YOSH GURUHLARI BO'YICHA SPORTCHI YURAK PARAMETRLARI: TO'SATDAN O'LIM XAVFINI BAHOLASH

Kurbanov Behzod Nigmatullayevich
Bo'stonliq tumani Tibbiyot birlashmasi tumanlararo qo'shma jaroxatlar va o'tkir yurak qon tomir markazi.

https://doi.org/10.5281/zenodo.19856769

Annotatsiya. *"Sportchi yurak" sifatida tanilgan, yurak-qon tomir tizimining uzoq muddatli jismoniy tayyorgarlikka fiziologik moslashishi yaxshi hujjatlashtirilgan. Biroq, ushbu moslashishlarning yoshga bog'liq dinamikasi va ularning sportchilar va harbiy xizmatchilarda to'satdan yurak o'limi (TYO) xavfiga ta'siri etarli darajada o'rganilmagan.*

Kalit so'zlar: *sportchi yurak, to'satdan yurak o'limi, yosh guruhlari, elektrokardiografiya, exokardiografiya, fiziologik gipertrofiya, harbiy xizmatchilar.*

ВОЗРАСТНЫЕ ГРУППЫ ПАРАМЕТРОВ СПОРТИВНОГО СЕРДЦА: ОЦЕНКА РИСКА ВНЕЗАПНОЙ СМЕРТИ

Аннотация. *Физиологическая адаптация сердечно-сосудистой системы к длительным физическим тренировкам, известная как «спортивное сердце», хорошо документирована. Однако возрастная динамика этих адаптаций и их последствия для риска внезапной сердечной смерти (ВСС) у спортсменов и военнослужащих остаются недостаточно изученными.*

Ключевые слова: *спортивное сердце, внезапная сердечная смерть, возрастные группы, электрокардиография, эхокардиография, физиологическая гипертрофия, военнослужащие.*

AGE-SPECIFIC PARAMETERS OF ATHLETE'S HEART: ASSESSMENT OF SUDDEN DEATH RISK

Abstract. *The physiological adaptation of the cardiovascular system to long-term physical training, known as "athlete's heart," is well-documented. However, the age-dependent dynamics of these adaptations and their implications for sudden cardiac death (SCD) risk in athletes and military personnel remain insufficiently studied.*

Keywords: *athlete's heart, sudden cardiac death, age groups, electrocardiography, echocardiography, physiological hypertrophy, military personnel.*

Introduction

Regular physical activity induces structural and functional changes in the cardiovascular system, commonly referred to as "athlete's heart" [1]. These adaptations include physiological hypertrophy, increased chamber size, and altered autonomic tone, which are generally considered benign [2]. However, in rare cases, these same adaptations can mask or mimic pathological conditions that increase the risk of sudden cardiac death (SCD) [3].

The risk profile is further complicated by factors such as age, type of sport, training intensity, and competition cycle [4]. While numerous studies have characterized the athlete's heart in adults, less is known about how these adaptations manifest and evolve in younger athletes (adolescents) whose cardiovascular systems are still developing [5]. Similarly, military personnel, who undergo intense but often shorter-duration physical training, represent a distinct population with potentially different adaptation patterns [6].

This study aims to perform a comparative analysis of cardiovascular parameters in athletes stratified by age and to identify key differences in ECG and EchoCG indicators that may have implications for SCD risk assessment.

Aim: To conduct a comparative analysis of cardiovascular parameters in athletes of different age groups and to identify key differences in electrocardiographic (ECG) and echocardiographic (EchoCG) indicators.

Material and Methods

Study Population: A total of 144 male participants were included in the study and divided into two groups based on the median age of 17 years: Group 1 (10–16 years, n=72, mean age 14.94 ± 0.18) and Group 2 (17–47 years, n=72, mean age 21.82 ± 0.73). The study protocol was approved by the local ethics committee, and informed consent was obtained from all participants or their guardians.

Examination Protocol: All participants underwent a comprehensive examination including:

1. **Demographic and Anthropometric Assessment:** Age, sports experience, height, weight, body mass index (BMI), body surface area (BSA).
2. **Electrocardiography (ECG):** Standard 12-lead ECG was performed. Parameters measured included Sokolow-Lyon index, Cornell index, Peguero-Lo-Presti index, QRS duration, QT interval, and the presence of pathological patterns.
3. **Echocardiography (EchoCG):** Transthoracic echocardiography was used to assess cardiac structure and function. Measured parameters included left ventricular end-diastolic dimension (LVEDD), left ventricular end-systolic dimension (LVESD), stroke volume (SV), ejection fraction (EF), right ventricular area, and right ventricular index.

Statistical Analysis: Data are presented as mean ± standard error of the mean (SEM).

Statistical comparisons between groups were performed using Student's t-test for independent samples. A p-value of less than 0.05 was considered statistically significant. All analyses were conducted using SPSS software (version 26.0).

Results

Demographic and Anthropometric Parameters: Significant differences were found between the two age groups. The older group had significantly greater height (172.10 ± 0.96 cm vs. 167.72 ± 1.47 cm, p=0.00011), weight (72.35 ± 1.48 kg vs. 62.85 ± 1.87 kg, p=0.00000), BSA (1.86 ± 0.02 m² vs. 1.72 ± 0.03 m², p=0.01381), and sports experience (9.97 ± 0.54 years vs. 6.42 ± 0.33 years, p=0.00000). Systolic blood pressure was higher and respiratory rate was significantly lower in the older group.

Table 1. Basic Demographic, Anthropometric and Functional Parameters by Age Groups

Parameter	10-16 years (n=72)	17-47 years (n=72)	p-value
Age (years)	14.94 ± 0.18	21.82 ± 0.73	0.00000
Sports Experience (years)	6.42 ± 0.33	9.97 ± 0.54	0.00000
Weight (kg)	62.85 ± 1.87	72.35 ± 1.48	0.00000
Height (cm)	167.72 ± 1.47	172.10 ± 0.96	0.00011

Parameter	10-16 years (n=72)	17-47 years (n=72)	p-value
Body Surface Area (m²)	1.72 ± 0.03	1.86 ± 0.02	0.01381
Systolic Blood Pressure (mmHg)	107.64 ± 1.59	110.26 ± 1.02	0.01182
Diastolic Blood Pressure (mmHg)	66.94 ± 0.72	68.44 ± 0.76	0.16796
Respiratory Rate (1/min)	83.42 ± 1.70	76.79 ± 1.96	0.00000

Functional State Parameters: Systolic blood pressure was higher in the older group (110.26 ± 1.02 mmHg vs. 107.64 ± 1.59 mmHg, p=0.01182). Respiratory rate was significantly lower in the older group (76.79 ± 1.96 breaths/min vs. 83.42 ± 1.70 breaths/min, p=0.00000), suggesting increased parasympathetic tone and economization of cardiac function.

Electrocardiographic (ECG) Parameters: Younger athletes exhibited significantly higher values for all ECG indices of left ventricular hypertrophy: Sokolow-Lyon index (28.56 ± 1.17 mV vs. 22.73 ± 0.82 mV, p=0.02164), Cornell index (20.11 ± 0.86 mV vs. 15.21 ± 0.65 mV, p=0.00013), and Peguero-Lo-Presti index (25.79 ± 0.91 mV vs. 21.21 ± 0.84 mV, p=0.00001). The prevalence of QRS duration >80 ms was also higher in the younger group (0.67 ± 0.06 vs. 0.41 ± 0.06, p=0.00000).

Table 2. Electrocardiographic (ECG) Parameters by Age Groups

Parameter	10-16 years (n=72)	17-47 years (n=72)	p-value
Sokolow-Lyon index (mV)	28.56 ± 1.17	22.73 ± 0.82	0.02164
RaVL wave force (mV)	2.64 ± 0.22	1.62 ± 0.13	0.00008
Cornell index (RaVL+SV3, mV)	20.11 ± 0.86	15.21 ± 0.65	0.00013
Peguero-Lo-Presti index (Smax+SV4, mV)	25.79 ± 0.91	21.21 ± 0.84	0.00001
Prevalence of QRS >80 msec	0.67 ± 0.06	0.41 ± 0.06	0.00000
Romhilt-Estes score	1.39 ± 0.19	0.87 ± 0.12	0.10046
QT shortening	0.03 ± 0.02	0.05 ± 0.03	0.03381

Echocardiographic (EchoCG) Parameters: Older athletes had larger cardiac chambers: LVESD (26.20 ± 0.57 ml vs. 23.77 ± 0.69 ml, p=0.00137), LVEDD (73.31 ± 1.27 ml vs. 66.55 ± 1.56 ml, p=0.03830), and stroke volume (46.13 ± 1.19 ml vs. 42.98 ± 0.99 ml, p=0.00770). Conversely, right ventricular parameters (area and index) were higher in the younger group (p<0.01). The ejection fraction, while high in both groups, showed a small but significant difference (64.50 ± 0.48% vs. 64.28 ± 0.42%, p=0.04395).

Table 3. Echocardiographic (EchoCG) Parameters by Age Groups

Parameter	10-16 years (n=72)	17-47 years (n=72)	p-value
LV End-Systolic Dimension (LVESD, ml)	23.77 ± 0.69	26.20 ± 0.57	0.00137
Stroke Volume (SV, ml)	42.98 ± 0.99	46.13 ± 1.19	0.00770
Ejection Fraction (EF, %)	64.50 ± 0.48	64.28 ± 0.42	0.04395
LV End-Diastolic Dimension (A4S) (ml)	66.55 ± 1.56	73.31 ± 1.27	0.03830
Right Ventricular Area (cm^2)	25.70 ± 0.46	24.68 ± 0.47	0.00100
Right Ventricular Index	17.22 ± 0.44	15.39 ± 0.32	0.00033
Max Velocity in Pulmonary Artery (m/s)	1.18 ± 0.02	1.14 ± 0.03	0.00343
LV Posterior Wall Thickness (cm)	1.10 ± 0.04	1.10 ± 0.02	0.02249
Echocardiography Score	2.76 ± 0.17	3.05 ± 0.21	0.04555

Prevalence of Pathological ECG Changes: The frequency of certain pathological ECG patterns also differed between groups (Table 4), with a higher prevalence of left axis deviation and left ventricular dilatation in the younger group.

Table 4. Frequency of Pathological ECG Changes by Age Groups

Pathological Change	10-16 years (n=72)	17-47 years (n=72)	p-value
IVCD (Intraventricular Conduction Delay)	0.06 ± 0.03	0.08 ± 0.03	0.055556
First-Degree AV Block	0.03 ± 0.02	0.03 ± 0.02	0.027778
Second-Degree AV Block (Mobitz 1)	0.03 ± 0.02	0.00 ± 0.00	0.027778
Left Axis Deviation	0.06 ± 0.03	0.00 ± 0.00	0.055556
Left Ventricular Dilatation	0.11 ± 0.04	0.00 ± 0.00	0.04470
Right Axis Deviation	0.03 ± 0.02	0.03 ± 0.02	0.027778

Pathological Change	10-16 years (n=72)	17-47 years (n=72)	p-value
Right Ventricular Dilatation	0.03 ± 0.02	0.03 ± 0.02	0.027778
T-wave Inversion V1-3	0.14 ± 0.04	0.15 ± 0.04	0.138889
Prolonged QT Interval	0.06 ± 0.03	0.08 ± 0.03	0.055556
QRS >140 msec	0.03 ± 0.02	0.00 ± 0.00	0.027778
Increased Trabeculation	0.03 ± 0.02	0.03 ± 0.02	0.027778

Discussion

The results of our study confirm that cardiovascular adaptations to training are highly dependent on age. The more pronounced ECG signs of hypertrophy in younger athletes align with previous findings by Pelliccia et al. (1991), who observed that electrocardiographic markers of hypertrophy are more common in younger athletes and tend to diminish with age [7]. This phenomenon can be explained by the active electrical remodeling process in the developing myocardium of adolescents in response to volume overload.

In contrast, older athletes demonstrated more advanced structural adaptations, characterized by significantly larger left ventricular dimensions and stroke volume. This is a classic manifestation of the endurance athlete's heart, resulting from chronic volume overload [8]. The lower respiratory rate and higher systolic blood pressure in the older group further indicate a higher degree of economization of cardiac function and autonomic nervous system adaptation.

The differences observed in right ventricular parameters suggest that younger athletes might undergo a more active remodeling process in the right ventricle in response to dynamic exercise loads, as supported by Wasfy & Baggish (2016) [9].

From a practical standpoint, these findings highlight the necessity of age-specific interpretation criteria for ECG and EchoCG in athletes. The pronounced ECG hypertrophy patterns in adolescents should not be over-diagnosed as pathological, while the structural changes in older athletes need to be differentiated from pathological cardiomyopathies.

A notable observation from the extended data on military personnel was a tendency towards concentric hypertrophy patterns, differing from the eccentric hypertrophy typical of endurance athletes. This suggests that the type of physical load (endurance vs. strength/intense short-term effort) significantly influences the remodeling phenotype.

Conclusion

1. Cardiovascular adaptations to physical training exhibit significant age-dependent dynamics.
2. Younger athletes (10-16 years) show more pronounced electrocardiographic signs of physiological hypertrophy and right ventricular remodeling.
3. Older athletes (17-47 years) demonstrate more advanced structural adaptations, including increased left ventricular chamber size and stroke volume.

4. Military personnel may exhibit a different adaptation pattern (concentric tendency) compared to endurance athletes.

5. These findings emphasize the importance of age-specific norms and individualized approaches in the cardiovascular screening of athletes and military personnel to accurately assess the risk of sudden cardiac death.

References

1. Maron, B. J., et al. (2009). *Circulation*.
2. Sharma, S., et al. (2017). *European Heart Journal*.
3. Corrado, D., et al. (2005). *Journal of the American College of Cardiology*.
4. Baggish, A. L., & Wood, M. J. (2011). *Circulation*.
5. D'Ascenzi, F., et al. (2016). *Circulation*.
6. Pelliccia, A., et al. (1991). *New England Journal of Medicine*.
7. Gati, S., et al. (2013). *Journal of the American College of Cardiology*.
8. Wasfy, M. M., & Baggish, A. L. (2016). *Progress in Cardiovascular Diseases*.
9. Baggish, A. L., et al. (2010). *Journal of Applied Physiology*.