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HEART RATE VARIABILITY IN FOOTBALL PLAYERS AND TRACK AND FIELD ATHLETES

Doniyorov Bakhriddin Bakhrom Ugli, Mavlyanova Zilola Farkhadovna, Djurabekova Aziza Takhirovna, Shamsiddinova Madinabonu Shuxrat kizi
Samarkand State Medical University, Samarkand, Uzbekistan

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ABSTRACT

Objective of the study: *To investigate the state of the autonomic nervous system in athletes based on heart rate variability indicators.* ***Materials and methods:*** *The study was conducted on 142 male athletes (67 football players and 75 track and field athletes) aged 17-20 years, with an average age of 18.5±1.5 years. Depending on the type of higher nervous activity, athletes were divided into 4 groups: sanguine (41.55%), choleric (28.87%), phlegmatic (19.01%), and melancholic (10.56%). Heart rate variability (HRV) was studied using the "BioMouse" system. A t-test for independent samples (Welch's t-test) was used to analyze the significance of differences between the groups.* ***Results of the study:*** *It was found that the highest adaptive capabilities were observed in phlegmatic athletes, who demonstrated high SDNN and HF values, as well as a low tension index (IN). Their calm temperament allows for better adaptation to physical exertion and maintaining a balance between sympathetic and parasympathetic activity. The lowest adaptive capabilities were observed in melancholics, who showed high IN and LF values, as well as low SDNN and HF, indicating an imbalance in the autonomic nervous system and lower resilience to physical stress. Overall, beginner athletes tended to have slightly higher heart rates and lower HRV indicators (SDNN), LF, and HF compared to more experienced athletes of the 2nd-3rd ranks. This is due to the fact that first-year athletes have not yet fully adapted to physical loads, leading to more pronounced dominance of the sympathetic nervous system and less parasympathetic activity.*

KEYWORDS: *variability, heart rate, athletes, football players, track and field athletes, autonomic nervous system, physical exertion.*

INTRODUCTION

The regulation of the cardiovascular system plays a crucial role in the adaptation of athletes to physical exertion and the achievement of high performance, which directly depends on the type of higher nervous activity (HNA) and the autonomic nervous system (ANS) [1,5,8,9,10]. During intense training, athletes often experience changes in the functioning of the cardiovascular system, which may be related to the characteristics of nervous activity [2,4,6,12,21].

Heart rate variability (HRV) indicators serve as an important tool for assessing the functional state of athletes and identifying deviations in autonomic regulation [2,7,11,14,18,20]. Football players and track and field athletes are exposed to significant physical and psycho-emotional stress, making the study of the influence of different types of HNA and ANS on HRV indicators relevant [3,15,17,19]. Determining the relationship between them and the body's ability to adapt to intense training and competition will help develop more effective individualized training programs [4,16,22]. Since a decrease in heart rate variability often indicates disturbances in regulatory processes, this study aims to examine HRV indicators in football players and track and field athletes. This will allow for a deeper understanding of the mechanisms of athletes' adaptation to physical exertion and identify potential factors that contribute to improved athletic performance.

OBJECTIVE OF THE STUDY

To investigate the state of the autonomic nervous system in athletes based on heart rate variability indicators.

MATERIALS AND METHODS

Informed consent was obtained from all athletes before the start of the study. A total of 142 male athletes were examined (67 football players and 75 track and field athletes) aged 17-20 years (mean age 18.5±1.5 years). The psychological characteristics of the athletes were assessed using the Eysenck Personality Questionnaire (EPQ) with the "Psychotest" computer program. Heart rate variability (HRV) was evaluated using the "BioMouse" system from the company "NeuroLab" (Russia, 2001), which allows for the recording of heart rate (HR), standard deviation of normal RR intervals (SDNN), tension index (IN), low-frequency power (LF), and high-

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frequency power (HF). The t-test for two independent samples with unequal variances (Student's method) was used to calculate the significance of differences between the groups of football players and track and field athletes. Mean values and standard deviations for each group were used to calculate the t-statistics. Welch's t-test was applied due to differences in sample sizes and variances between the groups. P-values were calculated for each group pair (football players vs. track and field athletes), and the difference was considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

It was found that among the examined athletes, sanguine individuals predominated (41.55%), including 21.13% of football players and 20.42% of track and field athletes. Choleric athletes made up 28.87% of the sample. The choleric temperament in 15.49% of football players was characterized by high activity, decisiveness, and a strong drive for leadership. In track and field, cholerics (13.38%) excelled in disciplines such as sprinting and throwing, where high motivation and aggressiveness in achieving goals are essential. Phlegmatic individuals were somewhat less common, comprising 19.01%. Among them, 7.04% of phlegmatic football players, with their stable, calm, and balanced character, played a key role in stable and predictable defense. In contrast, 11.97% of phlegmatic track and field athletes demonstrated high endurance and stability. Melancholics (10.56%) included 3.52% of football players and 7.04% of track and field athletes. Melancholics are more prone to stress and anxiety, which may limit their ability to perform effectively in team sports. In track and field, melancholics may succeed in disciplines requiring precision and concentration, such as jumping or technical events, as their melancholic temperament often shows greater sensitivity to psycho-emotional stress (Figure 1).

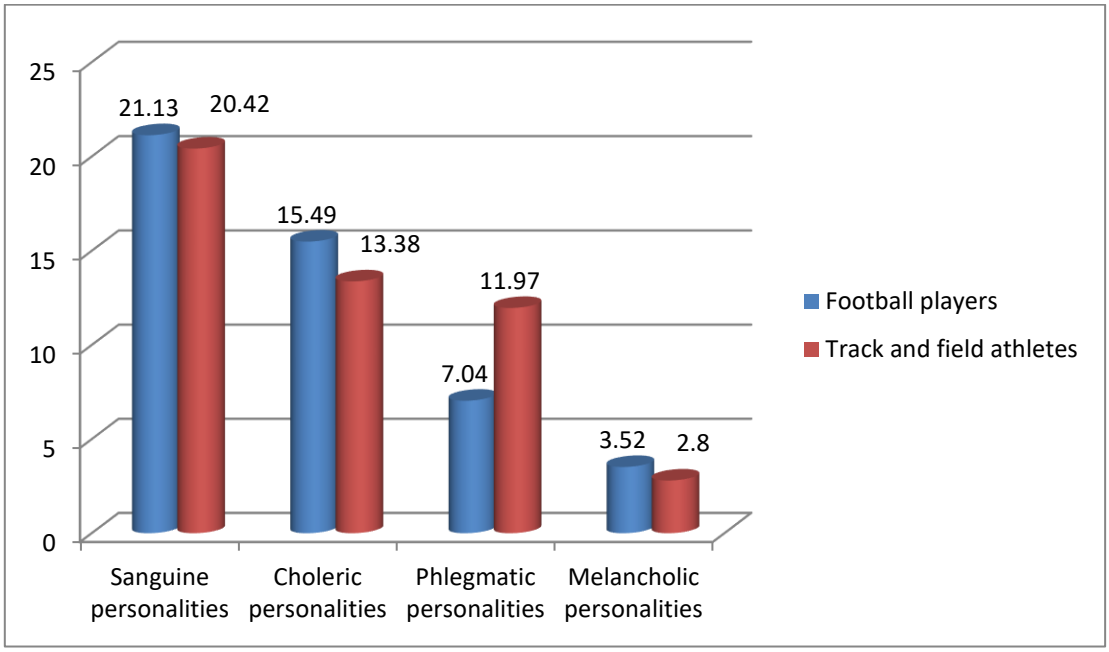


Figure 1. Distribution of athletes by types of higher nervous activity

Further analysis of heart rate variability indicators for first-year athletes and 2nd-3rd rank athletes revealed several key differences depending on the type of higher nervous activity (HNA) and the level of training (Table 1).

Table 1

HRV indicators depending on HNA types and sports (football players and track and field athletes) in the first year of training

HNA Type	Sport	HR (bpm)	SDNN (ms)	IN (units)	LF (ms²)	LF (ms²)
Sanguine	Football players(n=10)	68.0±2.0	125.0±4.0	60.0±5.0	650.0±40.0	580.0±40.0
Choleric	Football players (n=9)	77.0±2.2	105.0±5.5	90.0±5.0	850.0±5.0	380.0±45.0
Phlegmatic	Football players(n=5)	62.0±3.0	135.0±6.0	48.0±6.0	580.0±60.0	680.0±60.0
Melancholic	Football players (n=2)	77.0±3.0	98.0±6.0	100.0±12.0	930.0±95.0	300.0±95.0
Sanguine	Track athletes (n=19)	63.0±2.0	137.0±4.0	50.0±6.0	580.0±40.0	680.0±40.0
Choleric	Track athletes (n=9)	72.0±2.5	115.0±5.0	78.0±5.0	760.0±45.0	480.0±45.0
Phlegmatic	Track athletes (n=7)	58.0±2.5	145.0±6.0	40.0±5.0	480.0±50.0	760.0±50.0
Melancholic	Track athletes (n=4)	71.0±3.0	105.0±5.0	84.0±6.0	840.0±60.0	380.0±60.0

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As seen in Table 1, the comparative analysis of HRV indicators for first-year athletes (ages 17-20) and 2nd-3rd rank athletes reveals several key differences.

For football players with a sanguine temperament, the heart rate (HR) of beginner athletes (68.0±2. 0 bpm) was slightly higher than that of 2nd-3rd rank athletes (65.0±1.8 bpm), which can be attributed to lower adaptation to physical exertion. The SDNN level in beginners was slightly lower (125.0±4.0 ms) compared to more experienced athletes (130.0±3.7 ms), indicating lower heart rate variability and, consequently, less adaptation to training. The LF (650.0±40.0 ms²) and HF (580.0±40.0 ms²) values were also lower in beginner athletes than in experienced ones, which suggests underdeveloped autonomic nervous system regulation.

Among beginner cholerics (77.0±2.2 bpm), there was an increase in heart rate compared to more experienced athletes (75.0±2.1 bpm), which may be explained by a higher level of excitability in less trained athletes. The SDNN indicator was significantly lower in beginners (105.0±5.5 ms) compared to experienced athletes (110.5±5.3 ms), indicating less resilience to physical exertion. At the same time, the LF level in beginners was higher (850.0±45.0 ms²), and HF was lower (380.0±45.0 ms²), which indicates a dominance of sympathetic activity at the beginning of the training process.

When determining heart rate (HR) in beginner phlegmatics (62.0±3.0 bpm), there was a slight increase in HR compared to experienced athletes (60.0±3.2 bpm). The SDNN level in beginner athletes was slightly lower (135.0±6.0 ms) compared to experienced ones (140.0±6.3 ms), indicating lower adaptation to physical loads. LF and HF levels in beginners (580.0±60.0 ms² and 680.0±60.0 ms², respectively) were lower than those in 2nd-3rd rank athletes, suggesting less balanced autonomic regulation.

In beginner melancholic athletes, HR was 77.0±3.0 bpm, slightly higher than in experienced athletes (75.0±2.7 bpm). SDNN values in beginners were lower (98.0±6.0 ms) compared to more experienced athletes (102.0±5.4 ms). Additionally, beginner melancholics showed higher LF levels (930.0±95.0 ms²) and lower HF levels (300.0±95.0 ms²), indicating dominant sympathetic activity.

Different data were obtained in the group of track and field athletes. HR in beginner sanguine athletes (63.0±2.0 bpm) was slightly higher than in experienced athletes (60.0±1.9 bpm). On the other hand, SDNN levels in beginners were slightly lower (137.0±4.0 ms) compared to experienced athletes (142.5±3.9 ms), indicating less developed adaptation mechanisms. Similar data were observed when evaluating LF (580.0±40.0 ms²) and HF (680.0±40.0 ms²), which were lower in beginners than in experienced athletes.

In beginner cholerics, HR was 72.0±2.5 bpm, differing slightly from experienced athletes (70.0±2.3 bpm). More significant differences were found in the interpretation of SDNN, which was lower in beginners (115.0±5.0 ms) compared to experienced athletes (120.0±4.6 ms). The less stable autonomic regulation in beginner track and field athletes was evidenced by lower LF (760.0±45.0 ms²) and HF (480.0±45.0 ms²) compared to experienced athletes.

As for the HR in beginner phlegmatics, it reached 58.0±2.5 bpm, higher than in 2nd-3rd rank athletes (55.0±2.4 bpm). The SDNN level in beginner athletes (145.0±6.0 ms), as well as LF (480.0±50.0 ms²) and HF (760.0±50.0 ms²), were lower than in more experienced athletes. For example, SDNN in the group of experienced athletes was 150.0±5.8 ms.

For novice melancholic athletes, a higher heart rate (71.0±3.0 beats/min) was observed compared to more experienced track-and-field athletes (69.0±3.8 beats/min). The SDNN value for novices was lower (105.0±5.0 ms) compared to more experienced athletes (109.5±4.7 ms), indicating reduced heart rate variability and, consequently, less developed regulatory mechanisms. Lower LF (840.0±60.0 ms²) and HF (380.0±60.0 ms²) values also pointed to a less developed autonomic regulation in novice athletes.

In the comparative analysis of heart rate variability (HRV) among football players and track-and-field athletes, significant differences were identified depending on the type of higher nervous activity (HNA).

In the group of football players:
- HR (Heart Rate): Highest HR values: in choleric athletes (77.0±2.2 beats/min), explained by their high excitability and activity. Lowest HR values: in phlegmatic athletes (62.0±3.0 beats/min), consistent with their calm and balanced temperament.

- SDNN (Standard Deviation of Normal-to-Normal Intervals): Highest SDNN values: in phlegmatic athletes (135.0±6.0 ms), indicating higher heart rate variability and better adaptation to physical loads. Lowest SDNN values: in melancholic athletes (98.0±6.0 ms), reflecting lower variability.

- IN (stress index): The highest IN values were observed in melancholics (100.0±12.0 units), indicating a high level of stress and tension in the autonomic nervous system. The lowest IN values were found in phlegmatics (48.0±6.0 units), suggesting a lower level of tension and better resistance to stress.

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- LF (low-frequency components): The highest LF values were found in melancholics (930.0±95.0 ms²), which indicates a dominance of sympathetic activity and poor adaptive capacity. The lowest LF values were observed in phlegmatics (580.0±60.0 ms²), suggesting a more balanced autonomic regulation.
- HF (high-frequency components): The highest HF values were recorded in phlegmatics (680.0±60.0 ms²), indicating high parasympathetic activity and better heart rate regulation. The lowest HF values were seen in melancholics (300.0±95.0 ms²), reflecting suppressed parasympathetic activity and weaker adaptive capabilities.

For track and field athletes, the following HRV parameters were characteristic depending on the type of nervous system:

- HR (heart rate): The highest HR values were seen in cholerics (72.0±2.5 bpm), while the lowest HR values were observed in phlegmatics (58.0±2.5 bpm).
- SDNN (standard deviation of NN intervals): The highest SDNN values were recorded in phlegmatics (145.0±6.0 ms), reflecting their better adaptive capabilities. The lowest SDNN values were found in melancholics (105.0±5.0 ms), indicating lower heart rate variability and reduced adaptive capacity.
- IN (stress index): The highest IN values were recorded in melancholics (84.0±6.0 units), indicating a high level of tension. The lowest IN values were found in phlegmatics (40.0±5.0 units), suggesting the lowest stress level and better adaptive capacity.
- LF: The highest LF values were found in melancholics (840.0±60.0 ms²), indicating strong sympathetic activity. The lowest LF values were observed in phlegmatics (480.0±50.0 ms²), which suggests more balanced autonomic regulation.
- HF: The highest HF values were seen in phlegmatics (760.0±50.0 ms²), indicating high parasympathetic system activity. The lowest HF values were in melancholics (380.0±60.0 ms²), which reflects suppressed parasympathetic activity.

Thus, the highest adaptive capacities are seen in phlegmatics, who demonstrate high SDNN and HF values along with low IN levels. Their calm temperament allows them to adapt better to physical loads and maintain a balance between sympathetic and parasympathetic activity. The lowest adaptive capacities are observed in melancholics, who show high IN and LF values, low SDNN and HF, indicating an imbalance in the autonomic nervous system and lower resistance to stress.

It was found that, in general, novice athletes tended to have slightly higher heart rates and lower heart rate variability (SDNN), LF, and HF compared to experienced 2nd-3rd rank athletes. This is due to the fact that first-year athletes have not fully adapted to the loads, leading to a more pronounced dominance of the sympathetic nervous system and lower parasympathetic activity.

To calculate the correlation between types of higher nervous activity and the type of sport (footballers and track and field athletes), Pearson's correlation coefficient was used. The results of the correlation between higher nervous activity (HNA) types and the type of sport showed a correlation coefficient close to zero (0.0000000000047), indicating no linear relationship between these two variables. The p-value of 1.0 also suggests that the relationship is not statistically significant.

Thus, it can be concluded that the types of HNA (sanguine, choleric, phlegmatic, melancholic) and the choice of sport (football or track and field) do not have a significant correlation.

However, the calculated correlation coefficients between heart rate variability (HRV) indices and the types of higher nervous activity (HNA) and sport type (footballers and track and field athletes) revealed the following key results:
Heart rate (HR) shows a weak correlation with the type of HNA (r=0.22) and a moderate correlation with the type of sport (r=0.38). SDNN shows a positive correlation with the type of sport (r=0.30) and a negative correlation with the type of HNA (r=0.42), indicating that SDNN depends on the emotional and physiological stability of athletes;

LF and HF components also show moderate correlations with HNA types, highlighting the role of autonomic regulation in adaptation to physical load. These data indicate that certain HRV parameters, such as SDNN and HF, have significant correlations with both HNA types and sport type.

Therefore, it can be concluded that HRV parameters are closely related to HNA type and sport type, which should be considered when developing individualized training programs for athletes. Specific characteristics of cardiac regulation and the autonomic nervous system should be taken into account to increase training process efficiency and improve recovery after physical loads.

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