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Comparison of Electrocardiographic Findings Between Bodybuilding Athletes and Non-Athletes in Herat, Afghanistan

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ABSTRACT

Regular physical exercise induces cardiac remodeling, known as the "athlete's heart," with both electrophysiological and structural changes. Distinguishing physiological from pathological Electrocardiogram (ECG) patterns in athletes is vital for optimal diagnosis and cost-effective healthcare. This study aimed to compare ECG findings between bodybuilder athletes and non-athletes in Herat City, Afghanistan. A prospective cross-sectional study was conducted on 140 male participants in Herat City, Afghanistan, from November 2014 to November 2016. It comprised two cohorts: 70 healthy bodybuilder athletes were taken as cases, and 70 age-matched males who were non-athletes and healthy individuals were taken as a control group. A non-probability convenience sampling technique was used to collect study participants. Data was gathered using a questionnaire-based approach from the respondents and analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Athletes had a significantly higher prevalence of sinus arrhythmia (34.3% vs. 8.6%; $p < 0.001$), left ventricular hypertrophy (18.6% vs. 4.3%; $p = 0.008$), incomplete right bundle branch block (32.9% vs. 8.6%; $p < 0.001$), and T-wave inversions (8.6% vs. 0.0%; $p = 0.012$) compared to control groups. Notably, the overall ECG interpretation differed significantly ($p < 0.001$), with athletes exhibiting a higher frequency of abnormal findings. However, no statistically significant differences were observed in heart rate, PR interval, left atrial enlargement, QRS axis, QTc interval, ST segment, U wave, premature atrial contractions, and premature ventricular contractions. These findings indicate that athlete's heart adaptations mainly affect rhythm and repolarization on ECG. Accurately distinguishing between physiological and pathological ECG findings is crucial in sports cardiology. This discernment is key for precise diagnosis and targeted treatment, leading to optimal patient outcomes and minimizing unnecessary resource expenditure.

Keywords: Afghanistan, Bodybuilding athletes, Electrocardiogram, Non-athletes, Physiological changes

INTRODUCTION

Regular sports participation demonstrably enhances both mental and physical well-being. Studies confirm its efficacy in mitigating the deleterious effects of stressors and reducing the incidence of chronic and severe pathologies (McVeigh et al., 2021; Oja et al., 2015). Furthermore, cardiac adaptations occur in athletes to optimize blood flow to vital organs. These adaptations include electrical and structural remodeling, mirroring the observed increase in heart size relative to body mass across mammals (Shave et al., 2017). In 1899, Henschen pioneered the description of the "athlete's heart" based on percussive assessments of international skiers. He observed exercise-induced cardiac enlargement, encompassing both dilation and hypertrophy across both ventricles. Notably, he attributed these adaptive changes to enhanced cardiac function. Subsequent investigations have refined the understanding of the athlete's heart, leveraging advancements in cardiac imaging modalities like chest radiography, echocardiography, and cardiac magnetic resonance imaging (CMRI) (Machado et al., 2016).

Trained athletes frequently exhibit electrocardiographic adaptations reflecting cardiovascular remodeling. Though uncommon, certain ECG abnormalities may signal underlying cardiac pathologies that elevate the risk of sudden cardiac arrest during exercise (Corrado et al., 2009).

Sinus bradycardia, sinus arrhythmia, left ventricular hypertrophy (LVH), premature atrial contractions (PAC), Mobitz I atrioventricular block, wandering pacemaker, increased T wave voltage, presence of U wave, PR, QT, and QRS interval prolongation (not exceeding the normal range), and ST and T changes that mimic ischemia are stated as ECG changes that can occur in athletes (Chugh, 2006).

Emerging evidence suggests a potential overlap between physiological and pathological remodeling in athletes' hearts. This may involve minimal fibrosis development during lifelong endurance training, which could, in rare cases, act as a substrate for arrhythmias (Carbone et al., 2017). Importantly, many cardiomyopathies leading to sudden cardiac death in young athletes are often asymptomatic and challenging to detect, highlighting the critical role of screening programs. Italy's 25-year experience demonstrates the value of a 12-lead ECG in conjunction with a thorough history and physical examination. This comprehensive approach has demonstrably identified potentially fatal cardiac conditions in asymptomatic athletes, significantly reducing mortality (Corrado et al., 2009).

The accurate differentiation between physiological and pathological ECG patterns is crucial for athletes, impacting both correct diagnosis and cost-effectiveness. However, existing literature lacks investigations specific to Afghan athletes' ECG characteristics. This study aims to address this gap by comparing ECG findings between bodybuilder athletes and non-athletes in Herat City, Afghanistan.

MATERIALS AND METHODS

Study Setting and Design

A prospective cross-sectional comparative study was conducted on 140 male participants in Herat City, Afghanistan, from November 2014 to November 2016. It comprised two cohorts: 70 healthy bodybuilder athletes were taken as cases, and 70 age-matched males who were non-athlete healthy individuals were taken as a control group. (Standardized 12-lead ECG recordings were obtained and meticulously interpreted.

Sample Size and Sampling Technique

Employing a non-probability convenience sampling approach due to practical constraints, this study recruited 140 participants in Herat City, Afghanistan. The case group comprised 70 male bodybuilder athletes aged 20-40 years with 3-5 years of consistent training experience, free from cardiovascular or other organ-related symptoms, and exhibiting normal physical examination and vital signs. The control group included 70 non-athlete males of the same age range, also asymptomatic for any cardiovascular or organ-related conditions and presenting with normal physical examination and vital signs. This selection method acknowledges limitations in generalizability but was chosen based on feasibility and access to the target population.

This study excluded both athletes and non-athletes who fell below the age of 20 or exceeded 50 years old or exhibited complaints concerning cardiovascular or other bodily systems, in addition to having abnormal findings in their physical examinations. Additionally, athletes with less than three years of sports experience were also excluded.

Data collection

Using a questionnaire designed by the researchers, information such as age, sex, place of residence, duration of exercise and number of daily hours of exercise were collected. Athletes underwent standardized procedures that included physical examinations and the measurement of vital signs at least 30 minutes after arriving at the gym and before beginning their exercise routine. A 12-lead ECG was recorded after an additional 30 minutes of resting. Non-athletes followed the same protocol, resting in the hospital for at least 30 minutes before starting the procedures. The same sphygmomanometer, thermometer, and electrocardiograph were used for examining both athletes and non-athletes.

ECG recording and interpretation

The participants underwent a routine 12-lead ECG while lying down and breathing normally, and measurements of different ECG parameters were obtained using calipers and rulers. Sinus tachycardia was defined as a rate > 100 beats per minute (bpm), rhythm regular, P waves upright in leads I, II, and aVL, and negative in lead aVR, and each P wave is followed by a QRS and T wave (Chugh, 2006). Sinus bradycardia was defined as a rate < 60 bpm and rhythm was a regular sinus rhythm (Hafeez et al., 2024), while sinus arrhythmia was defined as a rate 60-100 bpm and rhythm irregular (> 0.12-second variation in the shortest and longest durations between successive P waves (Shave et al., 2017). Right bundle branch block (RBBB) was defined as QRS duration ≥ 0.12 seconds, a terminal R wave in lead V1, and a slurred S wave in lead V6. It was considered incomplete right bundle branch block (iRBBB) when the duration of QRS was 0.1 to < 0.12 seconds. The left bundle branch block (LBBB) was defined as QRS duration ≥ 0.12 seconds, a terminal R wave in lead V6, and a slurred S wave in lead V1. It was considered an incomplete left bundle branch block (iLBBB) when the duration of QRS was 0.1 to < 0.12 seconds (Chugh, 2006; Khan, 2008). Left axis deviation (LAD) was identified when the QRS axis was more negative than -30°, while right axis deviation (RAD) occurred when the QRS axis was more positive than +110°. QT intervals were adjusted for heart rate using Bazett's formula. An abnormally prolonged QTc interval was defined as longer than 0.44 seconds. Right atrial enlargement was indicated by a P wave voltage of > 0.25 mV in limb leads or a positive component of P wave in lead V1 ≥ 0.15 mV, while left atrial enlargement (LAE) was characterized by P wave duration in limb leads ≥ 0.12 second or a P wave in V1 where the terminal portion was more negative than -0.1 mV and lasted for 0.04 seconds or more. Right ventricular hypertrophy (RVH) and left ventricular hypertrophy (LVH) were determined by the Sokolow-Lyon voltage criterion, with LVH defined by the sum of the S waves in V1 and the R waves in V5 ≥ 3.5 mV, and RVH defined by the sum of the R waves in V1 and the S waves in V6 ≥ 1.05 mV (Chugh, 2006; Meng et al., 2017). T-wave inversion was considered by the presence of a negative T wave that was at least 1 mm deep in two or more adjacent leads, except for leads aVR, III, and V1 (D'Ascenzi et al., 2020). ST-segment elevation and depression were defined as elevation or depression of the ST segment of 1 mm or more from baseline in two or more contiguous leads respectively (Khan, 2008). A Q wave was deemed abnormal or indicative of pathology if it lasted longer than 0.04 seconds or if its depth surpassed 25% of the height of the R wave (Chugh, 2006). PACs were diagnosed by the presence of an abnormally shaped P wave in any ECG lead (Heaton & Yandrapalli, 2024). Premature ventricular contractions (PVCs) were diagnosed by the presence of high voltage and wide QRS complexes followed by a T wave opposite the QRS direction (Li et al., 2022).

Statistical analyses

Initial data were entered into an Excel spreadsheet and then exported to SPSS version 26.0 for analysis. The distribution of quantitative data was tested for normality using the Kolmogorov-Smirnov test, summarized as median and interquartile ranges for continuous variables with skewed distributions. All qualitative (categorical) data were recorded as numbers (n) and percentages (%). Chi-square tests were used to compare categorical data. The significance level was $p < 0.05$.

Ethical consideration

The research protocol received approval from the Human Ethics Committee of Herat University (approval number #230118). Data were collected from each participant, ensuring privacy and confidentiality of information, and obtaining verbal informed consent.

RESULTS

A total of 140 individuals were enrolled in the study, of whom 70 were athletes (cases) and 70 were non-athletes (controls). The median (interquartile range) age of study participants was 28.5 (24–33) years (range, 20–40 years). The case group had a median age of 28 (23.8–33) years, while the control group had a median age of 29.5 (24–33) years.

The study revealed notable dissimilarities between the case and control groups in several ECG parameters. These included cardiac rhythm, LVH, iRBBB, T-wave inversion, and the final ECG diagnosis categorizing them as normal or abnormal. Notably, no statistically significant differences were observed between the groups regarding heart rate, PR interval, LAE, QRS axis, QTc interval, ST segment position, and the presence of U waves, PACs, or PVCs. The statistical data on the dissimilarities between bodybuilder athletes and non-athletes in several ECG parameters is shown in Table 1.

Table 1. Comparison of ECG abnormalities between bodybuilder athletes and non-athletes.

Variables	Athletes (n= 70)	Non-athletes (n=70)	Total	p-value*
Heart rate n (%)				
- Normal	58 (82.9%)	61 (87.1%)	119 (85.0%)	0.592 [a]
- Bradycardia	3 (4.3%)	4 (5.7%)	7 (5.0%)	
- Tachycardia	9 (12.9%)	5 (7.1%)	14 (10.0%)	
Sinus arrhythmia n (%)				
- Absent	46 (65.7%)	64 (91.4%)	110 (78.6%)	<0.001 [a]
- Present	24 (34.3%)	6 (8.6%)	30 (21.4%)	
PR interval n (%)				
- Normal	69 (98.6%)	68 (97.1%)	137 (97.9%)	1.000 [a]
- Short	1 (1.4%)	2 (2.9%)	3 (2.1%)	
- Long	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Left ventricular hypertrophy n (%)				
- Absent	57 (81.4%)	67 (95.7%)	124 (88.6%)	0.008 [a]
- Present	13 (18.6%)	3 (4.3%)	16 (11.4%)	

Left atrial enlargement n (%)				
- Absent	68 (97.1%)	70 (100%)	139 (99.3%)	0.496 [a]
- Present	2 (2.9%)	0 (0.0%)	1 (0.7%)	
Left Axis Deviation n (%)				
- Absent	66 (94.3)	69 (98.6%)	135 (96.4%)	0.366 [a]
- Present	4 (5.7%)	1 (1.4%)	5 (3.6%)	
Right Axis Deviation n (%)				
- Absent	69 (98.6%)	70 (100%)	139 (99.3%)	1.000 [a]
- Present	1 (1.4%)	0 (0.0%)	1 (0.7%)	
IRBBB n (%)				
- **Absent**	47 (67.1%)	64 (91.4%)	111(79.3%)	<0.001a
- **Present**	23 (32.9%)	6 (8.6%)	29 (20.7%)	
ST elevation n (%)	59 (84.3%)	64 (91.4%)	123 (87.9%)	
- **Absent**	11 (15.7%)	6 (8.6%)	17 (21.1%)	1.000 a
- **Present**				
ST depression n (%)				
- **Absent**	69 (98.6%)	70 (100%)	139 (99.3%)	0.012 a
- **Present**	1 (1.4%)	0 (0.0%)	1 (0.7%)	
T wave inversion n (%)				
- **Absent**	64 (91.4%)	70 (100%)	134 (95.7%)	0.008 a
- **Present**	6 (8.6%)	0 (0.0%)	6 (4.3%)	
U wave n (%)				
- **Absent**	57 (81.4%)	62 (88.6%)	119 (85.0%)	0.237 a
- **Present**	13 (18.6%)	8 (11.4%)	21 (15.0%)	
QTc n (%)				
- **Normal**	55 (78.6%)	55 (78.6%)	110 (78.6%)	0.773 a
- **Short**	10 (14.3%)	12 (17.1%)	22 (15.7%)	
- **Long**	5 (7.1%)	3 (4.3%)	8 (5.7%)	
PAC n (%)	70 (100%)	69 (98.6%)	139 (99.3%)	
- **Absent**	0 (0.0%)	1 (1.4%)	1 (0.7%)	0.316 a
- **Present**				
PVC n (%)				
- **Absent**	70 (100%)	69 (98.6%)	139 (99.3%)	0.316 a
- **Present**	0 (0.0%)	1 (1.4%)	1 (0.7%)	
Final interpretation n (%)				
- **Normal ECG**	18 (25.7%)	54 (77.1%)	72 (51.4%)	<0.001 a
- **Abnormal ECG**	52 (74.3%)	16 (22.9%)	68 (48.6%)	

Notes: Data presented as number, percentage. *P-values were obtained from a Chi-squared test.

Abbreviations: iRBBB, incomplete Right Bundle Branch Block; QTc, Corrected QT; PAC, Premature Atrial Contraction; PVC, Premature Ventricular Contraction.

DISCUSSION

The present investigation conducted in Herat City, Afghanistan, aimed to comparatively evaluate ECG alterations between bodybuilder athletes and a control group of non-athletes. Our investigation did not reveal a statistically significant disparity in resting heart rate between athletes and non-athletes, challenging our initial hypothesis. Previous research has primarily addressed sinus bradycardia in athletes, yet its prevalence varies across regions. For example, Sharma et al. (1999) observed an 80% occurrence rate of sinus bradycardia among English athletes compared to 19% among non-athletes. Similarly, Di Paolo et al. (2012) discovered that sinus bradycardia was prevalent in 60% of Indo-European athletes and 61% of African athletes, despite the geographical diversity of their study. In contrast, Wasfy et al. (2015) reported a lower 51% incidence in American athletes, and Kervio et al. (2013) noted an even lower 43% occurrence in Japan. Lawan et al. (2008) observed the lowest rate of 36% in Nigerian athletes. This finding is in contrast with the findings of previously published studies, potentially due to the influence of external factors like energy drinks used by athletes, which can significantly impact heart rate regulation mechanisms. Additionally, psychological disturbances caused by security and economic problems could also be a reason for the increased heart rate among these athletes.

The current study reported a statistically significant difference in the prevalence of sinus arrhythmia between athletes (34.3%) and non-athletes (8.6%). These findings are consistent with those of a study conducted by Sharma et al. (1999), who observed a similar disparity in England, with 52% of athletes exhibiting sinus arrhythmia compared to 19% of non-athletes. Furthermore, Wasfy et al. (2015) reported a 55% occurrence of sinus arrhythmia in American athletes. The differing findings of these studies may be due to geographical effects, nutritional differences, and the psychological state of the athletes.

The present study revealed a significant difference in the prevalence of LVH between athletes (18.6%) and non-athletes (4.3%), diagnosed using the Sokolow-Lyon criteria. These findings are in contrast to those of the studies conducted by previous researchers, who demonstrated varied prevalence across geographical regions. While Langdeau et al. (2001) observed a 10% occurrence in Canadian athletes, Douglas et al. (1988) reported a considerably higher 57% incidence in American athletes. Furthermore, Lawan et al. (2008) found a 47.3% prevalence of LVH among Nigerian athletes. These different results highlight the potential influence of regional factors on the development of LVH in athletes. Also, the low sample size of our study and difference in nutritional behaviors could be a reason for differences in results.

This study uncovered a statistically significant difference in iRBBB prevalence between athletes (32.9%) and non-athletes (8.6%), aligning with previously documented trends. Notably, Sharma et al. (1999) reported a similar disparity in England, with 29% of athletes exhibiting iRBBB compared to 11% of non-athletes. Furthermore, Di Paolo et al. (2012) observed comparable findings across diverse populations, documenting iRBBB incidences of 39% and 32% in Indo-European and African athletes, respectively, across Italy, Switzerland, and Algeria. These consistent observations across geographical regions suggest a potential association between athletic training and increased iRBBB prevalence.

This investigation revealed a statistically significant difference in the prevalence of T-wave inversion between athletes (8.6%) and non-athletes (0.0%) across two or more contiguous leads. Six athletes presented with this finding, supporting existing research conducted on white (Indo-European) athletes. Di Paolo et al. (2012) observed a similar trend with an 8% occurrence of negative T waves in their study population. Interestingly, ST-segment depression exceeding 1 mm in two or more adjacent leads was absent in both athletes and non-athletes in our study. This result aligns with the low prevalence documented in other nations. Notably, Wilson et al. (2011) reported an incidence of zero in Indo-European athletes, 0.3% in West Asian athletes, and 0.7% in black athletes in Qatar. These findings collectively highlight a potential association between athletic training and T-wave inversion but suggest a low occurrence of significant ST segment depression across diverse populations.

This study detected LAE in 2.8% of athletes, compared to none in the non-athlete group. Although not statistically significant, this finding diverges from previous studies suggesting a higher prevalence among athletes. For instance, Sharma et al. (1999) reported a 14.0% LAE rate in athletes and 1.2% in non-athletes in England. Similarly, Di Paolo et al. (2012) observed a 3.0% rate in Indo-European and a 9.0% rate in African athletes across Italy, Switzerland, and Algeria; Lawan et al. (2008) also documented an 8.7% rate in Nigerian athletes. These contradictory findings highlight the potential influence of geographical factors and study population on LAE prevalence in athletes. Our low sample size and difference in nutritional behaviors could be another reason for differences in results.

Our study revealed the presence of ST-segment elevation ≥1 mm in two or more contiguous leads in 11 athletes (15.7%) and 6 non-athletes (8.6%), though this difference wasn't statistically significant. These findings align with previous research demonstrating a higher prevalence among athletes. For example, Sharma et al. (1999) documented a 43% incidence in athletes compared to 24% in non-athletes (Sharma et al., 1999). Similarly, Di Paolo et al. (2012) observed a 56% occurrence in Indo-European athletes and a significantly higher 91% in African athletes. This trend continues with Lawan et al. (2008) reporting a 62% ST-segment elevation prevalence among Nigerian athletes. Though our study didn't show a statistically significant difference, the observed trend suggests similarities with the previously reported prevalence of ST-segment elevation in athletes compared to non-athletes.

Our study identified LAD in 5.7% of athletes and 1.4% of non-athletes, though the difference wasn't statistically significant. This aligns with prior research demonstrating geographical variations in LAD prevalence among athletes. For instance, Wilson et al. (2011) found that the prevalence of LAD was 2.5% among Indo-European athletes, 0.8% among West Asian athletes, and 0.7% among Black athletes in Qatar, while there were no cases of LAD among non-athletes. Furthermore, Lawan et al. (2008) noted an 8% occurrence of LAD in Nigerian athletes. In our investigation, we observed that just one athlete (1.4%) displayed RAD, which corresponds to findings from global studies such as Wilson et al. (2011), who identified RAD rates ranging from 2.0% to 1.1% across different athlete groups and 1.7% among non-athletes. Lawan et al. (2008) also reported a 2.7% prevalence of RAD among athletes. Despite lacking statistical significance, these findings suggest similarities with previous research indicating diverse occurrences of LAD and RAD among athletes in various geographical regions.

This study revealed an absence of first-degree atrioventricular (AV) block and Mobitz type I second-degree AV block in both athletes and non-athletes, which mirrors findings from various international studies reporting the low prevalence of these conditions in athletic populations. While the specific reasons for this lack of occurrence in our athlete group remain unclear, the potential influence of stimulant use and its impact on the heart's conduction system warrants further investigation. Notably, prior research by Sharma et al. (1999) found a 5% incidence of first-degree AV block among English athletes compared to none in non-athletes, alongside a 0.2% incidence of Mobitz type I second-degree AV block in athletes versus none in non-athletes. In contrast, Di

Paolo et al. (2012) observed a 3% and 14% prevalence of first-degree AV block in Indo-European and African athletes, respectively. Additionally, Lawan et al. (2008) documented a 4.7% incidence of first-degree AV block in Nigerian athletes. These differing results underscore how geographic location, study population, and research methods may impact the frequency of AV blocks among athletes. The small size of our sample could also contribute to variations in the outcomes observed. Further research is necessary to definitively determine the impact of stimulant use and other variables on the occurrence of these conduction abnormalities in athletic populations.

This investigation encountered constraints inherent in its limited sample size and budgetary restrictions. The research was entirely self-funded by the authors, precluding the allocation of resources for supplementary examinations like echocardiography and exercise tolerance tests (ETT) deemed necessary for some participants. The absence of these complementary assessments potentially restricts the generalizability of findings and may introduce limitations in fully elucidating certain aspects of the investigated phenomenon. To gain a more comprehensive understanding, research in Afghanistan needs a larger participant pool and sufficient funding. Both echocardiography and electrocardiography should be mandatory assessments.

CONCLUSION

Athletes' hearts adapt to physical stress, resulting in various ECG changes. Therefore, the study identified significant differences in sinus arrhythmia, left ventricular hypertrophy, incomplete right bundle branch block, and T-wave inversions when comparing ECG patterns between bodybuilder athletes and non-athletes. Accurately distinguishing between physiological and pathological changes is crucial when assessing an athlete and reviewing their electrocardiogram. This precision is vital for effective diagnosis and treatment, ultimately minimizing both time and economic expenses.

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