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Research Article

Physiological Markers of Changes in the Components of the Body Composition of Football Players

DV Golubev[1]*, Shchedrina Yu A[2] and Melnikov DS[3]

[1]Post-Graduate Student of the Department of Physiology, PF Lesgaft National State University of Physical Culture, Sports and Tourism, St. Petersburg, Russia

[2]Doctor of Biological Sciences, Professor of the Department of Physiology, PF Lesgaft National State University of Physical Culture, Sports and Tourism, St. Petersburg, Russia

[3]Professor of the Department of Physiology, PF Lesgaft National State University of Physical Culture, Sports and Tourism, St. Petersburg, Russia

***Corresponding Author:** DV Golubev, Post-Graduate Student of the Department of Physiology, PF Lesgaft National State University of Physical Culture, Sports and Tourism, St. Petersburg, Russia.

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Abstract

Purpose: To study the validity of heart rate variability parameters as markers of changes in the components of the body composition of football players.

Methods and Organization of the Study: We studied footballers n = 60 living in the northwestern region of the Russian Federation. Group data: age 16.2 ± 1.4 years; weight 72.1 ± 2.5 kg; height 179.3 ± 2.8 cm. Heart rate variability indicators were monitored by the hardware-software complex "Omega-Sport, St. Petersburg". The bioelectrical activity of the heart was recorded in the II standard lead from a sitting position in the morning (9:00 - 10:00). The body composition of football players was assessed twice (beginning and end of the study) using the Inbody 770 analyzer.

Research Results: SDNN has a strong direct correlation with the following indicators: "total amount of water in the body" (r = 0.787, P = 0.013); "Body mass index" (r = 0.864, P = 0.017), as well as a strong inverse relationship with body fat (-0.793, P = 0.011). A direct strong correlation was found between the RMSSD index and skeletal muscle mass (r = 0.891, P = 0.011), the total amount of water in the body (r = 0.973, P = 0.014). pNN50 has a strong inverse correlation with body fat content (r = 0.992, P = 0.017), in addition, there is a strong direct correlation with skeletal muscle mass (r = 0.987, P = 0.015). A strong direct relationship was shown between LF and body fat (r = 0.916, P = 0.017), and a strong inverse correlation was found with skeletal muscle mass (r = -0.847, P = 0.011), total body water (r = -0.798, P = 0.019), body mass index (r = -0.774, P = 0.011). HF and body fat (r = -0.923, P = 0.013) have a strong inverse correlation; and with indicators of skeletal muscle mass (r = 0.859, P = 0.017) and total water content in the body (r = 0.986, P = 0.011), a strong straight line.

Conclusion: The relationship between the indicators of skeletal muscle mass, total body water content, body mass index with a limited number of HRV parameters was determined: SDNN, RMSSD, pNN50, HF, LF. The minimum set of heart rate variability (HRV) variables contributes to the formation of a practice-oriented autonomous profile, which in our study was characterized by the absence of dysregulatory manifestations, stable adaptive capabilities and the optimal functional state of the studied sample: significant ($p < 0.05$) growth in skeletal muscle mass, fat content in the body, the body mass index of football players.

Keywords: *Body Composition; Heart Rate Variability; Regulation of Body Composition; Football*

Introduction

Assessment of body composition is an essential part of the functional diagnostics of athletes, in particular football players, and has applied value for the analysis of special physical performance [1]. Changes are mainly affected by indicators such as the mass of adipose and muscle tissues, the total water content in the body. The severity and direction of these characteristics form adaptive shifts in the energy supply system, causing the consumption of metabolic and information resources [2]. It is known that indicators of heart rate variability (HRV), reflecting the reactivity of regulatory systems and determining the effectiveness of adaptive reactions, are closely related to body weight and somatotype [3]. Therefore, information on the state of autonomic regulation and compensatory reactions of the circulatory system can help predict dysadaptation processes in changes in the body composition of football players [4-8].

Purpose of the Study

To study the validity of heart rate variability parameters as markers of changes in the components of the body composition of football players.

Organization and Research Methods

We examined footballers (n = 60) living in the northwestern region of the Russian Federation. Average morphological data: age 16.2 ± 1.4 years; weight 72.1 ± 2.5 kg; height 179.3 ± 2.8 cm. All players were informed of all experimental procedures before giving their verbal consent to participate. At the time of testing, the athletes had no diagnosed diseases. The hardware and software complex "Omega-Sport, St. Petersburg" (https://dyn.ru) was used for testing. Registration of indicators of heart rate variability was carried out in the morning period of time (9:00 - 10:00). The bioelectrical activity of the heart was recorded in the II standard lead from a sitting position. Statistical and spectral indicators of heart rate were analyzed: IN, c.u. (stress index); VR, ms (variation range); Mo, ms (mod); aMo,% (mode amplitude); SDNN, ms (standard deviation); RMSSD, ms (square root of the mean square of the differences in the values of consecutive pairs of NN intervals); pNN50,% (percentage of consecutive NN intervals); LF, ms^2 (low-frequency waves of the spectrum); HF, ms^2 (high-frequency waves of the spectrum); TP, ms^2 (total spectrum power); VLF, ms^2 (very low frequency waves). The assessment of the body composition of football players was carried out using a professional analyzer Inbody 770. This technology is based on an 8-point system of tactile electrodes. Inbody stand area is equipped with: installation with electrodes for legs and arms; built-in monitor with voice system; a height rod with a sensorimotor frame; a computer with software and a cloud server for storing information (https://inbody-ru.ru/about/o-kompanii). The following parameters were recorded: skeletal muscle mass (kg), fat percentage (%), total body water (l), body mass index (kg/m^2). Statistical analysis was carried out in accordance with the objectives of the study. Correlation analysis according to Pearson (r) was used to study how changes in body composition indicators in response to changes in heart rate variability indicators. Regression analysis was used to study the dynamics of heart rate variability indicators in training sessions. The significance of differences between the values of body composition components was determined using Fisher's Z-test. At $p < 0.05$, the differences were considered statistically significant. Statistical analysis was carried out in the application programs "STATISTICA 12.0" and "Microsoft Office Excel 2017".

Research Results and Discussion

The dynamics of the parameters of the heart rate variability of football players is interrelated with the parameters of the components of the body composition (Table 1). Figure 1 shows the prolonged increase in SDNN. The direction of the trend is positively stable - an increase of 0.0111 units during the study period. The regression equation got the form: SDNN = 0, 0111 * 246 + 27.03. This characteristic has a strong direct correlation with the indicators: "total amount of water in the body" (r = 0.787, P = 0.013); "Body mass index" (r = 0.864, P = 0.017), as well as a strong inverse relationship with body fat (-0.793, P = 0.011). The tendency of the RMSSD indicator is unidirectional with SDNN, which is interpreted as "stable activity of the parasympathetic link of the autonomic nervous system and the autonomic regulation circuit" (Figure 2). The regression equation is: RMSSD = 0.0189 * 246 +38.37. A strong direct correlation was found between the square root of the sum of squares of the differences of successive pairs of R-R intervals (RMSSD) and the mass of skeletal muscles (r = 0.891, P = 0.011), the total amount of water in the body (r = 0.973, P = 0.014). Changes in pNN50 values are abrupt (Figure 3). The growth of the indicator by 0.1619 units relative to each day of the study (Figure 3) and a single trend vector with SDNN and RMSSD characterizes the adequate functioning of regulatory mechanisms. The activity of the highest levels of control of the regulatory activity of the heart is suppressed by the stability of the autonomous regulation circuit. A strong inverse correlation was found between pNN50 and body fat (r = 0.992, P = 0.017), and there was also a strong direct correlation with skeletal muscle mass (r = 0.987, P = 0.015). The regression equation got the form: pNN50 = 0.1619 * 246 + 22.63. Significant ($p < 0.05$) changes in the low-frequency and high-frequency components of heart variability are presented in figure 4 and 5. The trend of the LF indicator for the study period of 246 days had a downward trend by -0.5433 units relative to each day of measurement (Figure 4). The regression equation looked like: LF = -0.5433 * 246 + 954.49. A strong direct correlation of this indicator with the body fat content (r = 0.916, P = 0.017) and an inverse strong correlation with the skeletal muscle mass (r = -0.847, P = 0.011), total body water content (r = -0.798, P = 0.019), body mass index (r = -0.774, P = 0.011). The high-frequency component of the spectrum (HF) was steadily increasing (Figure 5). The regression equation looks like this: HF = 0.5735 * 246 + 731.23. A strong inverse correlation was found between high frequency wavelengths (HF) and body fat (r = -0.923, P = 0.013). Additionally, a strong direct correlation was found with indicators of skeletal muscle mass (r = 0.859, P = 0.017), and total body water content (r = 0.986, P = 0.011).

Heart rate variability indicators	**Body composition indicators**		
	Fat content, %	**Skeletal muscle mass, kg**	**Total amount of water, l**
IN, usl. ed.	0,288 P = 0,123	0,643 P = 0,231	0,105 P = 0,414
MxDMn, ms	0,338 P = 0,227	0,216 P = 0,421	0,256 P = 0,232
Mo, ms	0,767 P = 0,713	0,574 P = 0,313	0,631 P = 0,751
aMo, %	0,287 P = 0,654	0,633 P = 0,511	0,311 P = 0,552
SDNN, ms	-0,793* P = 0,011	0,427 P = 0,616	0,787* P = 0,013
RMSSD, ms	0,288 P = 0,232	0,891* P = 0,011	0,973* P = 0,014
pNN50, %	-0,992* P = 0,017	0,987* P = 0,015	0,185 P = 0,519
TP, мs^2	0,454 P = 0,224	0,319 P = 0,255	0,316 P = 0,219
HF, ms^2	-0,923* P = 0,013	0,859* P = 0,017	0,986* P = 0,011
LF, ms^2	0,916* P = 0,017	-0,847* P = 0,011	-0,798* P = 0,019
VLF, ms^2	0,144 P = 0,311	0,253 P = 0,325	0,433 P = 0,228
ULF, ms^2	0,441 P = 0,221	0,351 P = 0,635	0,232 P = 0,818

Table 1: *Relationship between body composition parameters and heart rate variability*

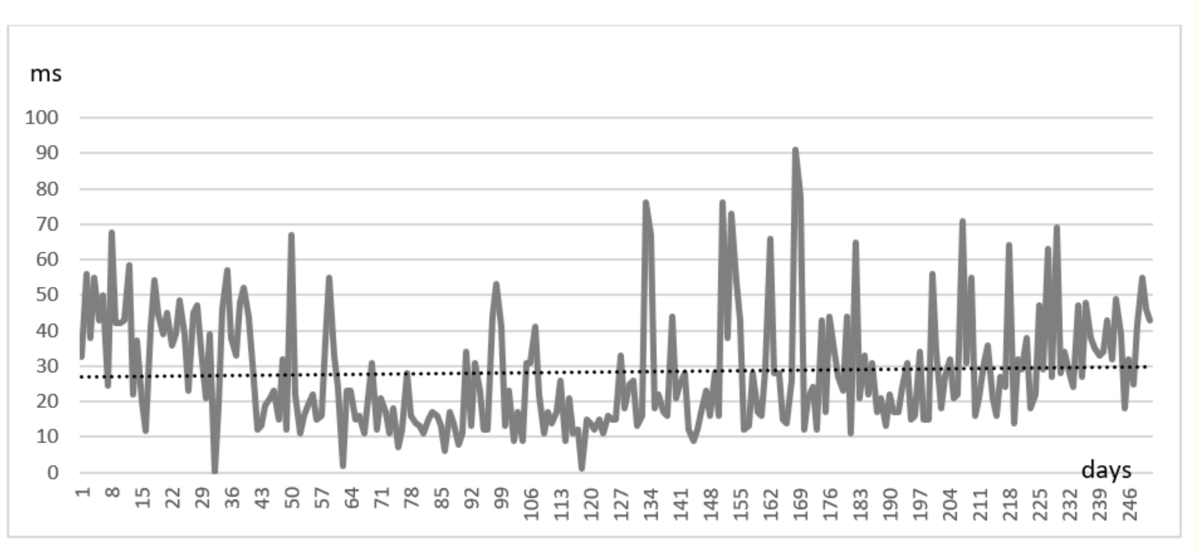

Figure 1: *Dynamics of SDNN in the study period, (ms).*

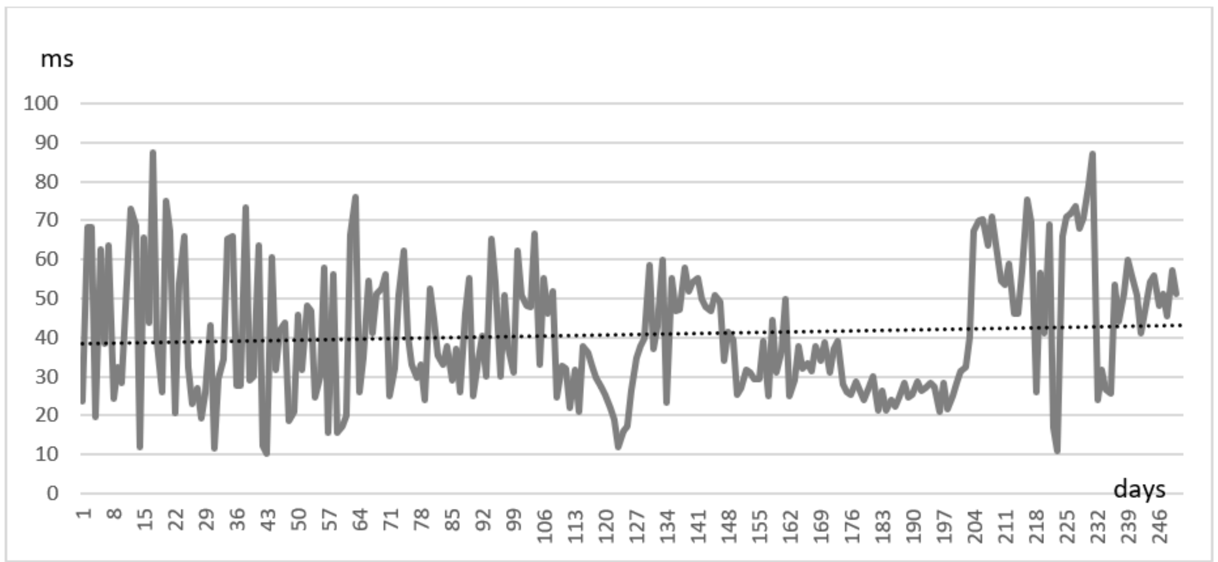

Figure 2: *Dynamics of RMSSD in the study period, (ms).*

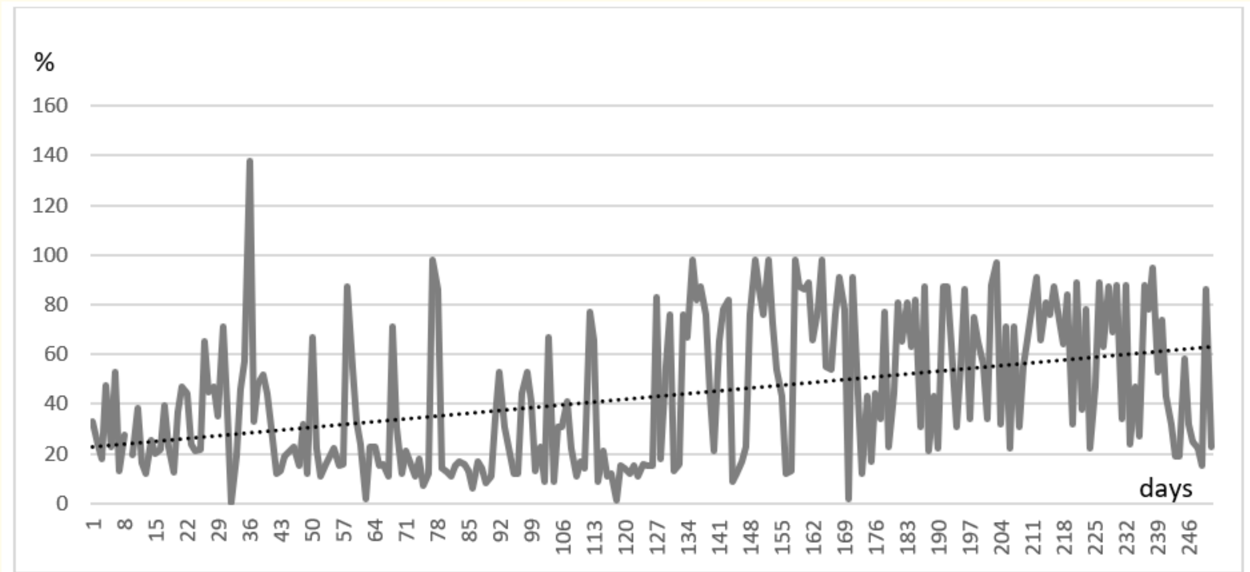

Figure 3: *Dynamics of pNN50 in the study period, (%).*

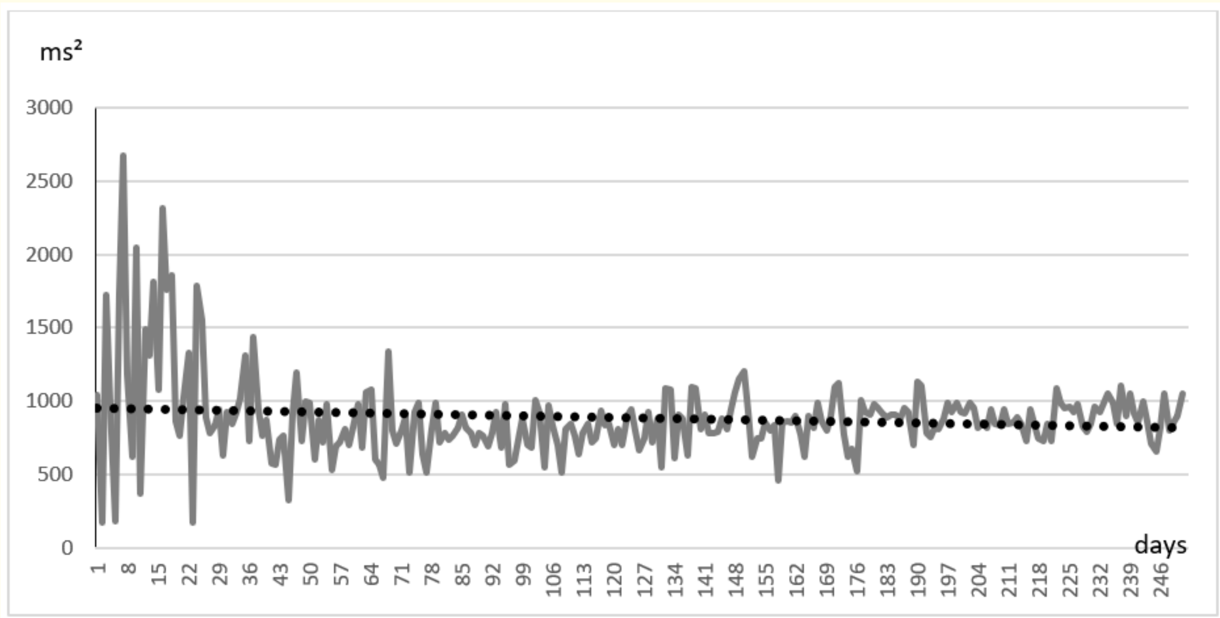

Figure 4: *Dynamics of LF waves during the study period, (ms2).*

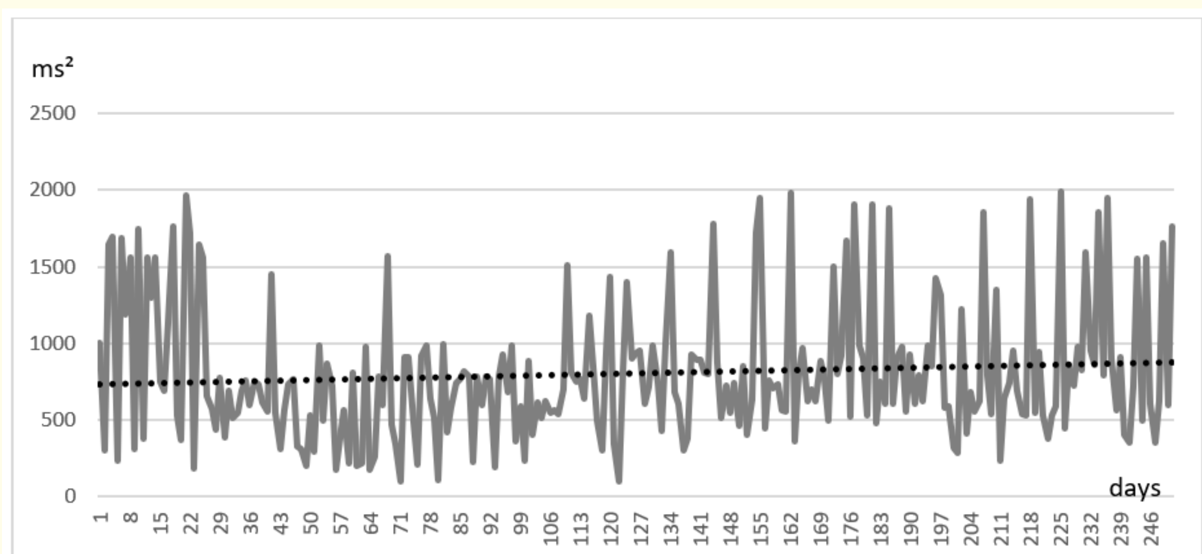

Figure 5 : *Dynamics of HF waves during the study period, (ms2).*

During the processing of the results, we found significant ($p < 0.05$) significant differences between the components of body composition (Table 2). The effect of parasympathetic regulation of the heart rate determined the optimality of autonomic changes in the body, which positively affected the increase in a number of indicators of body composition. Significantly ($p < 0.05$) increased: "skeletal muscle mass" ($p = 0.028$), "body mass index" ($p = 0.031$), "total amount of water in the body" ($p = 0.033$) of football players. We associate the maximum values of these parameters and their reliable ranges of growth with the absence of pronounced dysregulatory manifestations, a stable level of the organism's adaptive capabilities, which, in turn, accelerate anabolic and inhibit catabolic metabolic processes (Figure 7-9). Figure 6 shows negative dynamics in the difference in the indicator of body fat ($p = 0.238$), however, the differences do not have significant significance (Table 2).

Test	1 diagnostics M ± SD	2 diagnostics M ± SD	Z	P
Adipose tissue, %	10,99 ± 1,68	9,54 ± 2,32	2,303	0,238
Muscle tissue, kg	32,91 ± 3,47	34,81 ± 3,7	-1,021	0,028
Total water content, l	38,78 ± 5,32	41,57 ± 5,72	1,034	0,033
Body mass index, kg/m^2	19,57 ± 1,32	21,48 ± 1,31	2,207	0,031

Table 2: *The results of measuring the body composition of football players (n = 60).*
***-** *Differences are statistically significant (p < 0.05).*

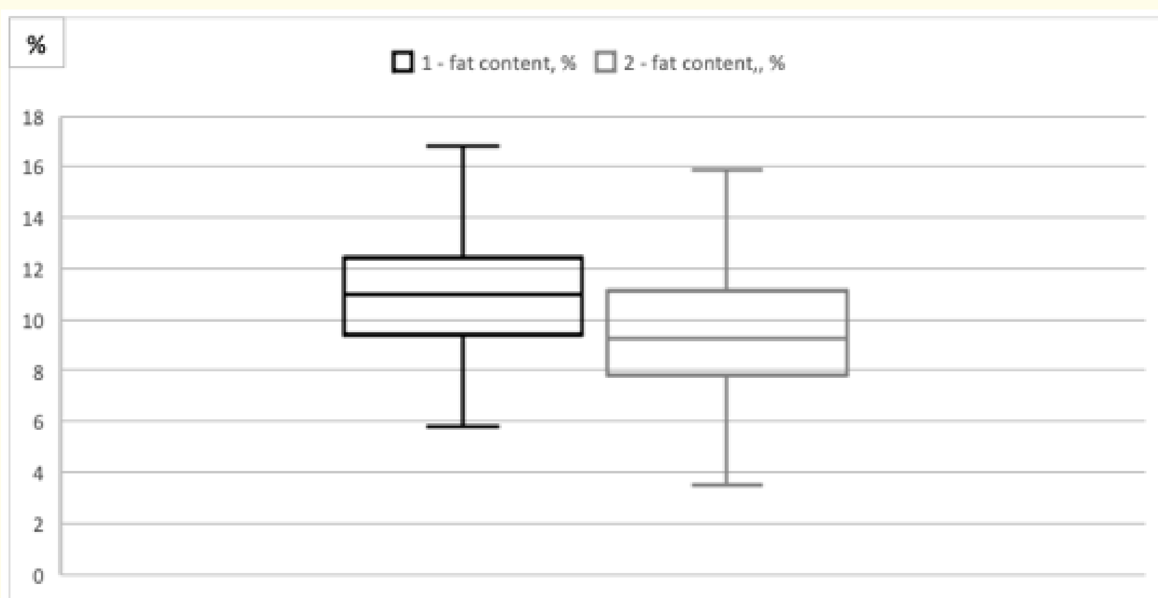

Figure 6: *Differences in the indicator of fat content (%) in the body of football players between measurements 1 and 2.*

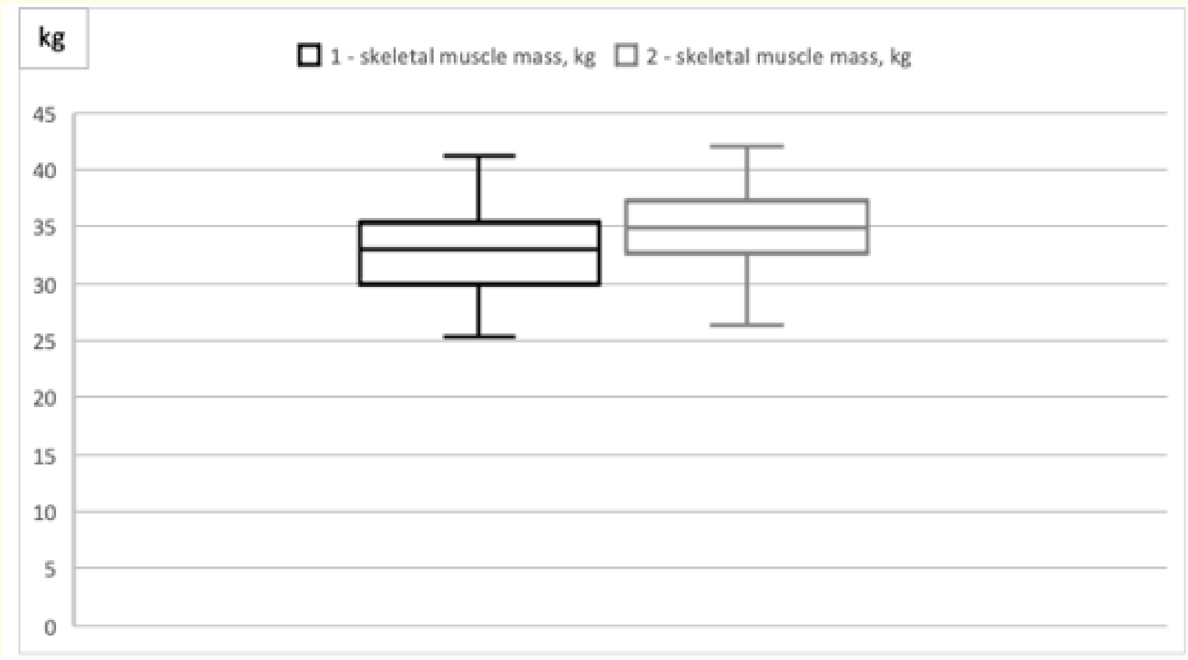

Figure 7: *Differences in the indicator of skeletal muscle mass (kg) of football players between 1 and 2 dimensions.*

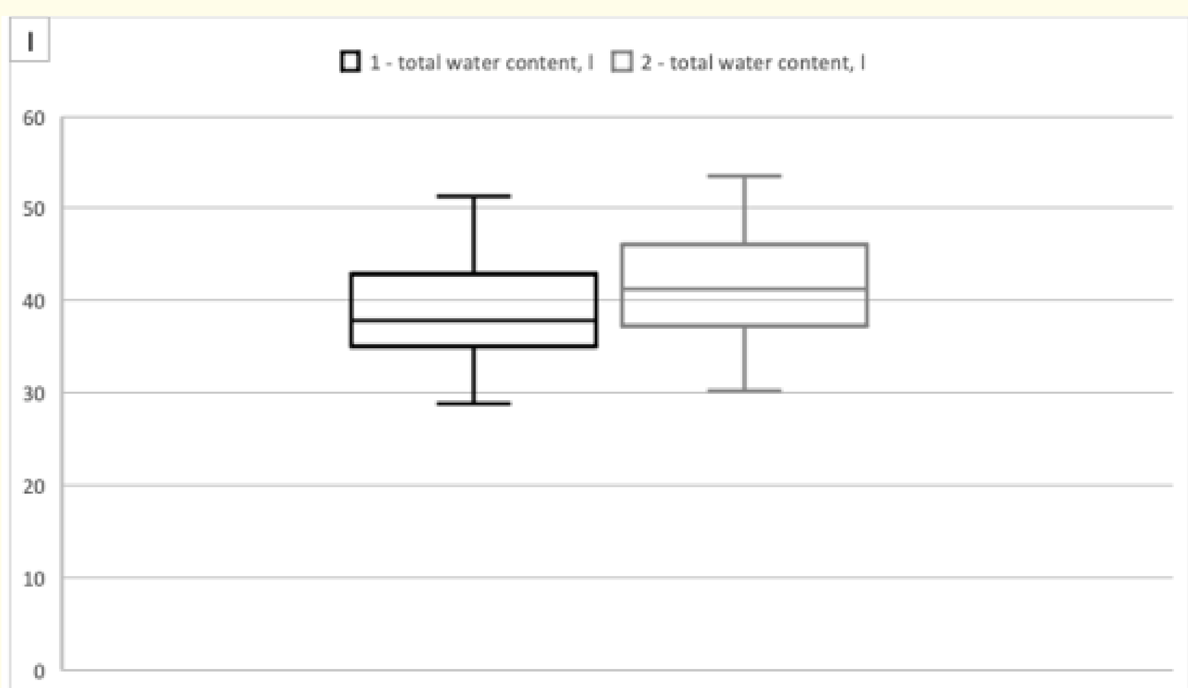

Figure 8: *Differences in the indicator the total amount of water (l) in the body of football players between 1 and 2 dimensions.*

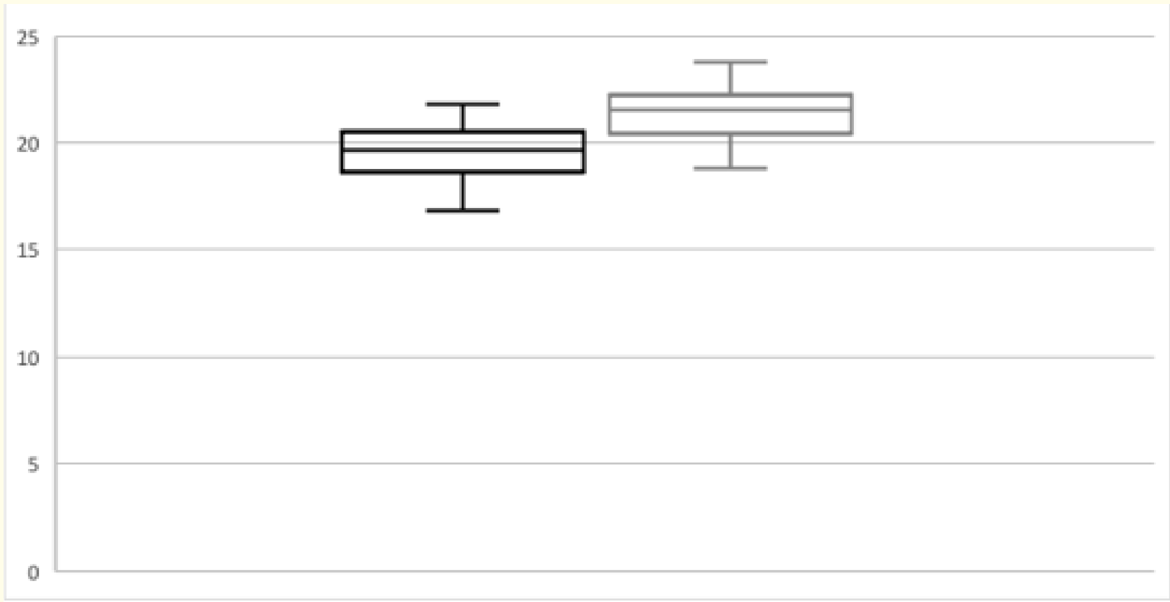

Figure 9: *Differences in the indicator of body mass index of football players between 1 and 2 dimensions.*

Conclusion

The following HRV parameters had the greatest relationship with the dynamics of skeletal muscle mass indicators, total body water content, and body mass index: SDNN, RMSSD, pNN50, HF, LF. Their informativeness and reliability were confirmed by statistical analysis ($p < 0.05$). This approach is justified in relation to the formation of a practice-oriented autonomous profile, which in our study was characterized by the absence of dysregulatory manifestations, stable adaptive capabilities and the optimal functional state of the studied sample: significant ($p < 0.05$) growth in skeletal muscle mass, body fat content, index body weight of football players. Thus, using the physiological interpretation of the selected characteristics and their modulation under various influences, it is possible to reveal the effect of regulation of the heart rate, which can be considered as a separate factor that determines the changes in the components of the body composition

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