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Electrocardiogram Screening in Elite Visually Impaired Football Players: Comparative Study Based on Vision Impairment

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Abstract

Introduction: Exercise cardiovascular research has historically focused on non-para athletes. Studies to date have under-represented the cardiac characteristics of para-athletes, despite their unique cardiovascular physiology and risks. There may be significant overlap of such conditions with cardiac pathology that could be overlooked. Therefore, we aim to study the outcomes of pre-participation cardiac screening including resting ECG in Sub-Saharan African visually impaired football players. **Material and methods**: A descriptive cross-sectional and comparative study was conducted in November 2025. The study population consisted of Senegalese male visually impaired football players who were divided into two groups according to the nature of their visual impairment: Group 1 (n = 17), composed of completely blind players (B1 category), and Group 2 (n = 8), composed of visually impaired players (B2 or B3 category) and sighted players. Participants were examined at the Functional Exploration Department of the Thies Regional Hospital, where they underwent a clinical examination followed by a resting ECG recording. **Results:** The study population consisted of 25 players from five Senegalese regions, reflecting a national representation of the discipline, with an average age of 18.92 ± 2.92 years, ranging from 15 to 25 years. The mean heart rate was 77 ± 9 bpm, with a range from 59 to 90 bpm. The mean systolic and diastolic blood pressures were 119 ± 8 mmHg and 73 ± 9 mmHg, respectively. Electrocardiographically, all players exhibited a normal sinus rhythm, axis, and QTc interval. Most athletes (96%) showed ECG signs consistent with an electrical athlete's heart, with a predominance of early repolarization (88%), following by LVH (84%), and LAE (28%). A significantly higher heart rate was found in Group 2 compared to blind players ($p = 0.01$). The common ECG changes were more numerous in Group 1 but occurred at lower percentages compared to Group 2, specifically regarding repolarization abnormalities, LVH, and LAE. **Conclusion**: Practice of blind football (Football 5-a-side) induces cardiac adaptations similar to those observed in sighted athletes, but less frequently, regardless of the degree of visual impairment.

Keywords

ECG, Athlete's Heart, Para-Sport, Senegal

1. Introduction

Pre-screening competitive athletes can improve detection of cardiac abnormalities and minimize the risks associated with athletic participation. Many medical societies and sports governing bodies recommend it, consisting of a focused history and physical examination following by a 12-lead electrocardiogram (ECG) [1] [2]. Para athletes are an atypical group with a wide variety of medical conditions. Some common medical issues will prevail in relation to the impairment types, and these need to be considered as part of the medical provisions at events. Paralympic sports medicine is a newly adopted term to describe the varied health care issues associated with athletes in the Paralympics [3]. Initial ECG screening was criticized for high false-positive rates that led to substantial costs associated with secondary testing and unnecessary (temporary) restriction of athletes from participation. This led to substantial efforts by the scientific community to better understand the difference between physiologic and pathologic ECG findings in athletes [4]. Para-footballers were more likely to require downstream testing after initial screening [5]. Footballers with vision impairment compete in blind or partially sighted football; both are adapted versions of futsal, but are distinctly different forms of Para football. Blind footballers rely on auditory information, such as verbal instruction from guides, a sounded ball (bellball), and shouts of "*voy*" so player location can be estimated; moreover, eyeshades are worn, and kickboards are mounted pitch side on an uncovered outdoor court to ensure optimum acoustics [6]. Studies to date have under-represented cardiac characteristics of para athletes, despite their unique cardiovascular physiology and risks. Cardiac remodeling in Paralympic athletes differed by disability and sport discipline [3]. Therefore, we aim to study the outcomes of pre-participation cardiac screening including resting ECG in Sub-Saharan African visually impaired football players.

2. Methodology

2.1. Study Design

We conducted a cross-sectional, descriptive, and comparative study in November

2025 in Thies, Senegal.

2.2. Study Population

The study population consisted of visually impaired Senegalese male footballers playing at the national and international levels and residing in centers for visually impaired people located in different regions of the country. Non-inclusion criteria were athletes who voluntarily refused to participate in the study and all staff members. The study involved 25 players recruited during the selection process for the men's national team, including 23 visually impaired outfield players, who wore eye shades during training and matches, and 2 sighted goalkeepers. The participants were then divided into two groups according to the nature of their visual impairment: Group 1 (n = 17), composed of completely blind players (B1 category), and Group 2 (n = 8), composed of visually impaired players (B2 or B3 category) and sighted players.

2.3. Study Protocol

The players were examined at the Functional Explorations Department of the Thies Regional Hospital, where all procedures were carried out. Explanations regarding the study procedure and the benefits of participation were provided beforehand.

The evaluation comprised a health questionnaire and standard 12-lead ECG. High blood pressure (BP) was defined as a systolic BP of ≥140 mm Hg and/or diastolic BP of ≥90 mm Hg at the time of screening. A player was only labeled as having hypertension if this was self-reported as a known diagnosis or if their BP was elevated on re-evaluation after the screening, having been confirmed on repeat measurements with a validated automated device (*Omron M4 Intelli IT*).

A standard 12-lead ECG was performed, with the participants in the supine position during quiet respiration using an ECG recorder (Eolys, France) at a paper speed of 25 mm/s and amplification of 10 mm/mV. Wave voltages were measured in each lead using callipers and a millimetre ruler as described elsewhere. Left ventricular (LV) and right ventricular (RV) hypertrophy were defined using the Sokolow-Lyon voltage criteria. T-wave inversion (TWI) was adjudicated per International Criteria, accounting for age and ethnicity: anterior TWI confined to V1 - V4 for the study population (Afro-Caribbean athletes), if preceded by ST elevation, were considered physiological; inferior and lateral TWI were considered abnormal. A short PR interval was defined as a PR interval of <120 ms. The QT interval was corrected for heart rate using Bazett's formula [7]-[9]. ECGs were initially analysed by a first cardiologist with expertise in sports cardiology and inherited cardiac conditions. All ECGs were re-evaluated independently by the first author (MSC) in 2025 with retrospective application of the International Criteria for Electrocardiographic Interpretation in Athletes [10]. The results of visually impaired football players with equivocal ECG findings were discussed with the second senior cardiologist who made the final adjudication.

The result of the cardiac evaluation for each football player was categorised as either “normal” (no findings requiring action), “borderline/uncertain-further testing required” (findings that are likely physiological or minor but require additional evaluation), or “abnormal—further testing required” (findings that may suggest cardiac pathology and require additional evaluation). The decision to deem football players fit to train and play was made in accordance with (1) a shared decision-making approach and (2) contemporary recommendations [10] [11].

2.4. Statistical Analysis

Clinical and demographic data were collected using Microsoft Excel 2023. Statistical analysis was performed using R Studio 2026 4.0. The normal distribution of all continuous variables was examined using the Shapiro-Wilk test. Continuous variables were presented as means and standard deviations. Categorical variables were described as percentages. Differences in proportion between two independent populations were analysed using the Chi^2 test or Fisher’s exact test as appropriate, and continuous variables were analysed using the t-test. The significance level for statistical tests was set at $p < 0.05$.

2.5. Ethical Considerations

Written consent for the screening was obtained from each football player or from the technical staff for visually impaired players following verbal authorization. They were assured of the anonymity and confidentiality of the information collected throughout the data collection, analysis, and dissemination process, in accordance with the principles of the Declaration of Helsinki.

3. Results

3.1. General Characteristics

The study population consisted of 25 young players from five Senegalese regions, reflecting a national representation of the discipline, with a mean age of 18.92 ± 2.92 years and a range of 15 to 25 years. Their weekly training volume exceeds 10 hours, with a daily session of at least 90 minutes. All players follow the same session, which begins with a warm-up and activation exercises, followed by high-intensity exercises with and without the ball, and ends with a scrimmage. Any cardiac symptoms were reported in para players, such as chest pain, dyspnea, palpitations, or anterior faintness during physical activity. The players have a mean height of 1.75 ± 0.72 m and a mean weight of 64.88 ± 11.534 kg, corresponding to a mean BMI of 21.04 ± 3.22 kg/m^2. However, we noted a mean BMI significantly higher in group 1 compared to group 2, in contrast to the higher heart rate (HR) recorded among players in group 2. **Table 1** summarizes the general and cardiovascular data of the two groups.

Table 1. General characteristics and cardiovascular data of visually impaired football players.

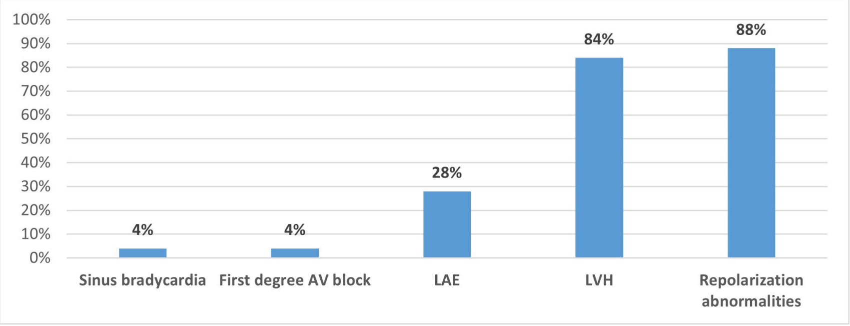
Parameters	Group 1 (mean ± SD)	Group 2 (mean ± SD)	p-value
Age (years)	19.59 ± 2.29	17.50 ± 1.75	0.1
Weight (kg)	67.88 ± 9.77	58.50 ± 3.25	**0.01**
Height (cm)	1.75 ± 0.61	1.74 ± 0.58	0.26
BMI (kg/m^2)	21.94 ± 2.62	19.31 ± 0.78	0.05
HR (bpm)	74 ± 7	84 ± 3	**0.01**
SBP (mmHg)	121 ± 7	116 ± 6	0.3
DBP (mmHg)	75 ± 7	71 ± 9	0.4
MBP (mmHg)	90 ± 7	86 ± 6	0.4

BMI: Body Mass Index, HR: Heart Rate, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MBP: Mean Arterial Blood Pressure.

3.2. ECG Characteristics

The following graphs (**Figures 1-4**) present the frequency of ECG changes in the general population and for both groups.

- **Frequency of ECG characteristics in the general population**



AV: Atrioventricular, LAE: Left atrial enlargement, LVH: Left ventricular hypertrophy.

Figure 1. Frequency of ECG characteristics.

Repolarization abnormalities were most frequent (88%), followed by LVH (84%) and LAE (28%).

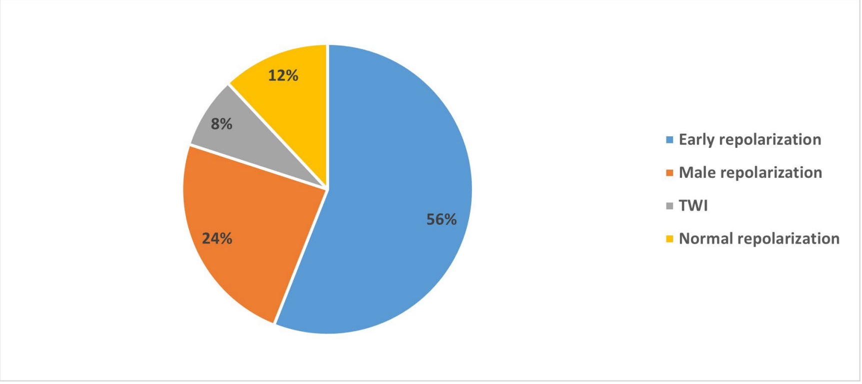
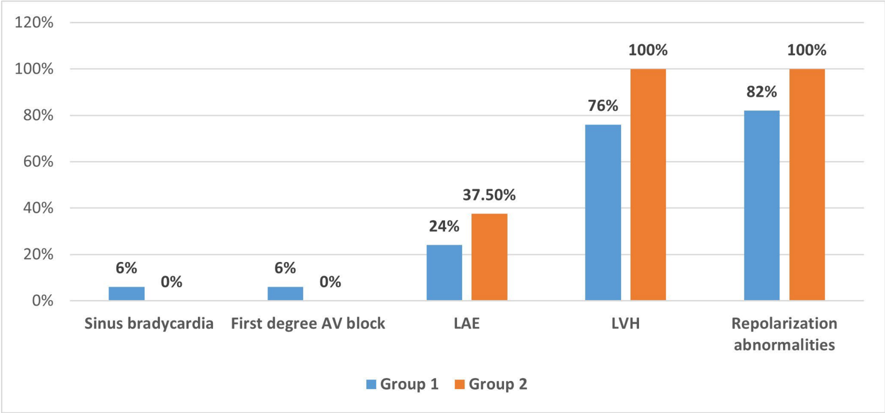


Figure 2. Frequency of repolarization variants.

Various repolarization variants were identified, with the highest frequency observed for early repolarization (56%), followed by male-pattern repolarization (24%), and T-wave inversion (8%).

- **Frequency of ECG characteristics in two groups**



AV: Atrioventricular, LAE: Left atrial enlargement, LVH: Left ventricular hypertrophy.

Figure 3. Frequency of ECG characteristics in two groups.

The common ECG changes were more numerous in Group 1 but occurred at lower percentages compared to Group 2, specifically regarding repolarization abnormalities (100% vs. 82%), LVH (100% vs. 76%), and LAE (37.5% vs. 24%).

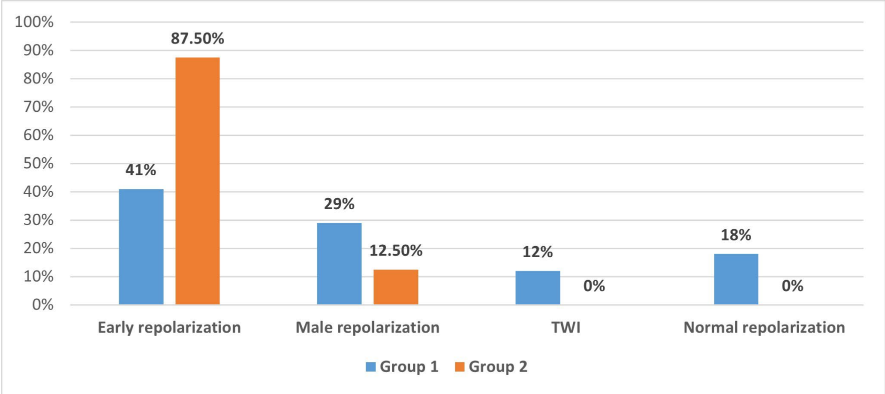


Figure 4. Frequency of repolarization variants in two groups.

Players in Group 1 exhibited a more pronounced percentage of early repolarization compared to the other group. However, for other repolarization variants (male-pattern repolarization and TWI), the blind players exhibited higher percentages.

4. Discussion

In Paralympic Sport, Football 5-a-side is a game played by athletes with visual impairment and is known worldwide as blind football. People are often surprised by how quick, physical, and technical blind football is. This is what makes it such a hugely popular parasport [6]. To date, the scientific literature specifically addressing the electrocardiogram (ECG) of visually impaired football players is still emerging compared to that concerning their sighted counterparts. However, it highlights fascinating features linked to a dual adaptation: physiological (high-level sport) and sensory (visual impairment). This study has shed light on clinical and ECG findings specific to Senegalese visually impaired football players. The sport-specific nature of ECG changes necessitates interpretation criteria that account for the physiological demands inherent to each discipline. The latest International criteria for interpreting athlete ECGs [10] provide a robust framework for distinguishing physiological adaptations from abnormalities, although further refinement is needed to address the unique cardiovascular responses observed in various non-Paralympic sports.

4.1. Anthropometric Characteristics

Regarding the anthropometric parameters of our study population, participants showed mean height, weight, and BMI values of 1.75 ± 0.72 m, 64.88 ± 11.53 kg, and 21.04 ± 3.22 kg/m^2, respectively, corresponding to a normal morphological profile. Recent studies describe profiles where the height is approximately 163.6 and 181 cm, the BMI is in the range of 22.3 and 25.6 kg/m^2, the lean mass is between 43.6 and 45.6 kg, and a somatotype with a predominance of the mesomorphic component [12]. These results are relatively comparable to the anthropometric characteristics typically found in elite sighted footballers. Similarly, no statistically significant differences were reported in fat mass or fat-free mass between visually impaired males and females and sighted athletes ($p > 0.05$) [13].

4.2. Cardiovascular Characteristics

Cardiovascular adaptations induced by various sports reflect the specific hemodynamic and physiological demands placed on the heart of the elite athlete. Cardiac vagotonia has previously been reported to be due to the predominance of the parasympathetic nerve over the sympathetic nerve and is manifested by a reduction in resting HR. Currently, it is rather considered that the main changes leading to a reduction in resting HR take place in the sinoatrial node [14]. The increase in vagal tone on the heart occurs as part of the adaptation processes to exertion, and the decrease in HR at rest is considered a physiological adaptation of the body to episodes of strong sympathetic stimulation by intense muscle work during sports. On the other hand, reduced resting HR was not found in strength sports [15]. Combined sports may result in a greater reduction in resting HR; for example, cricketers showed lower resting HR (57 beats per minute) than other athletes and non-athletes in one study [16].

4.3. ECG Changes

The biggest challenge in evaluating ECGs in elite athletes is identifying and distinguishing ECG findings that suggest an underlying pathology from those that are adaptive and benign and occur due to regular, intense training (e.g., exercise-induced cardiac remodeling or athlete's heart). However, differentiating between physiological adaptations and pathological abnormalities remains a significant challenge, particularly when considering variations across different sports, ages, and genders [17]. Therefore, it is essential to establish criteria for distinguishing normal ECG findings in athletes from ECG abnormalities to avoid a high rate of false positive findings, which require time-wasting additional exams. The overall experience in interpreting baseline 12-lead ECGs in elite athletes is condensed in the "International Criteria for Electrocardiographic Interpretation in Athletes" [10].

In this study with a specific young sportive population, commonly observed ECG changes, such as electrical signs of athlete's heart, included left ventricular hypertrophy (LVH), left atrial enlargement (LAE), early repolarization patterns, first-degree AV block, and sinus bradycardia. Indeed, intense physical activity substantially increases cardiac output to meet the metabolic needs of active muscles. This causes long-term electrical manifestations on the resting ECG that reflect increased vagal tone and dilation and/or hypertrophy of the cardiac chambers [10]. This implies that the participating players meet the criteria for recognizing ECG changes related to sports, thereby ensuring the reliability of the recorded results. Adolescents who engage in regular sports displayed fewer abnormal ECG findings than adults. The ECG changes studied were more frequent among players with visual impairment (Group 2) than among blind players (Group 1); in contrast, we noted many more ECG abnormalities in Group 1.

The results of a recent comparative study revealed no differences in ECG findings between para-football players and non-para-football players, except that sinus bradycardia was less frequent among para-football players (35.3% vs. 44.5%, $p = 0.037$; and 7.1% vs. 37.2%, $p < 0.001$, respectively) [5]. This finding indicates a decreased prevalence of sinus bradycardia among visually impaired football players, which could be explained by reduced training loads compared to those of elite soccer players. Laboratory studies on kinematics and perception provide complementary evidence. Visual restriction, whether real or simulated, significantly decreases maximum sprint speed with the ball and elicits technical modifications, with greater trunk flexion and increased muscle coactivation, which are understood as a safe strategy in the face of perceptual uncertainty [18]. Similarly, principal component analysis (PCA) of electromyography (EMG) revealed that the first component (PC1), associated with the magnitude of muscle activation, tends to decrease in sighted players after training. In contrast, in visually impaired players, this reduction is less pronounced. These findings suggest that motor modulation adapts differently across visual conditions, consequently affecting ECG results.

The frequency of LAE and LVH would result from remodeling of cardiac morphology in response to exercise or intensive running during matches [19]. Acceleration and intensive training can induce structural cardiac adaptations characterized by the hypertrophy of left cardiac cavities, which occurs in two successive phases: acute and chronic, respectively, marked by cavity dilation and ventricular wall thickening [19] [20]. Para-football players demonstrated a smaller biventricular size and left ventricular mass, as well as a decreased prevalence of sinus bradycardia, sinus arrhythmia, and a relatively longer PR interval compared with non-para-football players. This observation may be a consequence of reduced training loads as we have observed, which could also be limited by underlying health conditions [21] [22].

The frequency of electrical hypertrophy of the left ventricle reported in visually impaired football players was lower than that recorded in elite soccer players, which would be at the higher training level of the latter [23]. Participation in regular intensive exercise is associated with a modest increase in left ventricular wall thickness (LVWT) and cavity size. The magnitude of these physiological changes is predominantly determined by a variety of demographic factors and sporting discipline [24]. Regarding age, adolescents who were regular in sports showed a lower prevalence of abnormal ECG findings compared to adult athletes [17]. African and Afro-Caribbean athletes show a higher prevalence of repolarization anomalies, such as TWI, especially in the anterior and inferior leads. The prevalence of TWI was similar among para and non-para-football players, consistent with previous studies, although limited to non-para-athletes [21] [22]. Notably, black athletes are 2.5 times more likely to present with ECG abnormalities compared to white athletes, which are often misinterpreted as pathological. This increased prevalence of TWI in black athletes is typically a normal ethnic variant linked to the athlete's heart but can lead to unnecessary testing and interventions if not correctly identified. Nevertheless, clinicians must remain vigilant, particularly when faced with deep TWI in multiple leads or markedly prolonged QT intervals, as these findings warrant further investigation to exclude underlying pathology [25]. The low number of documented ECG abnormalities, combined with the absence of resting or exertional cardiac symptoms, can be viewed as indicators of a favorable prognosis for participating in blind football. As a Paralympic sport amassing popularity amongst visually impaired children and adults, blind football appears to be an effective game to improve the physical health and social wellbeing of this population [26]. However, it is important to remember that deafness and blindness can be secondary to syndromic diseases associated with heart involvement, particularly cardiomyopathies and channelopathies, thus justifying the importance of cardiac screening.

The study's main limitation was its small sample size, combined with its descriptive design. We relied on voluntary reporting of symptoms by para players through a health questionnaire. There is a risk of under-reporting of cardiac symptoms. Another limitation concerned the comparison of results with those of para-athletes other than visually impaired football players, which prevents the findings from being generalized to other Paralympic disciplines. It should also be noted that ECG voltage criteria, taken in isolation, have limited sensitivity and specificity for true structural chamber remodeling, frequently misclassifying normal variant high voltages or body habitus differences as structural enlargement.

5. Conclusion

This research highlights the unique ECG characteristics of para-athletes, particularly by identifying common ECG changes associated with visually impaired football players. Future studies must increasingly focus on para sport to facilitate the development of refined ECG guidelines tailored to the rapidly growing Paralympic disciplines that are now considered essential. The recent recognition of Paralympic sports medicine as a distinct specialty should enable the implementation of large-scale continuing medical education. At the same time, collaboration among clinicians, researchers, and policymakers is crucial for developing standardized and cost-effective ECG screening protocols, thereby ensuring that para-athletes receive the same quality of care as their counterparts in non-Paralympic sports. These findings suggest that a more comprehensive approach to cardiac screening in these populations may be necessary.

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Author Contributions

Conceptualization, Coly, M.S., Mbengue, A., and Sar, F.B.; methodology, Coly, M.S., Mbengue, A., and Sar, F.B.; software, Coly, M.S., Mbengue, A., and Sar, F.B.; validation, Sow, A.K., Diaw, M., Mbengue, A., and Sar, F.B.; formal analysis, Djite, M., Coly, M.S., and Sar, F.B.; investigation, Coly, M.S., Djite, M., Diop, E.D., Fall, M., Toure, M., Houndjo, S.D., and Mbengue, A.; resources, Coly, M.S., Mbengue, A., and Sar, F.B.; data curation, Coly, M.S., Diaw, M., Sow, A.K., Mbengue, A., and Sar, F.B.; writing—original draft preparation, Coly, M.S., Mbengue, A., and Sar, F.B.; writing—review and editing, all authors; visualization, Coly, M.S., Mbengue, A., and Sar, F.B.; supervision, Sow, A.K., Diaw, M., Ba, A., Mbengue, A., and Sar, F.B. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest and state that they received no funding from public or non-profit organizations regarding the publication of this article.

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