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Original article

Electrocardiographic manifestations in African black athletes: a Senegalese case-control study

Manifestations électrocardiographiques chez les athlètes noirs africains : une étude cas-témoins sénégalaise

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Abstract

Background: Intensive training can induce structural and functional changes in the heart, including changes in the electrocardiogram. There are many studies on ECG for Caucasian athletes, but for Africans, data remains scarce.

Objectives: The objectives of this study are to determine and compare the prevalence and distribution of ECGs of African military athletes and African non-athletes in the control group.

Methodology: This case-control study was conducted over a six-month period, from April 2021 to September 2021, at Principal Hospital in Dakar. Participants in this study were divided into two groups. The first was composed of 155 military athletes and the second of 155 non-military athletes. In both groups, all participants were between the ages of 18 and 35. A standard 12-lead ECG was performed for each of them and all ECG parameters were analyzed.

Results: The median age of participants was 25.19± 4.19 years for athletes and 25.93± 3.57 years for the control group. The weekly training time was 14.06 5.87 hours. Most athletes (90.3%) had ECG changes. The most significant changes were sinus bradycardia (66%), left ventricular hypertrophy (45.2%), early repolarization (42.5%), first-degree atrioventricular block (18.7%) in athletes. All of these parameters were significantly higher in the athlete group than the control group.

Conclusion: The interpretation of the ECG should take into account the individual training intensity and ethnicity. Sinus bradycardia, left ventricular hypertrophy, early repolarization and first-degree AV block are the most common ECG changes in athletes.

Résumé

La pratique d'une activité physique intense peut induire des modifications cardiaques structurelles et fonctionnelles, y compris électrocardiographiques. Il existe beaucoup d'études sur les athlètes caucasiens mais pour les athlètes africains les données sont pauvres.

Objectifs : Les objectifs de cette étude sont de déterminer et de comparer la prévalence et la distribution des aspects électrocardiographiques d'athlètes militaires africains comparés à ceux de non athlètes dans le groupe contrôle.

Méthodologie : Cette étude cas-témoin a été menée

sur une période de six mois, d'avril 2021 à septembre 2021 à l'Hôpital Principal de Dakar. Les participants étaient répartis en deux groupes. Le premier était composé de 155 militaires athlètes et le second groupe de 155 civils non athlètes. Dans les deux groupes, tous les participants étaient âgés de 18 à 35 ans. Un ECG standard 12 dérivations était réalisé pour chacun d'eux et tous les paramètres ECG étaient analysés.
Résultats : L'âge médian des participants était de 25,19 ± 4,19 ans pour les athlètes et 25,93 ± 3,57 ans dans le groupe contrôle. Pour les athlètes, la durée moyenne d'entrainement hebdomadaire était de 14,06 ± 5,87 heures. La majorité des sportifs avait des modifications sur l'ECG (90,3%). Les plus fréquents étaient la bradycardie sinusale (66%), l'hypertrophie ventriculaire gauche (45,2%), la repolarisation précoce (42,5%) et le bloc auriculoventriculaire du premier degré (18,7%). Tous ces paramètres étaient significativement élevés dans le groupe des athlètes comparé à celui du groupe contrôle.
Conclusion : L'interprétation d'un ECG doit tenir compte du niveau d'entrainement de l'individu. Les aspects électrocardiographiques les plus fréquemment rencontrés chez les sportifs sont la bradycardie sinusale, l'hypertrophie ventriculaire gauche, la repolarisation précoce et le bloc auriculoventriculaire de premier degré.
Mots-clés : électrocardiogramme, athlète, noir africain, bradycardie sinusale, repolarisation précoce.

Introduction

Intensive physical training can induce structural and functional changes in the heart called the athlete's heart, including changes to the electrocardiogram (ECG) [1]. It is important to know the physiological changes related to the practice of sport to avoid false assurances on the one hand, and on the other hand, the conduct of unjustified additional examinations due to misinterpretation. Interpretation of the ECG, however, is not easy, as manifestations of the athlete's heart, especially in African athletes, may resemble changes observed in cardiomyopathies and channelopathies [1-2].
In the literature, there are many studies on the electrocardiographic aspects of Caucasian athletes, but those on African black athletes remain few. There is therefore little data on the prevalence of ECG patterns in African athletes. The objective of this study is to determine the ECG aspects related to regular and intensive sports practice by comparing athletes and non-athletic subjects.

Methodology

This case-control study was carried out at the cardiology department of the Principal Hospital, a military hospital in Dakar. Dakar is the capital of Senegal, a country in West Africa. The study was conducted over a six-month period from April 2021 to September 2021. This is a case-control study to determine and compare the prevalence and distribution of ECG patterns among African military athletes and African non-athletes in the control group. Included in the first group were 155 military athletes who practiced competitive sports for at least one year with more than 8 hours of training per week. The ECGs were performed during their annual systematic visit. In the second group, there were 155 sedentary participants. In both groups, all participants were between the ages of 18 and 35. The exclusion criteria included symptoms suggesting underlying cardiovascular disease, a history of treatment or a previous diagnosis of chronic disease, or regular consumption of alcohol or tobacco. All participants completed a questionnaire administered by a researcher to obtain biographical data, relevant cardiovascular history, and information on sports discipline, duration and intensity of physical training. This questionnaire was developed for the study.
A standard 12-lead ECG was performed for all participants with a GE Healthcare MAC 2000 recorder. The ECG interpretation was performed by two different cardiologists.
All ECG parameters have been reviewed. Specifically,

the following criteria were considered evidence of ECG abnormality: heart rate 60 beats per minute (bradycardia) or> 100 bpm (tachycardia); extended PR interval defined as≥ 210 ms was considered as first Degree atrio-ventricular block (AV block), incomplete right bundle branch block (RBBB) as V1 rSR' with 120 ms QRS duration and left ventricular hypertrophy (LVH) on voltage criteria such as the sum of the S wave in V1 and the R wave in V5 or V6 35 mm. The QTc> was calculated by hand, using the "teach the tangent" method. The QT interval was measured in lead D2 or V5 (based on the best T-wave delineation), the previous RR interval was measured and the BAZETT formula was used to calculate QTc for participants with heart rates between 50 and 90 beats/min. For those with less than 50 beats/min, after jumping in the same place, the QTc has been calculated.

Statistical analysis of the data was conducted using SPSS Statistics version 25. The data were expressed as an average, standard deviation and p-value using the ANOVA test with the significant threshold value p≤ 0.05.

Results

Socio-demographic characteristics of the study population

A total of 310 participants were recruited for the study, 155 athletes and 155 non-athletes. The median age of participants was 25.19± 4.19 years for athletes and 25.93± 3.57 years for the control group. In both study groups, men accounted for 95% of the first group and 94% of the second group.

Sporting activities among athletes

The athletes represented a variety of sports. Martial arts, athletics, football and basketball were the most represented, as shown in Figure 1.

The weekly training time was 14.06± 5.87 hours, between 8 and 35 hours. The average age of sports practice was 5 years with extremes ranging from 1 to 15 years.

ECG patterns among athletes and controls

Fifteen athletes (9.7%) had a strictly normal ECG. The majority (90.3%) reported changes in their ECGs. The mean heart rate was significantly lower in athletes (p< 0.001). It was between 33 and 78 bpm. PR and QTc intervals, Sokolow-Lyon index were significantly higher in athletes. (Table 1). There was no significant difference between the two groups concerning P wave amplitude and duration.

Most of the ECG changes noted were sinus bradycardia (66%), left ventricular hypertrophy (45.2%), early repolarization (42.5%) and first-degree AV block (18.7%) in athletes. Other changes were 2nd degree Mobitz 1 atrio-ventricular block (3.9%), and incomplete right bundle branch block (6.5%). All of these parameters were significantly higher in the group of athletes than the second one. There was no significantly difference between the two groups concerning Left atrial enlargement (LAE), complete right bundle branch block and right ventricular hypertrophy (Table 2).

Most athletes had a sinus rhythm, except for 7 athletes (4.5%) who had a coronary sinus rhythm. The P-wave duration was on average shorter in athletes than in the control group, but this difference was not significant (p=0.281). Two cases of left atrial enlargement (LAE) have been found in athletes and non-athletes groups. These participants had an extended P-wave duration ≥ 120 ms in D1 or D2, with a negative part 1 mm deep and ≥ 40 ms in V1. The P-wave amplitude was normal in both groups.

The mean PR interval was longer (p=0.001) than the controls. It was between 120 and 320 ms for the athletes. Twenty-nine athletes (18.7%) had a first-degree AV block and six (3.9%) had a second-degree Mobitz I AV block on the ECG. There have been no cases of Mobitz II or complete AV block cases.

The incomplete RBBB was more common among sportspeople than among sedentary individuals (6.5% with p=0.005).

A complete RBBB was discovered in a sedentary athlete and participant. No cases of left branch bundle block were found in both groups.

Early repolarization was observed in 65 athletes (42.5%), mainly in V3, V4 and V5. These were the elevation of the J-spot, the elevation of the ST segment, and the notch of the terminal QRS (Figure 2).

Left ventricular hypertrophy (LVH) was the most common electrical change, except for sinus bradycardia, in athletes (45.2%). Of the athletes with LVH, 39 were active in endurance sports and 31 in resistance sports. There was no statistical difference by sport (p=0.469).

Right ventricular hypertrophy (RVH) was found on the ECG of three athletes.

The T-wave amplitude in V5 was also higher in the first group, but not statistically significant (p=0.260)

T-wave inversion (TWI) was noticed in 31 athletes on aVR, D3 and V1. Five presented J-spot elevation and ST-segment convex elevation, followed by TWI in V1-V4 leads. Three non-athlete participants also had this TWI on V1-V4.

The mean QT interval was significantly higher in the athlete group than in the non-sport group with an average QT of 369 ms versus 351 ms. No cases of long or short QT were found in either group.

Discussion

We report trends in ECG results among African military athletes and controls in Senegal. Our study population was almost the same age as found in other African studies between 23 and 25 years 3-5]. We found few women in the athlete subjects. This low proportion of women is also reported in African studies[4,6,7] and can be explained by the fact that few women, even today, reach a high level of training in our socio-cultural context. In addition, there is a small proportion of women in our military.

The ECG can usually have atypia's, as is the case in our study. Several authors have found that over 90% of athletes' ECGs show changes induced by intense and prolonged physical exercise [3,4,8].

Sinus bradycardia was the ECG characteristic presented by most of our athletes, at a statistically significant frequency, compared to other athletes (66% versus 7% with p< 0.001). TOGOUMA in her study reported 72.5% sinus bradycardia in athletes. This was also the most common electrocardiographic aspect of his study. Sinus bradycardia has also been reported by many other authors as the most common trend among athletes [3,8]. It is described as a frequent consequence of an increased vagal tone; and in the absence of symptoms, a frequency ≥ 30 beat/min heart rate is considered normal in highly trained athletes [1,9,10]

Changes in the rhythm and heart rate of coronary sinuses with respiration were found in our study among ECG changes, significantly higher in the athlete group than in the control group, at a respective prevalence of 4,5 and 7%. An ectopic atrial rhythm (e.g. a rhythm from the coronary sinus) or a junctional rhythm with a fine QRS and a HR of less than 100 bpm are also normal in athletes. In addition, respiratory arrhythmias (with increased heart rate during inhalation and slowing down during exhalation) are normal, especially in young subjects[10].

The first-degree AV block and the second-degree Mobitz 1 AV block (with progressive increase of the PR interval until a blocked P-wave is reached, the PR interval following the blocked P-wave being shorter than the last PR interval conducted) are also in the physiological range [1,9].

A Mobitz 1 and moderate PR interval extension (210-399 ms) are recognized benign features of athletic conditioning and usually resolve with hyperventilation or exercise [1,3,4,8,9,11,12]. Although a 400 ms PR interval or a resting heart rate of ≥ 30 beats/min, in rare cases, may be normal for a well-trained athlete. It should encourage further assessment of heart disease such as the assessment of chronotropic response to aerobic activity, echocardiography, Holter monitor [10].

LVH is a common ECG pattern of athletes in our study 41% (p=0.001) slightly lower than the prevalence of LVH found by African authors such as TOGOUMA (45.8%) and MOUSTAGHFIR, which also found a

Sokolow Lyon index (SLI) higher among athletes compared to controls ($p < 0.0005$) [3-4]. Some authors have suggested, comparing the ECG prevalence of LVH in Caucasian, West Asian and African athletes, that when using SLI even though blacks have a higher index than other ethnic groups, there was no significant difference in the presence of LVH between ethnicities. In contrast, using ROMHILT-ESTES probable score 4, the prevalence of LVH in black athletes was significantly higher ($p < 0.05$) than in West Asian and Caucasian athletes [11-12]. Studies have suggested a racial predilection for black athletes to develop LVH in response to exercise, perhaps because of a combination of genetic, endocrine and hemodynamic factors [9].

Pathological LVH is usually associated with additional ECG functions such as TWI in the inferior and lateral leads, ST-segment depression, and pathological Q-waves. Therefore, the isolated presence of ample QRS meeting the LVH stress criterion in the absence of other pathology-suggestive ECG or clinical markers is considered to be part of normal and training-related ECG changes in athletes and does not require further evaluation [10-14].

RVH was found in six of our participants, including two athletes. This electrocardiographic aspect, when present in isolation, does not correspond to the underlying pathology in athletes. In the latest ranking of athletes' ECG models, RVH has also been added to normal electrocardiographic variants in an athlete [9-16]. Indeed, in the previous rankings, RVH was considered abnormal for athletes, but with the new one, it is defined as a normal pattern of the athlete's ECG (Fig 3).

Several classifications of the athlete's ECG have followed one another. In 2010, the European Society of Cardiology published recommendations for the interpretation of the athlete's ECG, which were followed by two international consensuses in 2013 and 2014, refining the specificity of the criteria. Finally, new international recommendations were published in 2017 [10,16-18]. Even more striking, the refined criteria significantly improved the abnormal prevalence of ECG in black athletes to only 10% (versus 29.9% with ESC 2010 and 16.6% with Seattle criteria)[2].

These latest international recommendations for electrocardiographic interpretation in athletes present the current state of knowledge in a simple, clear and comprehensive manner. This consensus of experts classifies the athlete's ECG results into three groups: normal, limit, and abnormal : [2]

- *Normal*, not requiring assessment in the absence of symptoms or family history of hereditary heart disease or sudden death
- *Limit*, not requiring an evaluation if present in isolation, but requiring an evaluation if at least two of these anomalies are associated
- *Abnormal*, requiring further assessment of cardiovascular pathology that may be associated with sudden death in athletes (Figure 3).

We found few cases of LEA in our study (1.3%), much less than the proportion of LEA found in other studies such as 41.4% for TOGOUMA. LEA was many years ago, classified as abnormal. This aspect of ECG is now recognized as a "limit" outcome of physiological cardiac remodeling in athletes and does not represent pathological heart disease [10,19]. However, the criteria are restrictive for LAE due to the sports practice, which is defined by an extended P wave> 120 ms in D1 or D2, with a negative part ≥ 1mm deep and ≥ 40 ms in V1 [9].

In a large study of 2 533 athletes aged 14-35 years and 997 controls of similar age, echocardiographic evaluation of the 579 athletes and checks with tension criteria for enlargement did not identify major structural or functional abnormalities [18].

RAE was found in two of our athletes. This electrocardiographic scheme (≥ 2.5 mm P-wave in D2, D3 or aVF) is not yet recognized as abnormal for athletes. In addition, according to WILSON, black athletes had a significantly higher frequency ($p < 0.05$) of RAE than West Asian and Caucasian athletes. [11-12]

Like LAE and RAE, left axis deflection, right axis deflection, and the complete RBBB are considered boundary variants in athletes.

Some ECG functions require evaluation if at least two of them are present. In this case, an echocardiography should be performed first. This is the case of a complete RBBB (QRS duration between 120 and 140 ms), a deviation of the left axis (axis between -30° and -90°) or right axis (> 120°), a left or right atrial enlargement [9].

The presence of any of these results alone or with other recognized physiological electrical models of sports training does not warrant further evaluation in asymptomatic athletes. Conversely, the presence of more than one of these boundary discoveries places the athlete in the abnormal category warranting further investigation [8].

Early repolarization (ER) is common among athletes, with a prevalence ranging from 25% to 45 % among caucasian athletes, and ≥ 65% among athletes of afro-caribbean origin [9,20-22]. ER is defined as the 0.1 mV elevation of the QRS-ST junction (J-point) often associated with a late slurring or QRS notch (J-wave) affecting the inferior and/or lateral leads [10,23]. ER is common in healthy populations (2-44%) and is more common in athletes and Blacks aged beetween10-12 years.

In our study, we found an ER prevalence of 42.5% (Figure 2). Other studies on african or afro-carribean athletes found prevalences between 46 and 91% [2,3,5,20,21].

Thus, models of early repolarization in athletes in addition to black ethnicity, when they are present in isolation and without clinical markers of pathology, should be considered as benign variants in athletes [10-24].

In our study, we found other repolarization variants such as T Wave Inversion (TWI) on both groups, with a higher but not significant frequency in athletes. Anterior TWI is considered a normal variant in 16-year-old asymptomatic athletes, black athletes, when preceded by J-spot elevation and ST-segment convex elevation in black subjects, independently of the practice of sport [4,5,10,25,26]

It is important to emphasize the repolarization variants that are normal: T-waves can be negative in aVR, V1 and D3, and this is independent of sports practice. It is important to consider the effect of ethnicity on repolarization. Indeed, a ST segment elevation followed by a negative T-wave from V1 to V4 in an Afro-Caribbean athlete is also considered normal [10,25,26]. This variant is found in 13% of Afro-Caribbean athletes, while it is found in only 4% of sedentary people of the same ethnic origin. Seattle criteria had considered specific facets of ECG such as anterior TWI (V1-V4) (commonly seen in up to 13% of black athletes) to represent an ethnically benign variant of the athlete's heart among those of black ethnicity [2,10.14]. Black athletes typically have a repolarization variant consisting of a J-point elevation and a convex ST segment elevation in the anterior leads (V1 to V4), followed by a TWI that is considered a normal variant and should not be investigated further in the absence of other clinical features or ECGs of cardiomyopathy [10]. However, as TWI in V1 to V2/V3 leads is also a recognized trend in patients with arrhythmogenic right ventricular cardiomyopathy (ARVC) and rarely hypertrophic cardiomyopathy (HCM). Thus, it is justifiable with such ECG models to investigate non-black athletes or black athletes with other clinical or electrical characteristics of ARVC or HCM [10]. Conversely, a prior TWI associated with a minimum or missing 1 mm J-point elevation may reflect cardiomyopathy. Other ECG results suggesting ARVC include low limb bypass voltages, prolonged S-wave surge, ventricular ectopy with LBBB morphology, and an epsilon wave [10, 25]. A combination of tests is required to diagnose ARVC including echocardiography, cardiac MRI, Holter monitoring, stress ECG test and signal averaged ECG [10].

There are specificities regarding the QT interval in athletes. Indeed, the QT interval is extended by sports practice. In our study, the QTc was higher for the athlete group, but did not exceed 470 ms for men and 480 ms for women. These limit values are around the 99th percentile and correspond to the thresholds defined by the American Heart Association and the

American College of Cardiology [10].

Conclusion

Whether it is used for the assessment of cardiovascular symptoms or for the screening of asymptomatic athletes, ECG interpretation should consider the typical aspects of athletes but also the typical aspects of the African black athlete in particular those of repolarization. The most common ECG changes in athletes are sinus bradycardia, left ventricular hypertrophy, early repolarization, first-degree atrio-ventricular block, and T-wave inversion.

Strength of study

This is a case-control study that compares the ECG of athletes with that of non-athletes and thus determines the ECG models that are due to intensive sports practice.

Limitations

An associated echocardiographic study or inclusion in the study of athletes from other races, caucasians, asians or others may make this study useful.

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Conflict of interest : None

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