Sex differences and physical activity associations with electrocardiographic patterns in amateur athletes: a cross-sectional study

Diferencias sexuales y asociaciones entre la actividad física con patrones electrocardiográficos en atletas aficionados: un estudio transversal

Authors

Younes Brouki [1]
Youssef El machrouh [1]
Chaimae Khali [1]
Mohamed Barkaoui [1]
Aziz Eloirdi [1]
Boujemaa Zahi [1]
Aziz Chokri [1]

[1] Institute of Sports Science, Hassan 1st University of Settat, Morocco

Corresponding author:
Younes Brouki
younes.brouki@gmail.com

How to cite in APA

Brouki, Y., El Machrouh, Y., Khali, C., Barkaoui, M., Eloirdi, A., Zahi, B., & Chokri, A. (2025). Sex differences and physical activity associations with electrocardiographic patterns in amateur athletes: a cross-sectional study. *Retos*, *71*, 555–565. https://doi.org/10.47197/retos.v71.117255

Abstract

Introduction: The increase in sudden death cases among Moroccan amateur athletes highlights the importance of thorough medical examinations including electrocardiograms.
Objective: This cross-sectional study aimed to identify the frequency of ECG findings in Moroccan amateur athletes, examine sex disparities, and assess how physical activity levels affect cardiac electrical patterns.
Methodology: The study included 149 amateur athletes (70 men, 79 women) from the University Hassan 1st in Settat. Participants underwent 12-lead ECG, anthropometric measurements, and physical activity assessment using the International Physical Activity Questionnaire - Short Form. Results: Male athletes showed significantly higher rates of sinus bradycardia (41.4% vs 12.7%) and ST-segment elevation (41.4% vs 0%) than female athletes (p<.0001). High levels of physical activity were significantly associated with training-related ECG changes (p=.010) and ST-segment elevation (p=.027).
Discussion: These findings emphasize the importance of considering physical activity levels when interpreting ECG patterns in amateur athletes and highlight significant sex differences in cardiac adaptations.
Conclusions: Sex-specific ECG interpretation guidelines are needed for amateur athletes, with particular attention to training-related adaptations in males and the relationship between physical activity intensity and cardiac electrical patterns.

Keywords

Amateur athletes; electrocardiogram; physical activity; sex differences; sports cardiology.

Resumen

Introducción: El aumento de los casos de muerte súbita entre los atletas aficionados marroquíes destaca la importancia de realizar exámenes médicos exhaustivos que incluyan electrocardiogramas.
Objetivo: Este estudio transversal tuvo como objetivo identificar la frecuencia de los hallazgos en el ECG de atletas aficionados marroquíes, examinar las disparidades de género y evaluar cómo los niveles de actividad física afectan los patrones eléctricos cardíacos.
Metodología: El estudio incluyó a 149 atletas aficionados (70 hombres, 79 mujeres) de la Universidad Hassan I de Settat. Los participantes se sometieron a un ECG de 12 derivaciones, mediciones antropométricas y una evaluación de la actividad física mediante el Cuestionario Internacional de Actividad Física - Versión Corta (IPAQ-SF). Resultados: Los atletas masculinos mostraron tasas significativamente más altas de bradicardia sinusal (41.4 % frente a 12.7 %) y elevación del segmento ST (41.4 % frente a 0 %) que las mujeres (p<.0001). Los altos niveles de actividad física se asociaron significativamente con cambios en el ECG relacionados con el entrenamiento (p=.010) y con la elevación del segmento ST (p=.027).
Discusión: Estos hallazgos enfatizan la importancia de considerar los niveles de actividad física al interpretar los patrones del ECG en atletas aficionados y destacan las diferencias significativas de género en las adaptaciones cardíacas.
Conclusiones: Se necesitan guías de interpretación del ECG específicas por género para atletas aficionados, prestando especial atención a las adaptaciones relacionadas con el entrenamiento en los hombres y a la relación entre la intensidad de la actividad física y los patrones eléctricos cardíacos.

Palabras clave

Actividad física; atletas aficionados; cardiología deportiva; Diferencias sexuales; electrocardiograma.

Introduction

Engagement in competitive sports has grown substantially among amateur athletes in recent years, prompting researchers to closely examine cardiac health risks in this population, particularly sudden cardiac death (SCD) (Cotrim et al., 2023). Though SCD remains a statistically infrequent event among athletes, each occurrence represents a devastating outcome in otherwise healthy individuals, highlighting the importance of comprehensive cardiovascular evaluation before sports participation (Malhotra et al., 2020). Electrocardiography has emerged as a fundamental component of these preventative screening protocols, offering valuable insights into cardiac electrical function and potential abnormalities that might remain undetected (Ceornodolea et al., 2017). Epidemiological studies emphasize the importance of systematic physical fitness assessment and medical clearance protocols in educational and athletic settings, particularly for identifying individuals who may require specialized evaluation before participating in physical activities (Ben Rakaa et al., 2025). Interpreting electrocardiogram (ECG) results presents unique challenges in amateur athletic populations (Sokunbi et al., 2021).

Contemporary ECG interpretation guidelines have largely been developed from research on elite athletes who demonstrate pronounced physiological adaptations from intensive training regimens (Churchill et al., 2021). These cardiac adaptations, collectively termed 'athlete's heart,' encompass various ECG alterations including reduced resting heart rate, enhanced ventricular voltage patterns, and distinctive repolarization characteristics that may resemble pathological findings in non-athletic individuals (Borkytė & Žumbakytė-Šermukšnienė, 2018).

When these elite-derived interpretive frameworks are applied to amateur athletes—who typically demonstrate greater variability in training intensity and physiological adaptation—clinicians risk misclassification in both directions: false positive findings that prompt unnecessary investigations or, more concerning, failure to recognize genuine pathology (Güllich et al., 2023).

Moreover, researchers have not fully established the relationship between physical activity levels and specific ECG characteristics in amateur athletes (Kaleta et al., 2018). Research suggests that higher training volumes may influence specific electrocardiographic patterns, but the precise activity thresholds required to produce these adaptations across different athletic populations remain undefined (Hostrup & Bangsbo, 2023). Recent research has demonstrated that structured physical activity programs, including adapted physical education interventions, can produce significant physiological adaptations and improve active populations' stress reaction and cardiovascular responses (Ben Rakaa et al., 2024). This knowledge gap further complicates ECG interpretation in amateur athletes and increases diagnostic uncertainty (Tougouma et al., 2019).

Sex-based differences in cardiac structure and function are well-established in the literature, with male athletes typically exhibiting larger cardiac dimensions and different patterns of electrical adaptation compared to female athletes (George et al., 2012; Afaghi et al., 2024). These physiological differences may manifest as distinct ECG patterns between male and female athletes, particularly in response to training adaptations. Male athletes often demonstrate more pronounced bradycardia and repolarization changes, potentially reflecting differences in autonomic regulation, cardiac mass, and hormonal influences on cardiac electrophysiology. Understanding these sex-specific patterns is crucial for accurate ECG interpretation and avoiding misclassification of physiological adaptations as pathological findings.

Our investigation aims to address this research gap by examining ECG patterns in Moroccan amateur athletes and exploring potential associations between these patterns and self-reported physical activity levels. The study objectives were threefold: to determine the prevalence of various ECG findings according to established classification systems; to identify potential sex-based differences in these findings; and to evaluate whether correlations exist between physical activity intensity and specific cardiac electrical adaptations in this population.

Method

Participants

This observational cross-sectional study was conducted at the Institute of Sport Sciences of Hassan I University of Settat in Morocco from April to June 2023. We included 149 qualified student-athletes (70 men and 79 women) registered at the Institute of Sport Sciences.

For the purposes of this study, an "amateur athlete" was defined as an individual who: (1) regularly participates in organized sports activities for at least 3 hours per week; (2) competes at the collegiate or amateur level; and (3) has been engaged in structured training for a minimum of 6 months.

Inclusion criteria: (1) Active enrollment as student-athletes at the Institute; (2) Age 18- 25 years; (3) Regular participation in organized sports activities; (4) Signed informed consent.

Exclusion criteria: (1) Known cardiovascular disease; (2) Current use of cardiac medications; (3) Recent cardiac symptoms requiring medical attention; (4) Pregnancy; (5) Inability to complete study assessments.

Measuring instruments

The assessment of all participants in this study encompasses a personal and familial history, a clinical examination with anthropometric measurements, a 12-lead electrocardiogram, and the IPAQ questionnaire to evaluate physical activity levels.

Anthropometric assessment

Participants were evaluated using a calibrated SECA 756® electronic scale with precision to the nearest 0.1 kg for weight measurement. Height was recorded using a SECA 213® stadiometer with 0.1 cm precision. We calculated Body Mass Index through the standard formula of weight in kilograms divided by height in meters squared. Body composition analysis was performed via bioelectrical impedance methodology using the Bodystat® 1500 analyzer to determine fat and lean mass percentages. A standard 150 cm measuring tape was employed to record waist and hip circumferences according to standardized anatomical landmarks. The anthropometric profile included height, weight, BMI, lean and fat mass percentages, waist and hip measurements, and waist-to-hip ratio calculations.

Electrocardiographic evaluations

We obtained standard 12-lead resting electrocardiograms with participants in a supine position after a minimum five-minute rest period. Recordings were made using an Aspel AsCARD Grey electrocardiograph configured at 25 mm/s paper speed and 10 mm/mV amplitude calibration. All ECG tracings were digitally stored as PDF files and independently analyzed by two specialists—a cardiologist and a sports medicine physician—using the established Seattle International Criteria specifically developed for ECG interpretation in athletic populations (Drezner et al., 2017). The ECG was obtained after 5 minutes of rest during quiet breathing and after anthropometric assessment and completion of the IPAQ questionnaire.

Physical Activity Quantification

To quantify physical activity habits, we employed the Short Form version of the International Physical Activity Questionnaire (IPAQ-SF), a validated instrument for activity assessment (Lee et al., 2011). The IPAQ-SF demonstrates good test-retest reliability (Spearman's $\rho = 0.8$) and acceptable criterion validity when compared with accelerometry data ($\rho = 0.30$) (Craig et al., 2003). For university student populations similar to our sample, the IPAQ-SF has shown moderate to good reliability coefficients (ICC = 0.65-0.85) and adequate construct validity for distinguishing between different physical activity levels (Dinger et al., 2006). The questionnaire has been validated across diverse international populations, including Middle Eastern and North African contexts, supporting its applicability to our Moroccan sample.

Our implementation captured four distinct dimensions of daily activity patterns: vigorous-intensity physical activity (VPA), moderate-intensity physical activity (MPA), walking time (W), and average time spent sitting (ST) during a weekday. Weekly activity levels were quantified using standardized Metabolic Equivalent of Task minutes (MET-min/week) conversion factors for each activity category, calculated through an IPAQ-SF scoring spreadsheet developed in Microsoft Excel following the analytical framework proposed by Cheng (2016).

Ethical considerations

Ethical approval was obtained from the Moroccan Association for Research and Ethics (Reference No: 1/REC/24), and the Settat Institute of Sport Sciences granted institutional authorization. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study.

Data analysis

For this study, an analysis is carried out by calculating simple and relative (percentage) frequencies for the qualitative variables and means and standard deviations for the quantitative variables. Statistical tests are performed using IBM-SPSS v26.00. Pearson's Chi 2, Fisher's exact, Student's t, Analysis of Variance (ANOVA), Mann-Whitney, and Kruskal-Wallis tests are used according to the variables' nature and distribution. Two approaches were used to analyze the association between ECG findings and physical activity. A Chi-squared test was employed to compare prevalence across three distinct categories of physical activity (low, moderate, high), as presented in Table 3. To further investigate the impact of high-intensity training with greater statistical power, a separate analysis, presented in Table 3, assessed the association between each ECG finding and a high level of physical activity. A p-value < .05 was considered statistically significant.

To minimize potential bias, all ECG tracings were independently analyzed by two specialists using standardized criteria, and physical activity assessments were conducted using a validated questionnaire administered in a standardized manner to all participants.

Results

Baseline anthropometric, electrocardiographic, and physical activity data from 149 amateur athletes (70 men and 79 women) formed the basis of our analysis. Male participants averaged 20 ± 1 years, while female participants averaged 20 ± 2 years. Table 1 presents these foundational characteristics by sex. Statistically significant disparities between male and female subjects were identified in terms of height (p < .001), weight (p < .001), lean body mass (p < .001), body fat percentage (p < .001), waist circumference (p < .001), and hip circumference (p < .001).

Table 1. Anthropometric, Cardiac and Physical Activity Parameters Characteristics by sex

Parameter	Male (H)	Female (F)	P-value
Baseline Characteristics			
Age	20 ± 1	20 ± 2	.153
Weight (kg)	67.5 ± 10	59.3 ± 9.5	< .001
Height (cm)	176.4 ± 6	162.6 ± 5.7	< .001
BMI	21.61 ± 2.52	22.38 ± 3.18	.108
Lean Body Mass (%)	25.8 ± 2.3	22.4 ± 1.9	< .001
Body Fat (%)	11.8 ± 3	24.8 ± 4.3	< .001
Waist Circumference (cm)	76.9 ± 6.3	72.7 ± 7.1	< .001
Hip Circumference (cm)	97.3 ± 5.9	98 ± 8.4	.549
WC/HC Ratio	0.79 ± 0.03	0.74 ± 0.07	< .001
ECG Measurements			
Heart Rate (FC)	63 ± 10	74 ± 14	< .001
RR Interval (ms)	973 ± 150	838 ± 149	< .001
QRS Duration (ms)	87 ± 11	78 ± 10	< .001
QT Interval (ms)	382 ± 23	375 ± 25	.099
QTc Interval (ms)	389 ± 26	413 ± 26	< .001
Sokolow-Lyon Index(mm)	24.84 ± 7.32	18.02 ± 5.67	< .001
Cornell Index(mm)	18.36 ± 6.05	12.85 ± 4.03	< .001
Physical Activity Parameters			
MET Min (High)	1519 ± 1350	875 ± 963	.001
MET Min (Moderate)	691 ± 774	1029 ± 1088	.032
Total MET Min/Week	3851.2 ± 2026.2	3714.8 ± 1991.3	.679

Data are presented as mean ± standard deviation. FC: Heart Rate, RR: R-R interval, QRS: QRS duration, QT: QT interval, QTc: corrected QT interval, WC/HC: Waist-to-Hip Circumference ratio, MET Min: Metabolic Equivalent of Task Minutes. P-Value: Significance level.

ECG analysis revealed substantial sex differences in athletic training adaptations, as shown in Table 2. Male athletes showed significantly higher training-related ECG changes (70%) than females (18.9%). Sinus bradycardia emerged as the most common finding, affecting 41.4% (n=29) of males versus 12.7% (n=10) of females. ST-segment elevation appeared exclusively in males, affecting 41.4% (n=29) of the male participants.

Table 2. Electrocardiographic (ECG) Changes by sex

ECG Findings	Male (H)	Female (F)	Percentage (%)	χ^2	P-value
Training-related ECG findings	49	15	43	39.416	< .0001
Sinus bradycardia	29	10	26.2	15.898	< .0001
AVB1	1	3	2.7	0.797	.372
IRBBB	1	0	0.7	1.136	.286
LVH	9	4	8.7	2.831	.092
ST ELEVATION	29	0	19.5	40.638	< .0001
Early repolarization	5	0	3.4	5.839	.0155
Borderline ECG findings	5	4	6	0.283	.595
Right axis deviation	5	4	6	0.283	.595
Abnormal ECG findings	1	6	4.7	3.152	.076
LONG QTc	0	3	2	2.713	.100
Pathological Q wave	1	0	0.7	1.136	.286
ST DEPRESSION	0	3	2	2.713	.100

Data are presented as counts and percentages. ECG: Electrocardiographic, AVB1: First-degree Atrioventricular Block, IRBBB: Incomplete Right Bundle Branch Block, LVH: Left Ventricular Hypertrophy, QTc: corrected QT interval. χ^2: Chi-squared statistic. P-Value: Significance level.

Table 3 presents the analysis of ECG changes relative to physical activity levels, using two statistical approaches. First, no statistically significant associations were found for any individual ECG finding when stratifying athletes into low, moderate, and high activity groups (P-value Across Levels). For example, sinus bradycardia prevalence was 12.5% (n=1) in the low, 28.6% (n=12) in the moderate, and 26.3% (n=26) in the high activity group, with no significant difference (p=0.849).

A second, more focused analysis assessed the direct association with a high level of physical activity (P-value High Activity Assoc.). This revealed a statistically significant association for training-related ECG changes overall (p=.010) and specifically for ST-segment elevation (p=.027).

Table 3. ECG Changes by Physical Activity Level and Association with High Activity

ECG Findings	Low (n=8) (%)	Moderate (n=42) (%)	High (n=99) (%)	Total (N=149) (%)	P-value (Across Levels)	P-value (High Activity Assoc.)
Training-related ECG findings				43.0		.010
Sinus Bradycardia	1 (12.50)	12 (28.57)	26 (26.26)	39 (26.17)	0.849	.192
First-degree AV Block	0 (0.00)	1 (2.38)	3 (3.03)	4 (2.68)	0.792	.078
Incomplete IRBBB	0 (0.00)	1 (2.38)	3 (3.03)	4 (2.68)	0.123	.856
Left Ventricular Hypertrophy	0 (0.00)	2 (4.76)	11 (11.11)	13 (8.72)	0.194	.080
ST-segment Elevation	2 (25.00)	7 (16.66)	20 (20.20)	29 (19.46)	0.662	.027
Early Repolarization	0 (0.00)	2 (4.76)	3 (3.03)	5 (3.35)	0.645	.448
Borderline ECG findings				6.0		.368
Right Axis Deviation	2 (25.00)	1 (2.38)	6 (6.06)	9 (6.04)	0.553	.368
Abnormal ECG findings				4.7		.737
Prolonged QTc	0 (0.00)	0 (0.00)	3 (3.03)	3 (2.01)	0.230	.882
ST-segment Depression	0 (0.00)	1 (2.38)	2 (2.02)	3 (2.01)	0.924	.311
Pathological Q Wave	0 (0.00)	0 (0.00)	1 (1.01)	1 (0.67)	0.492	.537

Data are presented as number (n) and percentage (%). P-value (Across Levels) refers to Chi-squared test for differences across low, moderate, and high activity groups. P-value (High Activity Assoc.) refers to a separate analysis for association with high physical activity. ECG: Electrocardiographic, AV Block: Atrioventricular Block, IRBBB: Incomplete Right Bundle Branch Block, QTc: corrected QT interval.

Discussion

This study aimed to determine the prevalence of various ECG findings in Moroccan amateur athletes according to established classification systems, identify potential sex-based differences in these findings, and evaluate correlations between physical activity level and specific cardiac electrical adaptations in this population, while considering anthropometric characteristics.

This study delineates the electrocardiographic profile observed among amateur athletes pursuing their studies at the Institute of Sport Sciences, University Hassan I, Settat, in Morocco. The results of our investigation identified several important findings, including notable sex disparities in the electrocardiogram results. The empirical findings correlate with Wen et al.'s research in China (Wen et al., 2021), demonstrating prevalent electrocardiographic abnormalities among recreational athletes, including sinus bradycardia, arrhythmia, LVH, and axial deviations (Climstein et al., 2025) (Abu Bakar et al., 2018). The current investigation additionally demonstrated a notable prevalence of training-associated electrocardiographic patterns in non-professional athletes, per the Seattle criteria (Drezner et al., 2017). A similar study of adolescent athletes also found sex differences in ECG findings, with a higher prevalence of abnormal patterns in males than in females (CORÎCI & MIREA-MUNTEANU, 2018). Furthermore, we found differences in the prevalence of ECG abnormalities between several studies due to variations in the criteria used to classify the ECG as "normal" or "abnormal," Seattle criteria, in addition to the characteristic peculiarities of the populations studied (Zorzi et al., 2020; Dores et al., 2016).

The identified sex disparities in electrocardiogram (ECG) findings, particularly the increased incidence of sinus bradycardia and ST-segment elevation among male athletes, may be ascribed to various physiological mechanisms (George et al., 2012; Lasocka-Koriat et al., 2024). Research indicates that males typically exhibit a larger left ventricular mass and systolic ejection volume than their female peers (Tebar et al., 2020). Furthermore, the hormonal variances between males and females may influence cardiac repolarization and autonomic regulation, potentially resulting in a heightened frequency of ST-segment elevation among male athletes (Afaghi et al., 2024). Supporting these exercise-induced adaptations, research by Rojas-Valencia and colleagues (2024) identified sinus bradycardia in 40.8% of physically active young adults at high altitude. The physiological explanation for this finding was attributed to intrinsic electrical modifications in the sinus node—specifically, downregulation of HCN4 (funny channel) rather than altered autonomic tone, as described in their discussion of previous literature (Rojas-Valencia et al., 2024). This physiological insight reinforces the understanding that exercise-induced bradycardia represents a fundamental cellular adaptation that manifests differently between male and female athletes due to distinct structural cardiac characteristics and hormonal environments. The higher prevalence of these ECG adaptations in male athletes reflects the combined influence of greater cardiac mass, hormonal factors, and the intrinsic electrophysiological remodeling described by Rojas-Valencia's team.

The participants in this study represent different regions of Morocco with ethnic and environmental characteristics that may influence the ECG pattern and, consequently, their cardiac adaptations to exercise (Petek et al., 2023). The prevalence rates in our cohort differ markedly from those in other populations. For instance, the overall prevalence of sinus bradycardia (26.2%) is substantially higher than the ~15% reported in a large study of Chinese runners (Wen et al., 2021). Even more striking, the 19.5% prevalence of ST-segment elevation is over 15 times higher than the 1.25% found in the same Chinese cohort (Wen et al., 2021). These profound differences highlight the necessity of conducting specific studies to comprehend the intricate interactions among genetic, environmental, and lifestyle factors (Delise & Zeppilli, 2022).

Our investigation employed dual analytical approaches to examine relationships between physical activity and electrocardiographic findings, with comprehensive results presented in Table 3. The initial stratification analysis—categorizing participants into low, moderate, and high activity subgroups—revealed no statistically significant associations between activity category and specific ECG patterns. This absence of significant findings in the stratified analysis may partially reflect limited statistical power, particularly due to the small sample size (n=8) in the low-activity cohort. However, we uncovered significant relationships when we conducted a more targeted analytical approach focusing specifically on associations with high-intensity physical activity. Specifically, elevated physical activity levels (quantified in MET-min/week) demonstrated significant associations with training-related ECG adaptations overall (p=.010) and with ST-segment elevation in particular (p=.027). This differential finding between analytical methods highlights the importance of statistical approach selection when evaluating exercise-induced cardiac adaptations.

Metabolic equivalent (MET) analysis in our study provides evidence supporting the physiological threshold theory underlying 'athlete's heart' adaptations. This concept suggests that sustained high-intensity physical activity triggers a cascade of cardiac adaptations characterized by both structural and electrical modifications (Fanale et al., 2024; Hądzlik et al., 2024; Malmgren et al., 2024). Contemporary research demonstrates that prolonged intensive training produces comprehensive cardiac remodeling across structural, functional, and electrical parameters (Malmgren et al., 2024), with adaptation magnitude proportional to both intensity and cumulative training volume (Pittaras et al., 2023; Arbab-Zadeh et al., 2014). The significant association between high-activity levels and ST-segment elevation in our cohort aligns with findings showing ST elevation in 43% of athletes versus 24% of non-athletes (Sharma et al., 1999), and early repolarization patterns in 40.2% of elite footballers, with J-wave morphology predominating (Stein et al., 2025). Recent longitudinal studies have confirmed that early repolarization patterns in athletes represent benign adaptations, with no reported cases of sudden cardiac death during extended follow-up (Stein et al., 2025; Tremamunno & Lanza, 2023). This evidence supports the physiological nature of exercise-induced electrical adaptations as reflections of underlying structural cardiac remodeling in response to intensive training (Fanale et al., 2024; Hądzlik et al., 2024; Kolenda Zloić & Hrabak-Paar, 2024). These findings are consistent with research demonstrating that structured training programs can produce measurable physiological adaptations in young athletes within an 8-week intervention. This suggests that the temporal relationship between training intensity and cardiac adaptation may be more rapid than previously understood (Bouzid et al., 2025).

Clinical Implications

These findings have important clinical implications for the assessment of athletes in Morocco. The observed higher prevalence of sinus bradycardia and ST-segment elevation in male athletes, as demonstrated in our cross-sectional analysis, suggests that these patterns may represent physiological adaptations rather than pathological findings (Bianco & Zeppilli, 2022). Healthcare workers need to understand the common physiological adaptations that occur due to training, which typically manifest as electrocardiographic (ECG) changes, especially in athletes who engage in intense physical activities (Drezner et al., 2017). The associations observed between high physical activity levels and training-related ECG changes in this study support the importance of considering training history and activity levels when interpreting ECG findings in amateur athletes.

Limitations

Several important limitations should be considered when interpreting our findings. First, our sample of 149 amateur athletes from Hassan I University may not fully represent the broader Moroccan athletic population, potentially limiting generalizability. Second, the cross-sectional design prevented us from evaluating temporal changes in cardiac adaptations across varying activity levels or training phases. Third, our physical activity assessment relied on participant self-reporting through the IPAQ questionnaire, which introduces potential measurement error through recall inaccuracies and social desirability effects—factors known to frequently result in activity level overestimation in questionnaire-based research (Roberts-Lewis et al., 2022).

Conclusions

This cross-sectional study of Moroccan amateur athletes revealed significant sex differences in cardiac adaptation, with male athletes showing a higher prevalence of sinus bradycardia and ST-segment elevation. No direct link was observed between low and moderate physical activity levels and ECG variations. However, higher levels of physical activity, measured in MET-min/week, were significantly associated with training-related ECG adaptations and ST-segment elevation. This analysis did not find A significant correlation for sinus bradycardia or early repolarization patterns at high activity levels. Physiological adaptations predominated in our results, while borderline and abnormal ECG changes remained relatively rare. The results highlight the need to consider possible ethnic specificities in addition to sex when interpreting the ECG.

Acknowledgements

The authors sincerely thank all participants for their voluntary cooperation and the Institute of Sport Sciences at Hassan I University for institutional support. We thank the Sports Science Research Team at the Institute of Sports Sciences, Hassan I University, Settat, Morocco, for their dedicated assistance and expertise throughout this research.

Special appreciation is extended to Mr. Omar Ben Rakaa from the Multidisciplinary Laboratory in Education Sciences and Training Engineering (LMSEIF), Sport Science Assessment and Physical Activity Didactics, Normal Higher School (ENS-C), Hassan II University of Casablanca, Morocco, whose expert collaboration and professional guidance were instrumental in the successful completion of this study.

Financing

This research received no external funding.

References

Abu Bakar, N. A., Luqman, N., Shaaban, E., & Abdul Rahman, H. (2018). Prevalence and predictors of electrocardiogram abnormalities among athletes. Asian Cardiovascular and Thoracic Annals, 26(8), 603–607. https://doi.org/10.1177/0218492318807533

Afaghi, S., Rahimi, F. S., Soltani, P., Kiani, A., & Abedini, A. (2024). Sex-Specific Differences in Cardiovascular Adaptations and Risks in Elite Athletes: Bridging the Gap in Sports Cardiology. Clinical Cardiology, 47(9). https://doi.org/10.1002/clc.70006

Arbab-Zadeh, A., Perhonen, M., Howden, E., Peshock, R. M., Zhang, R., Adams-Huet, B., Haykowsky, M. J., & Levine, B. D. (2014). Cardiac Remodeling in Response to 1 Year of Intensive Endurance Training. Circulation, 130(24), 2152–2161. https://doi.org/10.1161/circulationaha.114.010775

Ben Rakaa, O., Bassiri, M., & Lotfi, S. (2024). Epidemiological Study of The Physical Ability to Practice Physical Education in Children with School Pathologies. Journal of Biostatistics and Epidemiology. https://doi.org/10.18502/jbe.v10i4.18522

Ben Rakaa, O., Bassiri, M., & Lotfi, S. (2025). Impact of adapted physical education and para-athletics on mental skills and on pedagogical and school inclusion of teenagers with disabilities. *Retos, 68,* 82–94. https://doi.org/10.47197/retos.v68.111520

Bianco, M., Zeppilli, P. (2022). Electrocardiographic Changes in the Athlete's Heart. In: Delise, P., Zeppilli, P. (eds) Sport-related sudden cardiac death. Springer, Cham. https://doi.org/10.1007/978-3-030-80447-3_2

Borkytė, J., & Žumbakytė-Šermukšnienė, R. (2018). TRANSTHORACIC ECHOCARDIOGRAPHY AND DEPENDENCE OF ELECTROCARDIOGRAPHIC INDICATORS ON PHYSICAL ACTIVITY TYPE IN LITHUANIAN ATHLETES. Baltic Journal of Sport and Health Sciences, 2(109), 9–14. https://doi.org/10.33607/bjshs.v2i109.191

Bouzid, W., Ben Rakaa, O., Chokri, A., Eloirdi, A., Elhaboussi, A., & Barkaoui, M. (2025). Effect of an 8-week training program on the rebalancing of functional asymmetry in young footballers. *Retos, 70*, 1422–1437. https://doi.org/10.47197/retos.v70.117056

Ceornodolea, A. D., Bal, R., & Severens, J. L. (2017). Epidemiology and Management of Atrial Fibrillation and Stroke: Review of Data from Four European Countries. Stroke Research and Treatment, 2017, 1–12. https://doi.org/10.1155/2017/8593207

Churchill, T. W., Petek, B. J., Wasfy, M. M., Guseh, J. S., Weiner, R. B., Singh, T. K., Schmied, C., O'Malley, H., Chiampas, G., & Baggish, A. L. (2021). Cardiac Structure and Function in Elite Female and Male Soccer Players. JAMA Cardiology, 6(3), 316. https://doi.org/10.1001/jamacardio.2020.6088

Climstein, M., Graham, K. S., Stapelberg, M., Walsh, J., DeBeliso, M., Adams, K., Sevene, T., & Harris, C. (2025). Electrocardiographic Assessment of National-Level Triathletes: Sinus Bradycardia and Other Electrocardiographic Abnormalities. Sports, 13(1), 25. https://doi.org/10.3390/sports13010025

CORÎCI, O. M., & MIREA-MUNTEANU, O. (2018). Gender-Related Electrocardiographic Changes in Athletes. Current Health Sciences Journal, 1, 29–33. https://doi.org/10.12865/CHSJ.44.01.05

Cotrim, C., Palinkas, E. D., & Cotrim, N. (2023). The Importance of Left Ventricular Outflow Tract and Mid-Ventricular Gradients in Stress Echocardiography: A Narrative Review. Journal of Clinical Medicine, 12(16), 5292. https://doi.org/10.3390/jcm12165292

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-Country Reliability and Validity: Medicine & Science in Sports & Exercise, 35(8), 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Delise, P., & Zeppilli, P. (Eds.). (2022). Sport-related sudden cardiac death: Causes and prevention. Springer International Publishing. https://doi.org/10.1007/978-3-030-80447-3

Dores, H., Malhotra, A., Sheikh, N., Millar, L., Dhutia, H., Narain, R., Merghani, A., Papadakis, M., & Sharma, S. (2016). Abnormal electrocardiographic findings in athletes: Correlation with intensity of sport and level of competition. Revista Portuguesa de Cardiologia (English Edition), 35(11), 593–600. https://doi.org/10.1016/j.repce.2016.10.014

Dinger, M. K., Behrens, T. K., & Han, J. L. (2006). Validity and Reliability of the International Physical Activity Questionnaire in College Students. American Journal of Health Education, 37(6), 337–343. https://doi.org/10.1080/19325037.2006.10598924

Drezner, J. A., Sharma, S., Baggish, A., Papadakis, M., Wilson, M. G., Prutkin, J. M., Gerche, A. L., Ackerman, M. J., Borjesson, M., Salerno, J. C., Asif, I. M., Owens, D. S., Chung, E. H., Emery, M. S., Froelicher, V. F., Heidbuchel, H., Adamuz, C., Asplund, C. A., Cohen, G., … Corrado, D. (2017). International criteria for electrocardiographic interpretation in athletes: Consensus statement. British Journal of Sports Medicine, 51(9), 704–731. https://doi.org/10.1136/bjsports-2016-097331

Fanale, V., Segreti, A., Fossati, C., Di Gioia, G., Coletti, F., Crispino, S. P., Picarelli, F., Antonelli Incalzi, R., Papalia, R., Pigozzi, F., & Grigioni, F. (2024). Athlete's ECG Made Easy: A Practical Guide to Surviving Everyday Clinical Practice. Journal of Cardiovascular Development and Disease, 11(10), 303. https://doi.org/10.3390/jcdd11100303

George, K., Whyte, G. P., Green, D. J., Oxborough, D., Shave, R. E., Gaze, D., & Somauroo, J. (2012). The endurance athlete's heart: Acute stress and chronic adaptation. British Journal of Sports Medicine, 46(Suppl 1), i29–i36. https://doi.org/10.1136/bjsports-2012-091141

Güllich, A., Barth, M., Macnamara, B. N., & Hambrick, D. Z. (2023). Quantifying the Extent to Which Successful Juniors and Successful Seniors are Two Disparate Populations: A Systematic Review and Synthesis of Findings. Sports Medicine, 53(6), 1201–1217. https://doi.org/10.1007/s40279-023-01840-1

Hądzlik, I., Piotrowski, J., Biały-Karbowniczek, J., Słychan, K., Jędrasek, A., Bulska, K., Jędrasek, T., Łuczak, B., Pogoda, J., & Sławek, K. (2024). Balancing Cardiovascular Health: Assessing the Impact of Physical Activity on Athletic Cardiac Adaptations and Cardiac Pathology. Quality in Sport, 18, 53460. https://doi.org/10.12775/qs.2024.18.53460

Hoi Lun (Helen) Cheng. (2016). A simple, easy-to-use spreadsheet for automatic scoring of the International Physical Activity Questionnaire (IPAQ) Short Form [Dataset]. Unpublished. https://doi.org/10.13140/RG.2.2.21067.80165

Hostrup, M., & Bangsbo, J. (2023). Performance Adaptations to Intensified Training in Top-Level Football. Sports Medicine, 53(3), 577–594. https://doi.org/10.1007/s40279-022-01791-z

Kaleta, A. M., Lewicka, E., Dąbrowska-Kugacka, A., Lewicka-Potocka, Z., Wabich, E., Szerszyńska, A., Dyda, J., Sobolewski, J., Koenner, J., & Raczak, G. (2018). Electrocardiographic abnormalities in amateur male marathon runners. Advances in Clinical and Experimental Medicine, 27(8), 1091–1098. https://doi.org/10.17219/acem/73700

Kolenda Zloić, S., & Hrabak-Paar, M. (2024). The Role of Cardiac Magnetic Resonance Imaging in Distinguishing the Athlete's Heart From Hypertrophic Cardiomyopathy–A Brief Literature Review. Echocardiography, 41(11). https://doi.org/10.1111/echo.70021

Lasocka-Koriat, Z., Lewicka-Potocka, Z., Kaleta-Duss, A., Siekierzycka, A., Kalinowski, L., Lewicka, E., & Dąbrowska-Kugacka, A. (2024). Differences in cardiac adaptation to exercise in male and female athletes assessed by noninvasive techniques: A state-of-the-art review. American Journal of Physiology-Heart and Circulatory Physiology, 326(5), H1065–H1079. https://doi.org/10.1152/ajpheart.00756.2023

Lee, P. H., Macfarlane, D. J., Lam, T., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. International Journal of Behavioral Nutrition and Physical Activity, 8(1). https://doi.org/10.1186/1479-5868-8-115

Malhotra, A., Dhutia, H., Yeo, T.-J., Finocchiaro, G., Gati, S., Bulleros, P., Fanton, Z., Papatheodorou, E., Miles, C., Keteepe-Arachi, T., Basu, J., Parry-Williams, G., Prakash, K., Gray, B., D'Silva, A., Ensam, B., Behr, E., Tome, M., Papadakis, M., & Sharma, S. (2020). Accuracy of the 2017 international recommendations for clinicians who interpret adolescent athletes' ECGs: A cohort study of 11 168 British white and black soccer players. British Journal of Sports Medicine, 54(12), 739–745. https://doi.org/10.1136/bjsports-2017-098528

Malmgren, A., Trägårdh, E., Gudmundsson, P., Kjellström, B., Stagmo, M., & Dencker, M. (2024). Electrocardiographic manifestations in female team handball players: Analyzing ECG changes in athletes. Frontiers in Sports and Active Living, 6. https://doi.org/10.3389/fspor.2024.1384483

Petek, B. J., Drezner, J. A., & Churchill, T. W. (2023). The International Criteria for Electrocardiogram Interpretation in Athletes. Cardiology Clinics, 41(1), 35–49. https://doi.org/10.1016/j.ccl.2022.08.003

Pittaras, A., Faselis, C., Doumas, M., Grassos, C., & Kokkinos, P. (2023). Physical Activity and Cardiac Morphologic Adaptations. Reviews in Cardiovascular Medicine, 24(5). https://doi.org/10.31083/j.rcm2405142

Roberts-Lewis, S. F., White, C. M., Ashworth, M., & Rose, M. R. (2022). The validity of the International Physical Activity Questionnaire (IPAQ) for adults with progressive muscle diseases. Disability and Rehabilitation, 44(23), 7312–7320. https://doi.org/10.1080/09638288.2021.1983042

Rojas-Valencia, J. T., Higuera-Dagovett, E., Vega Llamas, R., Prieto Mondragón, L. D. P., Buitrago Espitia, J. E., & Rodríguez Buitrago, J. A. (2024). Electrocardiographic findings in a group of physically active young adults who reside at 2,600 meters above the sea level: An exploratory study. *Retos, 59*, 577–583. https://doi.org/10.47197/retos.v59.103145

Sharma, S., Whyte, G., Elliott, P., Padula, M., Kaushal, R., Mahon, N., & McKenna, W. J. (1999). Electrocardiographic changes in 1000 highly trained junior elite athletes. British Journal of Sports Medicine, 33(5), 319–324. https://doi.org/10.1136/bjsm.33.5.319

Sokunbi, O. J., Okoromah, C. A. N., Ekure, E. N., Olawale, O. A., & Eke, W. S. (2021). Electrocardiographic pattern of apparently healthy African adolescent athletes in Nigeria. BMC Pediatrics, 21(1). https://doi.org/10.1186/s12887-021-02557-8

Stein, R., Ferrari, F., Da Silveira, A. D., Rossi, A. P., Pedrotti, L. G., Dilda, G. D., Aleixo, H. C., Magalhaes, F. C. O., Emed, L. G. M., Soares, L. G., Alo, R. O. B., Ritt, L. E. F., Braga, F., Herdy, A. H., & Froelicher, V. F. (2025). Distinct early repolarization patterns in male brazilian football players: Insights from a multicenter study. European Journal of Preventive Cardiology, 32(Supplement_1). https://doi.org/10.1093/eurjpc/zwaf236.422

Tebar, W. R., Ritti-Dias, R. M., Mota, J., Farah, B. Q., Saraiva, B. T. C., Damato, T. M. M., Delfino, L. D., Aguilar, B. A. S., Dos Santos, A. B., Silva, S. C. B., Vanderlei, L. C. M., & Christofaro, D. G. D. (2020). Relationship between domains of physical activity and cardiac autonomic modulation in adults: A cross-sectional study. Scientific Reports, 10(1). https://doi.org/10.1038/s41598-020-72663-7

Tougouma, S. J.-B., Yaméogo, N. V., Kambiré, Y., Yaméogo, A. A., Sidibé, S., Kologo, J. K., Millogo, G., Ouédraogo, S., Bamouni, J., & Zabsonré, P. (2019). Electrocardiography of a Top Athlete in Bobo-Dioulasso, Burkina Faso. World Journal of Cardiovascular Diseases, 09(07), 449–457. https://doi.org/10.4236/wjcd.2019.97040

Tremamunno, S., & Lanza, G. A. (2023). Is Early Repolarization Syndrome a Risk for Sudden Cardiac Death in Young Athletes? Current Treatment Options in Cardiovascular Medicine, 25(10), 561–571. https://doi.org/10.1007/s11936-023-01007-1

Wen, X., Huang, Y., Shen, T.-H., Gong, Y.-L., Dong, R., Xia, L., & Xie, T. (2021). Prevalence of abnormal and borderline electrocardiogram changes in 13, 079 Chinese amateur marathon runners. BMC Sports Science, Medicine and Rehabilitation, 13(1). https://doi.org/10.1186/s13102-021-00268-2

Zorzi, A., Vio, R., Bettella, N., & Corrado, D. (2020). Criteria for interpretation of the athlete's ECG: A critical appraisal. Pacing and Clinical Electrophysiology, 43(8), 882–890. https://doi.org/10.1111/pace.14001

Authors' and translators' details:

Younes Brouki	Younes.brouki@gmail.com	Author/Translator
Youssef El machrouh	Youssef El machrouh	Author
Chaimae Khali	Chaimaekhali17@gmail.com	Author
Mohamed Barkaoui	Mohamed.barkaoui@uhp.ac.ma	Author
Aziz Eloirdi	aziz.eloirdi@uhp.ac.ma	Author
Boujemaa Zahi	zahiboujemaa1954@gmail.com	Author
Aziz Chokri	Aziz.chokri@uhp.ac.ma	Author