG changes found were not associated with age categories, officiating categories and refereeing level ($p > 0.05$). Abnormal ECG changes were infrequent among Burkinabè referees. Extensive investigations and clinical interventions are needed to forestall the risk of latent heart disease in football referees.

Keywords: Male football referee, resting electrocardiogram changes, Burkina Faso.

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Introduction

In modern football, the physiological and physical demands of refereeing place a heavy load on the cardiovascular system, which must adapt to meet the metabolic demands of active muscles (Castagna *et al.*, 2007). In the presence of latent heart disease, very high intensity physical exercise can cause an accident, even sudden cardiac death (SCD), the leading cause of athlete death during sports (Drezner *et al.*, 2017). Athletes, specifically male, black and soccer athletes, are 2.5 to 4.5 times more exposed to SCD than the general population (Asif & Harman, 2017).

The resting 12-lead electrocardiogram (ECG) is currently recommended in athletes to detect abnormalities that may indicate SCD-associated heart disease (Georgijević & Andrić, 2016). Over the past 15 years, criteria for the interpretation of the athlete's ECG have been developed and refined to reduce the risk of error, which could have profound repercussion for the professional career of practitioners. Recently, an expert consensus statement defined three categories of ECG readings in athletes as including normal, borderline and abnormal ECG changes (Drezner *et al.*, 2017).

Normal ECG changes are associated with the athlete's heart and do not require additional testing in asymptomatic athletes with no family history of heart disease or SCD (Meyer & Gabus, 2017). Abnormal ECG changes systematically require additional cardiac exploration, so as not to overlook an underlying heart disease associated with SCD (Sharma *et al.*, 2017). Borderline ECG changes are those whose clinical significance depends on the number of cases observed, as they require extensive investigation, only when more than one case is recorded in the same athlete (Drezner *et al.*, 2017).

Since 2010, the ECG has been mandatory for football referees (Bizzini *et al.*, 2012). This is probably why the electrocardiographic profile of male referees preselected for the 2010 World Cup was studied and 13% of them had presented with abnormal ECG changes (Bizzini *et al.*, 2012). Currently, there is a dearth of studies on the referee's heart in relation to the 2017 criteria. Furthermore, little data is available on the electrical parameters of the heart of football referees in West Africa. The collective electrocardiographic specificities of referees in Burkina Faso have not been formally studied despite that it could help to identify trends to institute follow-up clinial intervention for the referees, who are highly exposed to the risk of cardiac incidents during officiating. Therefore, this study was undertaken to evaluate the resting electrocardiographic characteristics of male elite and sub-elite soccer referees in Burkina Faso.

Methodology

Study design and participants

This cross-sectional study was conducted in Burkina Faso with male central and assistant referees, (both elite, i.e. FIFA or federal grade and sub-elite, i.e. League grade). They were selected from the official list of the Burkinabè Football Federation (FBF) referees assigned to officiate at Burkinabè elite championships, as well as FIFA recognised international competitions. The study received approval from the Ethics Committee for Health Research (CERS) in Burkina Faso (Ref. no.: 2020-10-234/MS/MESRSI/CERS of 07/10/2020). Informed consent was obtained from the referees.

Elite (FIFA or Federal) and sub-elite (League) male football referees, registered on the official list of the Central Commission of Referees (CCA)/Burkina Faso Football Federation (FBF) constituted the study population. Active elite and sub-elite male referees, available at the time of measurement and who had spent four years in football refereeing, were included in the sample. Of the 123 elite and sub-elite referees recognized by the FBF, 121 or 98.37% actually participated in the study.

Measurements

About 72 hours before ECG testing, data on socio-demographic characteristics, family history of heart attacks and number of years spent in football refereeing was collected using a questionnaire. Anthropometric measurements were also taken. These included height, measured by a wall-mounted body meter (Seca 206, France), body mass, measured by a Qe-2003A electronic scale (China) and body mass index (BMI), calculated by dividing body mass by the square of height (m). ECG testing was carried out in a specialised medical center by a qualified and experienced cardiologist, using an EK53 electrocardiograph (Hellige, France). For the ECG measurements, the referees were dressed in shorts, lying on their backs, relaxed, with eyes closed, legs uncrossed, arms outstretched and hands flat before the electrodes were placed according to international standards (Georgijević & Andrić, 2016). The skin was cleaned and dried or depilated if necessary to obtain better contact of the electrodes. Another experienced cardiologist, with a qualification in sports medicine and a good knowledge of the clinical context, validated the ECGs, after checking: calibration defects, absence of interference, stability of the baseline and plot consistency. The ECGs were then interpreted manually by the same cardiologist, following the 2017 international criteria (Drezner *et al.*, 2017).

Variables studied

Age category, referees' category, and level were the independent variables used in this study. The age categories included referees whose ages were ≤ 35 years old and older. The referees' category also had two sub-categories, i.e. central referees

and assistant referees. The referee levels included elite referees who comprised FIFA licensed or federal referees and sub-elite referees, i.e. League referees.

Dependent variables included normal, borderline and abnormal ECG changes, organised into composite variables, consisting of several sub-variables with the exception of two. The composite variables, as well as the sub-variables were all dichotomous and defined by their "*presence*" or "absence". To appreciate the presence of each composite variable, the presence of at least one associated sub-variable was necessary. The sub-variables were determined according to the definitions of the 2017 expert consensus document (Drezner *et al.*, 2017; Sharma *et al.*, 2017). A total of nine composite variables were identified: normal ECG change in rhythm, conduction, repolarization and morphology, borderline ECG change in conduction and morphology, abnormal ECG change in rhythm, conduction and repolarization.

Normal ECG change in rhythm consisted of sinus bradycardia, sinus arrhythmia, and junctional escape rhythm. Normal ECG change in conduction consisted of incomplete right bundle branch block, 1st degree atrioventricular block, and 2nd degree atrioventricular block Mobitz type I. Normal ECG change in morphology consisted of electrical hypertrophy of Sokolow-Lyon of the left ventricle and electric hypertrophy of Sokolow-Lyon in the right ventricle. The borderline ECG change in morphology was composed of right axis deviation, left axis deviation, right and left atrial hypertrophy. Normal ECG change of repolarization was composed of early repolarization. The borderline ECG change in conduction was complete right bundle branch block (Drezner *et al.*, 2017; Sharma *et al.*, 2017).

Abnormal ECG change in rhythm consisted of deep sinus bradycardia, at least 2 ventricular extrasystoles per 10-second tracing, doublets, triplets, unsustained ventricular tachycardia, atrial extrasystole, focal tachycardia, atrial fibrillation and atrial flutter. Abnormal ECG change in conduction comprised complete left bundle branch block, deep 1st degree atrioventricular block, 2nd degree atrioventricular block Mobitz type II, 3rd degree atrioventricular block, profound nonspecific intraventricular conduction delay, ventricular pre-excitation and epsilon wave. Abnormal ECG change of repolarization included long QT interval, negative T waves, ST-segment depression, pathological Q wave, and Brugada type I pattern (Drezner *et al.*, 2017; Sharma *et al.*, 2017).

Statistical analysis

Data was processed with SPSS software (IBM Statistics, Version 25). The normality of the distribution of the continuous quantitative variables was verified using the Kolmogorov-Smirnov test. Descriptive statistics such as means (m) ± standard deviations were calculated. Absolute and relative frequencies expressed as a percentage (%) were determined for categorical variables. The Chi-square (χ^2)

test was used to examine the effects of age categories, referee categories and referee level. The probability level for all inferential statistics was set at $p \leq 0.05$.

Results

The averages of age, height, body mass, body mass index and number of years spent in football refereeing for all referees are shown in Table 1. Elite, sub-elite, central, assistant referees, ≤ 35 years old and > 35 years old accounted for 47.1%, 52.9%, 41.3%, 58.6%, 80.1% and 19.8 % of referees studied, respectively (Table 1). There was neither a history of cardiovascular disease nor a history of heart attacks among the referees.

Table 1: Socio-demographic, anthropometric, and officiating history characteristics of participating referees (n = 121)

Variable	Entire referee population (n = 121)	Age category		Referee category		Refereeing level	
		≤ 35yrs (n = 97)	> 35yrs (n = 24)	Central (n = 50)	Assistant (n =71)	Elite (n = 57)	Sub-Elite (n = 64)
Age (years)	30.5 ± 5.7	28.1 ± 3.1	40.2 ± 2.7	30.3 ± 5.1	30.7 ± 6.1	32.6 ± 6.3	28.7 ± 4.5
Height (cm)	175.4 ± 0.0	175.0 ± 0.0	177.1 ± 0.6	175.8 ± 0.0	175.1 ± 0.0	175.4 ± 0.0	175.4 ± 0.0
Weight (kg)	68.3 ± 7.0	68.3 ± 7.1	68.3 ± 6.7	69.4 ± 7.4	67.5 ± 6.6	67.7 ± 7.6	68.7 ± 6.4
BMI (kg/m^2)	22.1 ± 1.8	22.3 ± 1.9	21.6 ± 1.5	22.4 ± 1.9	21.3 ± 1.8	21.9 ± 1.8	22.3 ± 1.8
YRref (yrs)	8.1 ± 3.6	6.8 ± 1.8	13.5 ± 4.3	8.2 ± 3.5	8.1 ± 3.8	9.9 ± 4.4	6.6 ± 1.6

Numbers in cases represent means ± standard deviation; n: number of people; BMI: Body Mass Index; YRref: number of years spent in football refereeing.

Normal, borderline, and abnormal ECG changes (Figure 1) were observed respectively in 85.1%, 9.1%, and 5.8% of the referees studied.

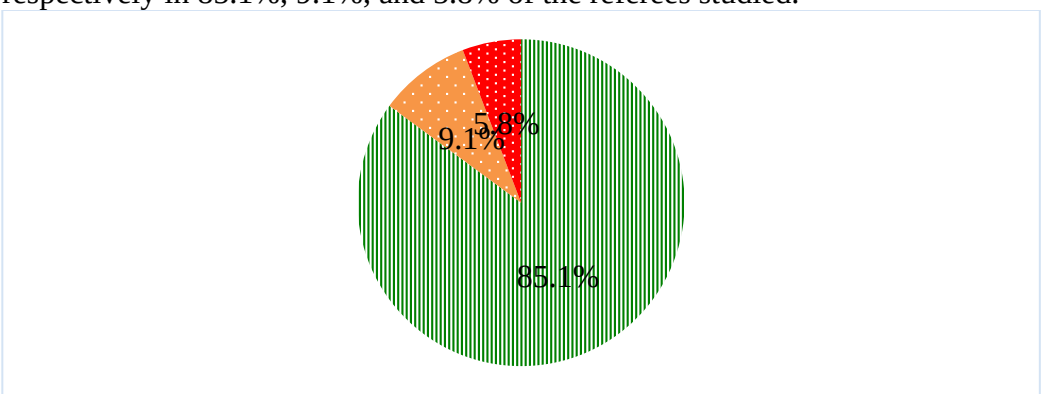

Figure 1: Frequency of normal, borderline, and abnormal ECG findings in elite and sub-elite soccer referees in Burkina Faso. The area colored in green represents the frequency of normal ECG changes; the area colored in orange represents the prevalence of borderline ECG changes: The area colored in red represents the prevalence of abnormal ECG changes.

The frequency of normal ECG changes in rhythm, repolarization, conduction, and morphology (Table 2) was 57.0%, 33.9%, 30.6%, and 28.1%, respectively. The most prevalent subvariable of normal ECG change in rhythm was sinus bradycardia with 52.1%, that of conduction was BBDi (28.1%) and for morphology it was left ventricular hypertrophy (LVH) (24.8%).

Table 2: Frequency of normal ECG findings in elite and sub-elite football referees in Burkina Faso (n = 121)

Variable	n	%
Normal ECG rythm findings	**69**	**57.0**
Sinus Bradycardia	63	52.1
Sinus Arythmia	8	6.6
Junctionnel rythm	2	1.7
Normal ECG repolarisation findings	**41**	**33.9**
Early repolarisation	41	33.9
Normal ECG conduction findings	**37**	**30.6**
Incomplete right bundle branch block	34	28.1
1st degree atrioventricular block	5	4.1
2nd degree atrioventricular block Mobitz 2	1	0.8
Normal ECG morphology findings	**34**	**28.1**
QRS voltage for LVH	30	24.8
QRS voltage for RVH	5	4.1

n: number of people: The numbers in the table represent the numbers, followed by the corresponding percentages (%); QRS: QRS complex; ECG: electrocardiogram: LVH: left ventricular hypertrophy; RVH: right ventricular hypertrophy; The same referee could have for the same composite variable of normal ECG findings in rhythm, repolarisation, conduction, and morphology two or three sub-variables.

The borderline ECG change in morphology was recorded with the following frequency of sub-variables (Table 3): left atrial hypertrophy (5.8%), right atrial hypertrophy (1.7%), left axis deviation (0.8%) and right axis deviation (0.8%). There was neither borderline ECG changes in conduction nor were there two cases of borderline ECG changes in the same referee.

Table 3: Prevalence of borderline ECG findings in elite and sub-elite football referees in Burkina Faso (n = 121)

Variable	n	%
Borderline ECG morphology findings:	11	9.1
Right Axis Deviation	1	0.8
Left Axis Deviation	1	0.8
Right Atrial Enlargement	2	1.7
Left Atrial Enlargement	7	5.8

n: number of people: The numbers in the table represent the number of people, followed by the corresponding percentages (%).

Abnormal ECG change of repolarization (Table 4) observed were negative T waves: anterior (2.5%), lateral (0.8%), inferolateral (1.7%) and ST segment depression (0.8%). There were no abnormal ECG changes in rhythm and conduction.

Table 4: Prevalence of abnormal ECG findings in elite and sub-elite football referees in Burkina Faso (n = 121)

Variable	n	%
Abnormal ECG repolarisation findings	***7***	***5.8***
Anterior T wave inversion	3	2.5
Lateral T wave inversion	1	0.8
Infero-lateral T wave inversion	2	1.7
ST segment depression	1	0.8

n: number of people: The numbers in the table represent the number of people, followed by the corresponding percentages (%).

The borderline ECG changes in morphology (Table 5) were observed in 9 referees ≤ 35 years old and 2 referees ≥ 35 years old; the category of referees, with 4 central referees and 7 assistant referees. In terms of referee level, the change was noted in 7 elite referees and 4 sub-elite referees. However, ECG changes in morphology were insignificantly associated with age category (p = 0.88), the category of referees (p = 0.72), and referee level (p = 0.24). The abnormal ECG change in repolarization (Table 5) was recorded in 5 referees ≤ 35 years old and 2 referees ≥ 35 years old; the category of referees, with 4 central referees and 3 assistant referees and the referee level, with 5 elite referees and 2 sub-elite referees. ECG changes in rhythm and conduction were not substantially associated with age category (p = 0.55), category of referees (p = 0.38), and refereeing level (p = 0.18).

Table 5: Relationships between borderline and abnormal ECG changes and age category, referee category, and refereeing level in elite and sub-elite football referees in Burkina Faso (n=121).

ECG characteristics	Referees characteristics		χ^2	p
	≤ 35 years (n = 97)	**> 35 years** (n = 24)		
Borderline ECG M find				
Present	9 (82)	2 (18)	0.02	0.88
Absent	88 (80)	22 (20)		
Abnormal ECG R find				
Present	5 (72)	2 (28)	0.35	0.55
Absent	92 (80)	22 (20)		
	Central (n = 50)	**Assistant** (n = 71)		
Borderline ECG M find				
Present	4 (37)	7 (63)	0.12	0.72
Absent	46 (42)	64 (58)		
Abnormal ECG R find				
Present	4 (57)	3 (43)	0.76	0.38
Absent	46 (40)	68 (60)		
	Elite (n = 57)	**Sub-elite** (n = 64)		
Borderline ECG M find				
Present	7 (64)	4 (34)	1.32	0.24
Absent	50 (45)	60 (55)		
Abnormal ECG R find				
Present	5 (71)	2 (29)	1.76	0.18
Absent	52 (45)	62 (55)		

n: number : Borderline ECG M find: borderline ECG morphology findings; Abnormal ECG R find: abnormal ECG repolarisation findings; Numbers in the table represent the numbers of referees, followed by the corresponding percentages (%) in parentheses.

Discussion

This study aimed to determine the electrocardiographic characteristics of elite and sub-elite soccer referees in Burkina Faso. Provisions have been made to guarantee the reliability of the data. This is why the ECGs were recorded in accordance with international recommendations (Georgijević & Andrić, 2016) by a cardiologist accustomed to this type of measurement. Considering that automatic interpretation can induce errors (Schlapfer & Wellens, 2017; Smulyan, 2019), the ECGs were interpreted manually by another well-experienced cardiologist, specialized in Sports Medicine, with a good knowledge of the clinical context. The interpretation criteria used in this research were developed for athletes up to 35 years old (Drezner *et al.*, 2017) and 19% of the referees studied were over 35 years old. It should be remembered, however, that the effectiveness of said criteria has more recently been demonstrated in athletes over the age of 35 (Panhuyzen-Goedkoop *et al.*, 2020), thus ensuring the reliability of the present results. The research was carried out with 98% of the study population, therefore the results recorded reflect well the electrocardiographic profile of elite and sub-elite football referees in Burkina Faso.

The main limitation of this study is the lack of data on the parameters of heart morphology and function, which would undoubtedly enrich our results. The comparison of the results of this study with those of non-referees could constitute a second limitation. But the fact is that little such data is available on football referees. These results obtained indicate normal, borderline and abnormal ECG changes were found in the referees. Normal ECG changes in rhythm, repolarization, conduction and morphology were also recorded. Borderline ECG change in morphology and abnormal ECG change in repolarization were detected but they were not associated with age group, referee category and referee level.

The prevalence of normal ECG changes, particularly those in rhythm, repolarization, conduction and morphology, recorded in the referees studied, supports the hypothesis that the demands of football refereeing impose a heavy physiological and physical load on the heart (Castagna *et al.*, 2007). Previous research has reported that intensive and regular sports activity cause physiological adaptations in cardiac rhythm, conduction, repolarization and morphology, which constitute an electrical characteristic of the athlete's heart (Basu & Malhotra, 2018).

These adaptations are mainly explained by a dilation of the cardiac chambers, a thickening of the cardiac walls, an increase in parasympathetic activity and a decrease in sympathetic activity (Sharma *et al.*, 2017). They aim to substantially increase the maximum cardiac onset, the main determining factor of VO_2max (Basu & Malhotra, 2018). Referees in our study had an average of six hours of training per week and eight years in soccer refereeing. This represents the

conditions necessary to observe the presence of the normal ECG changes (Bessem *et al*., 2018). The prevalence of normal ECG changes recorded in the referees of this study is lower than that observed in high-level training athletes in western Burkina Faso (Tougouma *et al.*, 2019). The high number of these athletes, namely 192, as well as the level of training, could explain the difference.

The prevalence of normal ECG changes in rhythm, conduction, repolarization and morphology observed in referees in the present study is greater than that reported in some European athletes (Hong *et al.*, 2015). The difference could essentially result from the fact that the variables used in the study cited were not organized into composite variables. Thus, only one sub-variable, namely sinus bradycardia, incomplete right bundle branch block, early repolarization, and LVH represented the normal ECG change in rhythm, conduction, repolarization, and morphology, respectively. However, although only one sub-variable was considered, namely sinus bradycardia, incomplete right bundle branch block and LVH, the results recorded in this study are less important than those observed in athletes of the Polish Olympic team (Swiatowiec *et al.*, 2009). The higher level of competition of the Polish athletes compared to that of our referees undoubtedly accounts for the disparity in the findings.

The prevalence of borderline ECG morphology change observed in referees in our study corroborates that reported in a study of black athletes (Wilson *et al.*, 2012). By contrast, it is lower than that reported in Macedonian athletes (Karagjozova *et al.*, 2017). The higher number of years spent in training among Macedonian athletes could explain the difference, since the athletes who present with a borderline ECG change are found among those who have accumulated several years of high intensity training (Gati *et al.*, 2013).

None of the football referees in the present study had more than one case of borderline ECG modification. This is good news as it is known that this observation is not correlated with the presence of cardiac pathology, but may partly reflect a structural cardiac adaptation to training (Drezner *et al.*, 2017). This is precisely why initially systematically classified in the category of abnormal ECG changes, a case of borderline ECG change is currently considered as a normal ECG change in the new criteria (Sharma *et al.*, 2017). The reconsideration of cases of borderline ECG modification is a significant development in athletes' cardiovascular screening protocol because it reduced the false-positive rate from 13% to 7.5%, improved specificity from 90% to 94% and reduced sensitivity from 91% to 89.5% (Gati *et al.*, 2013).

Abnormal ECG change of repolarization, including negative T wave and ST segment depression, has been observed in football referees. Abnormally negative T wave is associated with various structural heart diseases and ST segment depression is common in patients with hypertrophic cardiomyopathy (Di Paolo *et*

al., 2012). This is not good news for the referees concerned when it is known that hypertrophic cardiomyopathy is the main cardiac pathology associated with SCD (Drezner *et al.*, 2017). A more thorough clinical evaluation and intervention should be carried out to mitigate the risk of heart disease in the referees.

The prevalence of abnormal ECG modification of recorded repolarization in the group of referees studied corresponds to that reported in Macedonian athletes (Karagjozova *et al.*, 2017). However, it is lower than that observed in a population of 300 high-level black athletes (Wilson *et al.*, 2012). The higher number of these athletes, i.e. 300, could explain the difference observed in the data. It is also lower than that recorded among football referees preselected for the 2010 World Cup (Bizzini *et al.*, 2012). This difference could result from the degree of precision of the criteria used. The international criteria of 2017 used in our study is more recent, precise and refined than those used in the testing of referees preselected for the 2010 World Cup, namely the recommendations of the European Society of Cardiology of 2010 (Basu & Malhotra, 2018).

The borderline ECG changes in morphology and abnormal repolarization found in this study were not associated with age category, referee category or referee level. The small number of cases observed, in the sense that a few referees had revealed the borderline and abnormal ECG changes, did not yield any substantial statistical association.

In summary, normal ECG changes were common among elite and sub-elite football referees in Burkina Faso. However, borderline and abnormal ECG readings were uncommon. Further investigations should be carried out in order not to overlook the risk of latent heart disease among the football referees.

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