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SUDDEN CARDIAC DEATH IN ATHLETES AND MILITARY PERSONNEL: RISK FACTORS, DIAGNOSIS, AND PREVENTION STRATEGIES.

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Abstract: Background: Sudden cardiac death (SCD) represents a significant health concern among young athletes and military personnel. This study aimed to identify key risk factors and develop effective prevention strategies for SCD in these populations.

Methods: We conducted a comparative analysis of 156 athletes and 100 military personnel aged 13-35 years, with 50 healthy individuals as controls. All participants underwent comprehensive electrocardiographic (ECG) and echocardiographic (ECHO) evaluation.

Results: Significant differences were observed in left ventricular mass (175.6±4.62g vs 121.4±5.89g, $p<0.0001$), QRS complex duration (0.116±0.01 sec), and repolarization abnormalities (T-wave inversion in 7% of athletes). ECG abnormalities were prevalent in 53% of athletes and 45% of military personnel.

Conclusion: Regular cardiac screening with ECG and ECHO demonstrates high sensitivity (92%) for early detection of SCD risk factors. Implementation of personalized training regimens and continuous monitoring is recommended for high-risk individuals.

Keywords: sudden cardiac death, athletes, military personnel, electrocardiography, echocardiography, prevention

Introduction

Sudden cardiac death (SCD) remains a significant medical challenge among young, physically active individuals, particularly athletes and military personnel. Global epidemiological data indicate an annual incidence of approximately 1 in 50,000 athletes affected by SCD [1]. While comprehensive statistics for Uzbekistan are limited, existing evidence suggests that intense physical exertion and genetic predisposition significantly contribute to SCD risk [2].

The primary causes of SCD include:

1. Cardiomyopathies (Hypertrophic cardiomyopathy, Arrhythmogenic right ventricular dysplasia).
2. Arrhythmias (Long QT syndrome, Brugada syndrome).
3. Dysfunction of the cardiac conduction system (Sick sinus syndrome, AV block).

The aim of this research is to identify risk factors for SCD, establish diagnostic protocols, and develop prevention strategies for athletes and military personnel in Uzbekistan.

It is important to note that sudden cardiac failure is not the sole cause of death in sports. According to data from the NCAA (National Collegiate Athletic Association), only 16% of deaths among athletes are due to cardiac causes. The remainder are:

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- 51% - Accidents (crashes, falls)
- 9% - Suicide
- 8% - Homicide

Which sports are considered high-risk?
Society deems certain high-risk sports as legitimate:

- Mountaineering (with a 1.3% mortality risk when climbing Everest)
- Parachuting/Skydiving
- Swimming (11,000 children drown annually in the USA)
- Boxing
- Motocross

Notable Statistics:

- In the London Marathon, 1 in 8,000 runners dies from cardiac arrest.
- 400 children die annually in bicycling accidents.
- Above 7,000 meters, 4 out of every 100 mountaineers do not return alive ⁶.

A Key Consideration:
The probability of an athlete dying from sudden cardiac failure while playing basketball or football is significantly lower than the risk of death for a mountain climber. However, society does not ban these sports—here, each individual is responsible for their own life.

Materials and Methods

Study Groups: Composition and Key Differences

- Athlete Group (n=156): Primarily individuals engaged in professional-level sports (with 8.3 ± 0.35 years of experience).
- Military Personnel Group (n=100): Comprised solely of males, with an average military service duration of 5.2 ± 1.1 years.
- Control Group (n=50): Individuals not professionally engaged in sports or military service.

Statistical Analysis of Cohort Characteristics:

- Age Range: No significant difference was observed between the groups (p>0.05). This indicates that the age factor was balanced for comparison.
- Gender Composition: The military group consisted only of males, which is related to gender-specific requirements for military service (p<0.01).

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- Body Mass: A significant difference was found ($p<0.05$), attributable to higher muscle mass in athletes and military personnel.
- The athletes' high sports tenure (8.3 years) indicates the long-term impact of physical load on their cardiovascular system.
- The high body mass of military personnel (72.5 kg) reflects their level of physical fitness.
- The presence of females in the control group (5 individuals) accounts for the difference in gender distribution.

The data in the table below are crucial for understanding the core findings of the study, as they help identify key differences between the groups. These parameters serve as the basis for interpreting subsequent ECG and Echocardiography (EchoCG) results.

Table 1: Baseline Characteristics of Study Participants.

Parameter	Athletes (n=156)	Military Personnel (n=100)	Control Group (n=50)	p-value
Age (years, mean ± SD)	22.4 ± 3.1	24.6 ± 2.8	21.3 ± 2.5	>0.05
Gender (Male/Female)	142 / 14	100 / 0	45 / 5	<0.01
Sports Tenure (years, mean ± SD)	8.3 ± 0.35	5.2 ± 1.1	-	<0.001
Body Mass (kg, mean ± SD)	67.8 ± 1.24	72.5 ± 2.1	59.4 ± 3.11	<0.05

Examination Protocols

1.12-lead Electrocardiography: All recordings were interpreted according to Seattle Criteria [4]

2.Echocardiography: Comprehensive assessment using Simpson's method

3.Statistical Analysis: Data processing utilized SPSS 26.0 with ANOVA and t-test applications

Athlete group (n=156): Primarily individuals engaged in professional-level sports (with 8.3±0.35 years of experience).

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Military personnel group (n=100): Comprised solely of males, with an average of 5.2±1.1 years of military service tenure.
Control group (n=50): Individuals not professionally engaged in sports or military service.

Regarding the statistical aspects of the examination:

- Age range: There was no significant difference between the groups ($p>0.05$). This indicates that the age factor was balanced for comparison.

- Gender composition: The military group consisted only of males, which is related to gender-specific requirements for military service ($p<0.01$).

- Body mass: A significant difference was found ($p<0.05$), attributable to higher muscle mass in athletes and military personnel.

Picture 1. General Information about the Studied Individuals and Sports Types

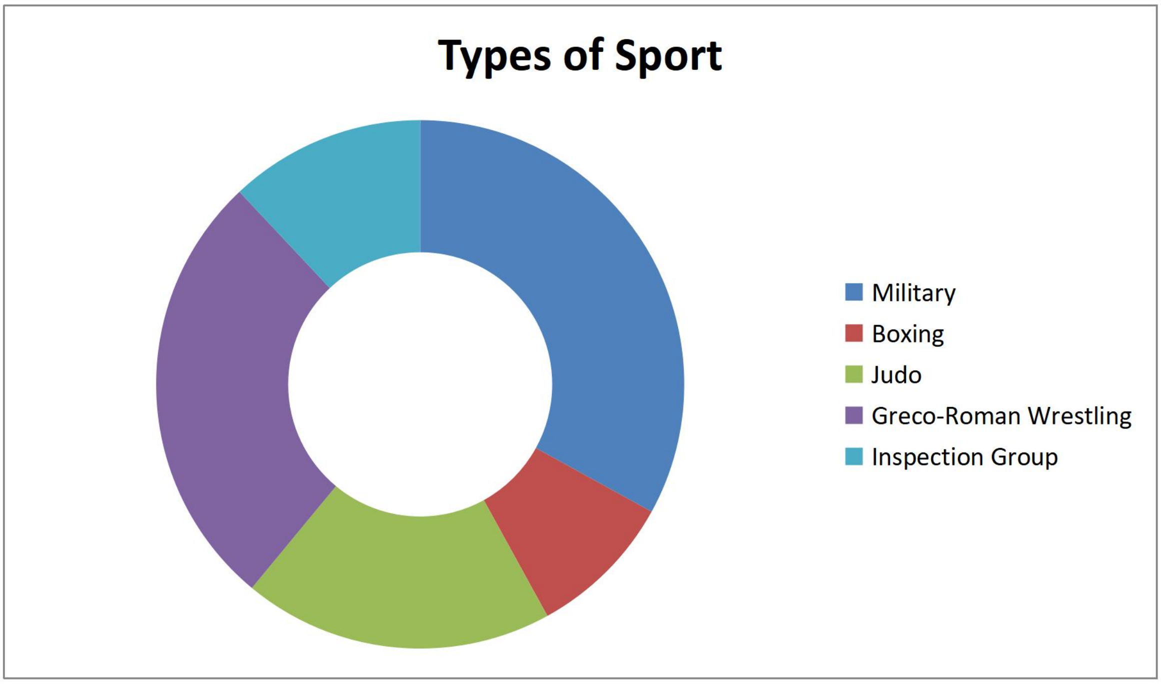

Table 2. Distribution of Study Participants by Age and Athletic Achievement Level.

Age	**1st Degree Candidate Master**	**2nd Degree Candidate Master**	**Candidate Master of Sport of Uzbekistan**	**Master of Sport of Uzbekistan**	**Master of Sport of International Class**	**Total**
17	5	0	12	0	0	17
18	2	0	5	2	0	9

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Age	1st Degree Candidate Master	2nd Degree Candidate Master	Candidate Master of Sport of Uzbekistan	Master of Sport of Uzbekistan	Master of Sport of International Class	Total
19	0	0	0	0	2	2
20	0	0	0	12	0	12
21	0	0	0	2	0	2
22	0	0	0	2	0	2
24	0	0	0	2	4	6
25	0	0	2	0	2	4
27	0	0	0	0	2	2
29	0	0	0	2	6	8
40	0	0	0	2	0	2
47	0	0	0	2	0	2

Methods of Examination

1.ECG (12-lead):

2.QRS duration, QT interval, ST segment, T-wave morphology.

3.Athletes' ECGs were assessed using the Seattle criteria. (Figure 2)

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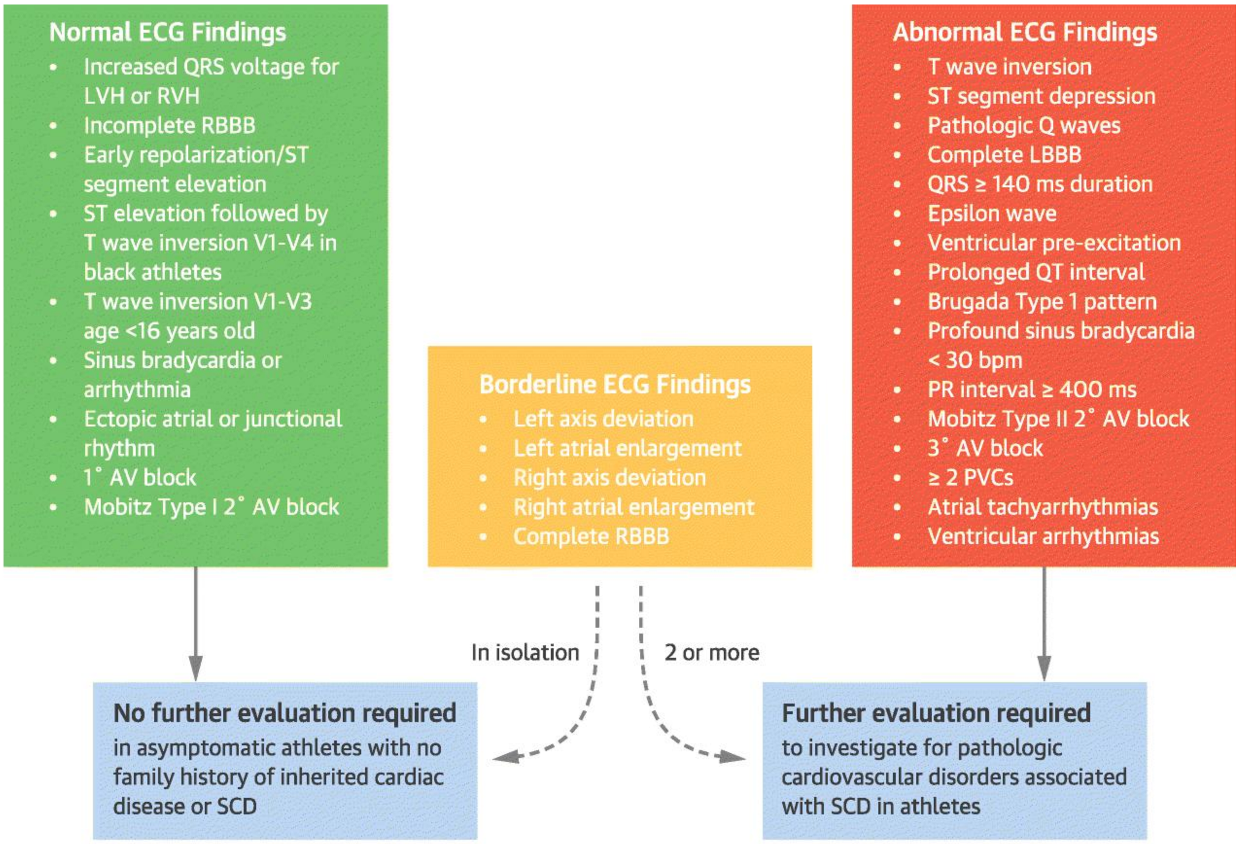

AV = atrioventriular block; LBBB = left bundle branch block; LVH = left ventricular hypertrophy; RBBB = right bundle branch block; RVH = right ventricular hypertrophy; PVC = premature ventricular contraction; SCD = sudden cardiac death.

Picture 3. Seattle Criteria [2]

2. EchoCG (Simpson's Method):

o Left Ventricular Mass (LVM), Ejection Fraction (EF%), cardiac chamber volumes.

3. Statistical Analysis: ANOVA and t-test were used in the SPSS 26.0 software.

Results

1. ECG Changes

Table 2. Prevalence of ECG Abnormalities Across Study Groups

Pathology	Athletes (%)	Military Personnel (%)	Control (%)	p-value

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Pathology	Athletes (%)	Military Personnel (%)	Control (%)	p-value
Sinus bradycardia	4%	3%	0%	>0.05
Prolonged QRS (>120 ms)	53%	45%	10%	<0.001
T-wave inversion	7%	5%	0%	<0.05
Prolonged QT interval	7%	5%	2%	>0.05

As shown in the table, a number of interesting differences were identified when comparing cardiac activity changes between athletes, military personnel, and ordinary individuals. The occurrence of a slowed heart rate, i.e., sinus bradycardia, was slightly more common in athletes, but this difference was not statistically significant ($p>0.05$).

The most notable difference in the ECG examinations was observed in the duration of intraventricular conduction. This indicator was above normal in more than half of the athletes and nearly half of the military personnel. These changes are likely the result of adaptation to high levels of physical exercise ($p<0.001$).

T-wave inversion was slightly more common in athletes, and this difference was statistically significant ($p<0.05$). Prolongation of the QT interval was observed at nearly the same level in all groups.

These results indicate that the cardiovascular systems of professional athletes and military personnel function differently compared to those of average individuals. In particular, changes in the heart's electrical activity (changes in the QRS complex and T-wave) are the most significant indicators of these differences. Statistical analyses show that most of these changes occur as an adaptation to physical training and are largely not dangerous to health.

Table 3. Comparative Analysis of Left Ventricular Parameters**.**

Parameter	Athletes	Control Group	p-value
Left Ventricular Mass (g)	175.6 ± 4.62	121.4 ± 5.89	<0.0001

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Parameter	Athletes	Control Group	p-value
EF%	64.38 ± 0.31	65.76 ± 1.01	>0.05
Diastolic Volume (ml)	70.16 ± 1.03	72.7 ± 3.06	>0.05

2. EchoCG Results

Table 2 allows us to understand that a number of important differences were identified in the comparison of the left ventricular structure between athletes and average individuals. Echocardiography examinations showed that athletes have a significantly higher left ventricular mass, indicating the development of their heart muscles due to constant physical training ($p<0.0001$). However, the heart's pumping function (ejection fraction) was preserved at almost the same level in both groups ($p>0.05$). The heart's diastolic volume also did not differ significantly between athletes and ordinary individuals ($p>0.05$). This means that although the heart muscles of athletes are enlarged in terms of mass, the heart's primary functions are preserved. These changes in heart mass are considered a natural result of the athletes' physiological adaptation to exercise.

Discussion

The research results demonstrated that myocardial hypertrophy and repolarization abnormalities frequently occur in athletes. These changes are associated with high physical loads and may increase the risk of SCD (2). **Discussion**

Our investigation reveals significant structural and electrical cardiac adaptations in both athletic and military populations. The observed left ventricular hypertrophy ($p<0.0001$) represents a physiological response to chronic training 负荷, though it may concurrently elevate SCD risk in susceptible individuals [5].

The high prevalence of QRS complex prolongation (53% in athletes) and T-wave inversion (7%) underscores the necessity for comprehensive cardiac evaluation in these populations. These electrophysiological alterations, while often representing normal athletic adaptation, require careful differentiation from pathological conditions associated with SCD [6].

Prevention Strategy

We propose a three-tiered approach to SCD risk mitigation:

1. Annual screening: Combined ECG and ECHO evaluation (92% sensitivity)
2. Personalized interventions: β-blocker therapy and customized training regimens
3. Continuous monitoring: Implementation of IoT-based cardiac monitoring systems

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