Scientific Research Publishing

World Journal of Cardiovascular Diseases, 2025, 15(10), 490-500
https://www.scirp.org/journal/wjcd
ISSN Online: 2164-5337
ISSN Print: 2164-5329

Electrocardiographic Abnormalities in High-Level Athletes in Brazzaville: A Cross-Sectional Study

Christian Michel Kouala Landa[1,2], Solange Flore Mongo Ngamami[1,2], Rosine Chris Melia Manzika Dzoussi[1], Rogue Pattern Bakekolo[1], Eric Gibrel Kimbally-Kaky[1,2], Kivie Mou-Moue Ngolo Letomo[1], Franck Yannis Kouikani[1], Bertrand Fikahem Ellenga-Mbolla[1,2]

[1]Department of Cardiology and Internal Medicine, University Hospital Center (CHU) of Brazzaville, Brazzaville, Republic of the Congo
[2]Faculty of Health Sciences, Marien Ngouabi University, Brazzaville, Republic of the Congo
Email: koualalanda@gmail.com

How to cite this paper: Kouala Landa, C.M., Mongo Ngamami, S.F., Manzika Dzoussi, R.C.M., Bakekolo, R.P., Kimbally-Kaky, E.G., Ngolo Letomo, K.M.-M., Kouikani, F.Y. and Ellenga-Mbolla, B.F. (2025) Electrocardiographic Abnormalities in High-Level Athletes in Brazzaville: A Cross-Sectional Study. *World Journal of Cardiovascular Diseases*, **15**, 490-500.
https://doi.org/10.4236/wjcd.2025.1510043

Received: September 19, 2025
Accepted: October 25, 2025
Published: October 28, 2025

Abstract

Background: The athlete's heart presents specific electrocardiographic adaptations that must be distinguished from pathological abnormalities to prevent sudden cardiac death. In Africa, specific challenges related to sports health require adapted screening protocols. Objective: To determine the prevalence and factors associated with electrocardiographic abnormalities in high-level athletes in Brazzaville. Methods: A cross-sectional analytical study was conducted from April to August 2019 at the Brazzaville sports medical center. Athletes aged 12 - 35 years with ≥6 hours weekly training were included. ECGs were interpreted according to ESC 2018 criteria, classifying abnormalities as physiological, borderline, or pathological. Results: Among 436 athletes (76.6% male, mean age 21.6 ± 5.1 years), ECG abnormalities were found in 87.6%: physiological (56.2%), borderline (7.8%), and pathological (23.6%). Male sex (ORa 4.4, 95% CI: 2.3 - 8.6) and endurance sports were significantly associated with abnormalities. Conclusion: he high prevalence of pathological abnormalities (23.6%) justifies reinforced cardiovascular screening in African athletes. ECG remains essential for preventing sudden cardiac death in this population.

Keywords

Athlete's Heart, Electrocardiography, Sudden Cardiac Death, Africa, Sports Medicine

1. Introduction

Regular and moderate physical activity is widely recognized for its cardiovascular health benefits [1]. However, intense and prolonged physical activity can lead to significant cardiovascular adaptations, commonly referred to as the "athlete's heart" [2], which, although generally benign, may obscure underlying cardiac pathologies. Sudden cardiac death in athletes, often associated with severe arrhythmias, remains a major concern [3]. Indeed, exertional sudden death primarily results from asymptomatic cardiopathies, which can be detected in 90% of cases through a resting Electrocardiogram (ECG) [4].

Non-invasive and cost-effective, the ECG has become an essential tool in screening for cardiac risks in athletes, with international guidelines making it a central element of the pre-participation sports medical examination [5] [6]. The risk of cardiac mortality is five times higher in competitive athletes than in recreational athletes of the same age [3]-[6].

In Africa, where there are specific challenges related to sports health [7] [8], the resting ECG is a key method for preventing sudden cardiac death by helping to differentiate between physiological anomalies and underlying pathologies. This study is set within a context where the monitoring of elite athletes in the Republic of Congo is being strengthened, aiming to better understand local ECG abnormalities and their implications for cardiovascular health in athletes.

2. Methodology

2.1. Study Design and Setting

A cross-sectional analytical study with prospective data collection was conducted from April 1 to August 31, 2019, at the Brazzaville sports medical center, located within the Alphonse Massamba Débat stadium. This center, placed under the coordination of the sports and anti-doping directorate, provides medical follow-up for all high-level athletes in Brazzaville and is equipped with an ECG-AM-3303G® electrocardiograph (Shanghai, China).

2.2. Population and Selection Criteria

The study included a thorough, exhaustive sampling of high-level athletes (≥6 hours training/week) who were seen for non-contraindication visits for the 2019 season. Inclusion criteria were age 12 to 35 years, sports practice for at least one year in a club affiliated with a recognized federation, and written consent. Symptomatic athletes and those who had ceased activity for more than six months were excluded.

Sports disciplines classification: for the purpose of this analysis, sports were classified into endurance and non-endurance categories based on their primary physiological demands. Endurance sports were defined as those requiring sustained cardiovascular effort with predominant aerobic metabolism for extended periods (>30 minutes). In our cohort, the following were classified as endurance

sports: football, marathon, and volleyball. Non-endurance sports included handball, taekwondo, and basketball, which are characterized by intermittent high-intensity efforts with shorter duration and greater reliance on anaerobic metabolism.

2.3. Data Collection and Procedures

2.3.1. Interview and Clinical Examination

A standardized interview [6] collected sociodemographic, sports-related data and medical history. Physical examination included blood pressure measurement (OMRON M3®), anthropometric parameters, and cardiovascular auscultation.

2.3.2. Electrocardiography

A 12-lead resting ECG was recorded after 15 minutes of rest in supine position, at 25 mm/second with standard calibration. Interpretation was performed according to ESC 2018 recommendations [9] for classification into physiological, borderline, and pathological abnormalities.

2.4. Variables and Definitions

Study variables included sociodemographic data (age, sex), sports-related factors (discipline, experience, weekly training duration), clinical parameters (history, physical examination), and electrocardiographic findings (rhythm, frequency, morphological abnormalities). ECG abnormalities were classified according to ESC 2018 criteria: physiological (athlete's heart), borderline (debated link with sports), and pathological (requiring thorough investigation) [9].

2.5. Statistical Analysis

Analysis was performed using EpiInfo 7.2®. Quantitative variables are expressed as mean ± standard deviation, qualitative variables as frequencies and percentages. Proportion comparisons used chi-square or Fisher tests. Multiple logistic regression identified factors associated with ECG abnormalities, including age, sex, sport type, and training duration. For the sport type variable in the multiple logistic regression analysis, handball was used as the reference category due to its largest representation in the cohort (31.4%). Variables with $p \leq 0.20$ in univariate analysis were included in the multivariate model. The significance threshold was set at $p < 0.05$.

3. Results

3.1. Population Characteristics

A total of 436 high-level athletes were included in the study. Men represented 76.6% of the sample (n = 334) with a sex ratio of 3.3:1. Mean age was 21.6 ± 5.1 years (range: 12 - 35 years), with a predominance of 12 - 19 years age group (43.1%).

Six sports disciplines were represented: handball (31.4%), football (21.6%), taekwondo (13.1%), basketball (12.4%), volleyball (11.7%), and marathon (9.8%). Mean weekly training duration was 8.6 ± 2.6 hours (range: 6 - 24 h), with 95.4% of athletes training 6 - 12 hours/week. Mean practice experience was 5.5 ± 4.5 years (range: 1 - 20 years).

3.2. Clinical Profile

Physical examination was normal in all athletes. Medical history revealed alcohol consumption in 13.5% of athletes (regular in 3.4%), current smoking in 2.7%, and family cardiovascular history in 11.5%. Mean body mass index was 20.6 ± 2.8 kg/m^2 with 8.3% overweight and 0.9% obesity. Blood pressure was normal in 81.4% of cases for systolic and 83.9% for diastolic.

3.3. Electrocardiographic Characteristics

Rhythm was sinus in 94% of athletes and regular in 75%. Mean heart rate was 64.3 ± 12.1 bpm with bradycardia in 37.6% of athletes. Mean cardiac axis was 59.1 ± 22.5˚, normal in 93.6% of cases.

Electrocardiographic Abnormalities

ECG abnormalities were detected in 87.6% of the athletes (n = 382). Among these, physiological abnormalities accounted for 56.2% (n = 245). Specifically, sinus bradycardia was observed in 37.6% of athletes (n = 164), early repolarization in 37.6% (n = 164), left ventricular hypertrophy in 43.3% (n = 189), right ventricular hypertrophy in 10.8% (n = 47), first-degree atrioventricular block in 5.7% (n = 25), Afro-Caribbean repolarization in 5.0% (n = 22), and sinus arrhythmia in 22.9% (n = 100).

Borderline abnormalities were present in 7.8% of athletes (n = 34). These included right axis deviation in 5.7% (n = 25), right atrial hypertrophy in 3.2% (n = 14), and both left axis deviation and left atrial hypertrophy in 0.7% each (n = 3).

Pathological abnormalities (23.6%, n = 103) are summarized in Table 1.

Table 1. Pathological ECG abnormalities.

Pathological Abnormality	Percentage (%)
T-wave inversion/flattening	19.3
Long QTc	1.6
Short QTc	1.2
Ventricular Extrasystoles	0.7
Pathological Q wave	0.2
Second-degree AV block (Mobitz II)	0.2

3.4. Factors Associated with ECG Abnormalities

Multivariate analysis identified several factors significantly associated with ECG abnormalities.

Overall, male sex was associated with a higher risk of ECG abnormalities, with

an adjusted Odds Ratio (ORa) of 4.4 (95% CI: 2.3 - 8.6; $p < 0.001$). Endurance sports were also linked to these abnormalities: football (ORa 2.4; 95% CI: 1.2 - 11.7; $p = 0.03$), marathon (ORa 2.5; 95% CI: 1.4 - 14.7; $p = 0.02$), and volleyball (ORa 4.2; 95% CI: 1.7 - 3.3; $p = 0.04$).

Regarding physiological abnormalities, sinus bradycardia was associated with male sex (ORa 3.8), age over 19 years (ORa 2.7), and training more than 13 hours per week (ORa 2.6). Early repolarization was strongly associated with male sex (ORa 17.4) as well as endurance sports. Finally, left ventricular hypertrophy was associated with male sex (ORa 4.5).

Overall factors associated with ECG abnormalities are presented in Table 2.

Figure 1. Representative 12-lead electrocardiogram demonstrating borderline abnormalities in a 17-year-old male handball player with 4 years of training experience. The ECG shows: (1) right axis deviation with QRS axis of 120˚; (2) right ventricular hypertrophy with $RV_1 + SV_5 = 16$ mm; and (3) early repolarization pattern with J-point elevation and upward concave ST segments (indicated by arrows) in the inferior and lateral leads.

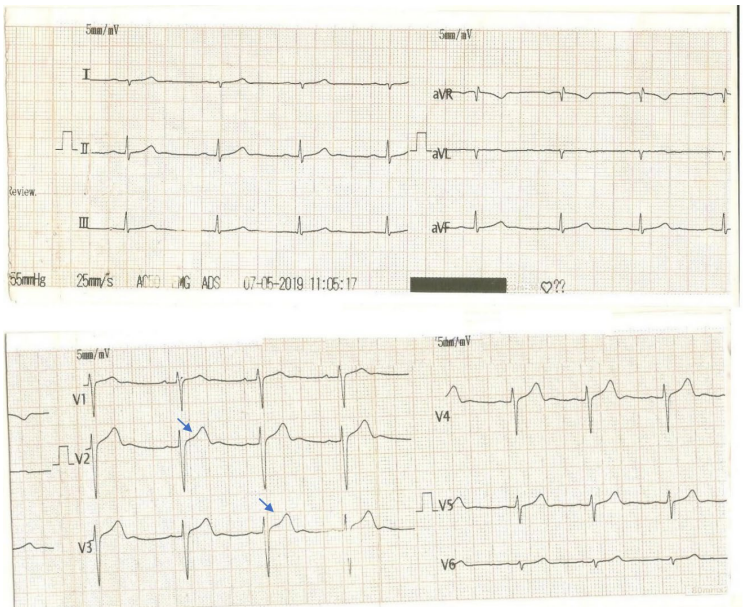

Figure 1. Electrocardiogram demonstrating borderline abnormalities, with right axis deviation (QRS axis 120˚), right ventricular hypertrophy (RV1 + SV5 = 16 mm), and early repolarization (arrows) in a 17-year-old handball player with 4 years of training.

Table 2. Overall factors associated with ECG abnormalities.

Variable	ECG Abnormalities Present n(%)	ECG Abnormalities Absent n(%)	OR [95% CI]	p-value	ORa [95% CI]	p-value
Sex						<0.001
Male	310 (81.2)	24 (44.4)	5.4 [2.9 - 9.7]	<0.001	4.4 [2.3 - 8.6]	<0.001
Type of sport						0.01
Handball	116 (30.4)	21 (38.9)	4.7 [1.1 - 20.8]	0.04	2.2 [0.5 - 10.2]	0.3

Continued

Football	85 (22.3)	9 (16.7)	2.7 [0.5 - 13.2]	0.2	2.4 [1.2 - 11.7]	0.03
Taekwondo	52 (13.6)	5 (9.3)	2.5 [0.5 - 13.5]	0.3	1.7 [0.3 - 9.5]	0.5
Marathon	39 (10.2)	4 (7.4)	1.4 [0.5 - 4.1]	0.5	2.5 [1.4 - 14.7]	0.02
Volleyball	38 (10.0)	13 (24.1)	8.9 [1.9 - 41.7]	0.006	4.2 [1.7 - 3.3]	0.04
Years of practice						0.09
1 - 10 years	336 (88.0)	43 (79.6)	1.9 [0.9 - 3.9]	0.09	1.5 [0.7 - 3.3]	0.3

ORa: Adjusted Odds Ratio; Bold values indicate statistical significance ($p < 0.05$).

4. Discussion

4.1. Results Interpretation and Clinical Significance

The high prevalence of electrocardiographic abnormalities observed in our study (87.6%) reflects a fundamental duality between physiological adaptations of the athlete's heart and the potential presence of underlying pathologies. This distinction is of paramount importance for cardiovascular risk stratification in high-level athletes.

Typical abnormalities of physiological adaptations include sinus bradycardia (37.6%), early repolarization (37.6%), left ventricular hypertrophy (43.3%), and first-degree atrioventricular blocks (5.7%) [9]. These modifications reflect cardiac adaptation to intensive training through harmonious electrical and morphological remodeling.

The exceptionally high prevalence of pathological abnormalities (23.6%) observed in our cohort represents a significant clinical concern and warrants detailed analysis. The most frequent pathological finding was inverted or flat T waves, observed in 19.3% of athletes. These repolarization abnormalities can indicate underlying cardiomyopathies, including hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, or dilated cardiomyopathy—all conditions associated with increased risk of sudden cardiac death during exercise. Prolonged QTc intervals (1.6%) suggest channelopathies such as long QT syndrome, which can predispose to potentially fatal ventricular arrhythmias. Complex conduction disorders (1.1%) may indicate structural heart disease or infiltrative processes, while pathological Q waves (0.9%) could suggest previous myocardial infarction or cardiomyopathy. The presence of ventricular arrhythmias (0.7%) is particularly concerning, as these can be harbingers of more serious arrhythmic events during physical exertion. These findings collectively indicate that nearly one in four athletes in our study population requires a comprehensive cardiological evaluation to exclude life-threatening cardiac conditions.

4.2. International Comparative Analysis and Contextual Factors

Our results fall within the variability observed internationally but reveal a higher prevalence than European and North American studies. This difference is explained by several contextual factors: limited accessibility to preventive cardiovascular care in our context, socioeconomic conditions influencing medical management, and genetic specificities of African populations [10]-[12].

Regarding genetic specificities in African populations, previous research has demonstrated distinct electrocardiographic patterns in athletes of African descent. Studies by Rawlins *et al*. have shown that athletes of African/Afro-Caribbean origin exhibit higher rates of early repolarization patterns, T-wave inversions in the right precordial leads, and voltage criteria for left ventricular hypertrophy compared to Caucasian athletes. These findings are consistent with the "benign" repolarization variants described in up to 25% of young black athletes [18]. The Afro-Caribbean repolarization pattern observed in 5% of our cohort aligns with these ethnic-specific ECG characteristics. Research has also indicated that black athletes demonstrate greater cardiac chamber dimensions and wall thickness, which may explain the higher prevalence of voltage criteria for ventricular hypertrophy observed in our population. These genetic and ethnic influences on cardiac adaptation necessitate population-specific interpretation criteria for ECG screening in African athletes.

Male predominance (sex ratio 3.3:1) reflects local sociocultural realities where female access to high-level sports remains restricted [13]. The mean age of our athletes (21.6 ± 5.1 years) corresponds to international standards [14]-[16], confirming the representativeness of our cohort.

4.3. Risk Factors and Physiopathological Mechanisms

The significant association between male sex and ECG abnormality prevalence (ORa 4.4; 95% CI 2.3 - 8.6) is explained by fundamental physiopathological differences. Men present superior myocardial mass, a more pronounced hypertrophic response to training, and hormonal influence (testosterone) favoring certain cardiovascular adaptations [12] [17].

Endurance sports (football ORa 2.4, marathon ORa 2.5, volleyball ORa 4.2) impose specific cardiovascular stress characterized by chronic volume overload. This overload leads to cardiac cavity dilatation, intraventricular conduction modifications, and vagal hypertonia explaining the increased prevalence of ECG abnormalities [18] [19]. Sinus bradycardia, multifactorial in nature, results from cardiac hypertrophy, decreased intrinsic sinus node frequency, and autonomic balance modifications [18].

4.4. Abnormality Classification and Clinical Implications

The use of ESC 2018 criteria [9] allows precise classification into three categories:

Physiological abnormalities (56.2%): sinus bradycardia, early repolarization, ventricular hypertrophies, and first-degree AV blocks, reflecting the adapted athlete's heart.

Borderline abnormalities (7.8%): axial deviations, atrial hypertrophies, whose link with sports activity remains debated but is more frequent in black athletes [15] [17].

Pathological abnormalities (23.6%): inverted/flat T waves, prolonged QTc, requiring temporary cessation and thorough cardiological evaluation [9] [20] [21].

4.5. Methodological Aspects and Representativeness

4.5.1. Study Strengths

The strategic choice of Brazzaville sports medical center ensures optimal centralization of high-level athlete follow-up. Exhaustive sampling during major competition periods ensures maximum and diversified recruitment. The calculated sample size (n = 436) limits selection bias, and application of ESC 2018 criteria ensures standardized interpretation [9].

4.5.2. Limitations

The monocentric nature limits generalization to the entire Congolese territory. Modest training duration (8.6 ± 2.6 h/week) compared to international standards [22] [23] could influence adaptation prevalence. The absence of complementary explorations (echocardiography, exercise testing) constitutes a limitation for complete cardiovascular phenotype characterization.

4.6. Specific Population Characteristics

The observed electrocardiographic parameters (mean heart rate 64.3 ± 12.1 bpm, cardiac axis 59.1 ± 22.5˚) correspond to expected athlete's heart adaptations [24] [25]. Repolarization disorders, particularly frequent in African athletes [18], include Afro-Caribbean repolarization (5%), specific to the black athlete's heart and reflecting racial influences on cardiovascular adaptation [17].

The absence of symptoms in all athletes confirms the often asymptomatic nature of cardiac adaptations and certain potentially lethal pathologies, emphasizing the importance of electrocardiographic screening [26]-[28].

4.7. Clinical Implications and Perspectives

This study establishes the foundation for a cardiovascular screening protocol adapted to the African context. The high prevalence of pathological abnormalities (23.6%) justifies reinforced surveillance and integration of complementary explorations into management algorithms. Development of a national multicentric network would improve data representativeness and validation of norms specific to African populations.

The identification of 23.6% of abnormalities requiring thorough evaluation underscores the public health challenge represented by sudden cardiac death prevention in Sub-Saharan African athletes.

5. Conclusion

Athletes in Brazzaville are young, predominantly male, and present electrocardiographic abnormalities mainly related to male sex and endurance sports. More than half of the athletes have physiological abnormalities, and nearly a quarter present pathological abnormalities that may expose them to the risk of sudden death during exercise, requiring complementary investigations. ECG remains an important screening tool for the prevention of sudden cardiac death in athletes.

Good knowledge of the criteria for interpreting the athlete's electrocardiogram avoids erroneous and non-contextualized analysis.

Ethical Considerations

The study received approval from the Health Sciences Research Ethics Committee (CERSSA) and authorization from the sports medical center. Anonymity and confidentiality were guaranteed through an individual numbering system.

Acknowledgements

The authors thank the Brazzaville sports medical center staff and all participating athletes for their cooperation in this study.

Conflicts of Interest

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

References

[1] Ancion, A. and Lancellotti, P. (2018) Pratiques sportives: Risques et toxicité cardiaques potentiels. *Journal de Traumatologie du Sport*, **35**, 143-147. https://doi.org/10.1016/j.jts.2018.07.003

[2] Schnell, F. and Carré, F. (2013) Cardiomyopathie ou coeur d'athlète. *La Lettre du Cardiologue*, **469**, 18-21.

[3] Carré, F. (2014) La mort subite liée à la pratique sportive. *La Presse Médicale*, **43**, 831-839. https://doi.org/10.1016/j.lpm.2014.04.010

[4] Toure, K. (2009) Particularités de la repolarisation chez le footballeur noir africain de haut niveau. Thèse de Médecine, Université de Bamako.

[5] Corrado, D., Pelliccia, A., Bjørnstad, H.H., Vanhees, L., Biffi, A., Borjesson, M., *et al.* (2005) Cardiovascular Pre-Participation Screening of Young Competitive Athletes for Prevention of Sudden Death: Proposal for a Common European Protocol. *European Heart Journal*, **26**, 516-524. https://doi.org/10.1093/eurheartj/ehi108

[6] Carré, F., Brion, R., Douard, H., Marcadet, D., Leenhardt, A., Marçon, F., *et al.* (2009) Recommandations concernant le contenu du bilan cardiovasculaire de la visite de non contre indication à la pratique du sport en compétition entre 12 et 35 ans. *Archives des Maladies du Coeur et des Vaisseaux*, **102**, 1169-1176.

[7] Gassina, L.G., Mekoulou Ndongo, J., Guessogo, W.R., Assomo Ndemba, P.B., Tchoundjin, E., Bika Lele, E.C., *et al.* (2019) Electrocardiographic Characteristics of Athletes of Mount Cameroon Ascent: Prevention of Sudden Death. *European Journal of Physical Education and Sport Science*, **5**, 47-60.

[8] Goeh Akue, E., Aba Maloum, I., Djibril, M., Assou, K., Kossidze, K. and Agbetra, A. (2012) Etude des anomalies électrocardiographiques chez le sportif togolais. *Journal de la Recherche Scientifique de l' Université de Lomé*, **14**, 27-31.

[9] Sharma, S., Drezner, J.A., Baggish, A., Papadakis, M., Wilson, M.G., Prutkin, J.M., *et al.* (2017) International Recommendations for Electrocardiographic Interpretation in Athletes. *European Heart Journal*, **39**, 1466-1480. https://doi.org/10.1093/eurheartj/ehw631

[10] Sangare, I., Bâ, H.O., Camara, Y., Menta, I., Sidibé, N., Coulibaly, S., *et al.* (2019) ECG and Echocardiographic Findings of Athletes in Bamako—A Study among 227 Foot-

ballers. *World Journal of Cardiovascular Diseases*, **9**, 31-41. https://doi.org/10.4236/wjcd.2019.91004

[11] Rejeb, O.B., Ghali, H., Massoudi, Y., Gharbi, A., Bouhlel, I., Ernez, S., *et al.* (2019) Etude de la repolarisation chez les sportifs de race noire. *Pan African Medical Journal*, **33**, Article 114. https://doi.org/10.11604/pamj.2019.33.114.14241

[12] Abu Bakar, N.A., Luqman, N., Shaaban, E. and Abdul Rahman, H. (2018) Prevalence and Predictors of Electrocardiogram Abnormalities among Athletes. *Asian Cardiovascular and Thoracic Annals*, **26**, 603-607. https://doi.org/10.1177/0218492318807533

[13] Tougouma, S.J.-B., Zingue Ouattara, W.B.A., Yaméogo, N.V., Kambiré, Y., Millogo, G.R.C., Kologo, J.K., *et al.* (2019) Le cœur d'athlète de haut niveau d'entraînement: Résultats d'une enquête transversale menée à Bobo-Dioulasso, Burkina Faso. *Annales de Cardiologie et d'Angéiologie*, **68**, 17-21. https://doi.org/10.1016/j.ancard.2018.06.001

[14] Bakkum, A., Bresler, C., Nortie, L., Shaw, I. and Shaw, B.S. (2011) Prevalence of Risk Factors for Sudden Cardiac Death in Competitive South African Student Athletes. *African Journal for Physical Health Education, Recreation and Dance*, **17**, 581-590.

[15] Maillot, N., Guenancia, C., Yameogo, N.V., Gudjoncik, A., Garnier, F., Lorgis, L., *et al.* (2017) Impact of the Dynamic and Static Component of the Sport Practised for Electrocardiogram Analysis in Screening Athletes. *Scandinavian Journal of Medicine & Science in Sports*, **28**, 575-584. https://doi.org/10.1111/sms.12949

[16] García-Ortiz, J. (2017) Tamización cardíaca para prevención de muerte súbita en atletas de representación de la Universidad de Antioquia, Medellín, Colombia. *IATREIA*, **30**, 265-275. https://doi.org/10.17533/udea.iatreia.v30n3a02

[17] Rawlins, J., Carre, F., Kervio, G., Papadakis, M., Chandra, N., Edwards, C., *et al.* (2010) Ethnic Differences in Physiological Cardiac Adaptation to Intense Physical Exercise in Highly Trained Female Athletes. *Circulation*, **121**, 1078-1085. https://doi.org/10.1161/circulationaha.109.917211

[18] Gabus, V. and Monney, P. (2017) Cœur et sport. *Revue Médicale Suisse*, **13**, 1077-1082. https://doi.org/10.53738/revmed.2017.13.564.1077

[19] Burgan, H. and Burri, H. (2013) Sports d'endurance et arythmies. *Revue Médicale Suisse*, **9**, 514-519. https://doi.org/10.53738/revmed.2013.9.376.0514

[20] Carré, F. (2013) Le coeur de l'athlète. *Médecine du Sport*, **87**, 1-12.

[21] Meyer, D.P. (2017) Interprétation de l'électrocardiogramme de l'athlète Recommandations 2017 pour le non-cardiologue. *Revue Médicale Suisse*, **13**, 1318-1323. https://doi.org/10.53738/revmed.2017.13.569.1318

[22] Ouldzein, H., Azzouzi, F., Ayadi-Koubaa, D., Bartagi, Z., Cherradi, R. and Mechmeche, R. (2007) Analyse de l'électrocardiogramme et de l'échocardiographie de 181 footballeurs professionnels tunisiens. *Science & Sports*, **22**, 78-86. https://doi.org/10.1016/j.scispo.2006.12.006

[23] Moustaghfir, A., Hda, A., Benyass, A., Zahi, M., Boukili, A., Ohayon, V., *et al.* (2002) Cœur du sportif: Modifications électriques et échocardiographiques au repos. Étude de 75 sportifs et de 45 témoins. *Annales de Cardiologie et d'Angéiologie*, **51**, 188-192. https://doi.org/10.1016/s0003-3928(02)00100-2

[24] Berte, B., Duytschaever, M., Elices, J., Kataria, V., Timmers, L., Van Heuverswyn, F., *et al.* (2015) Variability in Interpretation of the Electrocardiogram in Young Athletes: An Unrecognized Obstacle for Electrocardiogram-Based Screening Protocols. *Europace*, **17**, 1435-1440. https://doi.org/10.1093/europace/euu385

[25] Griffet, V., Finet, G., Di Filippo, S., Lantelme, P., Caignault, J.-R. and Guérard, S. (2013) Le cœur d'athlète de l'adolescent: Aspects électrocardiographiques et échocardiographiques. À propos de 107 sportifs français. *Annales de Cardiologie et d'Angéiologie*, **62**, 116-121. https://doi.org/10.1016/j.ancard.2013.02.003

[26] Liesemer, K., Flanagan, R., Johnson, E., Devenport, M., Cartwright, V. and Puntel, R. (2010) The Role of Screening Electrocardiograms in the Evaluation of ROTC Cadets Applying for Flight Status. *Military Medicine*, **175**, 525-528. https://doi.org/10.7205/milmed-d-09-00090

[27] Price, D.E., McWilliams, A., Asif, I.M., Martin, A., Elliott, S.D., Dulin, M., *et al.* (2014) Electrocardiography-Inclusive Screening Strategies for Detection of Cardiovascular Abnormalities in High School Athletes. *Heart Rhythm*, **11**, 442-449. https://doi.org/10.1016/j.hrthm.2013.12.002

[28] Zorzi, A., ElMaghawry, M. and Corrado, D. (2015) Evolving Interpretation of the Athlete's Electrocardiogram: From European Society of Cardiology and Stanford Criteria to Seattle Criteria and Beyond. *Journal of Electrocardiology*, **48**, 283-291. https://doi.org/10.1016/j.jelectrocard.2015.01.007