Publication date: 01.12.2021
DOI: 10.51871/2588-0500_2021_05_04_12
UDC 57.054 +372.879.6 + 796.1/.3

FEATURES OF HEART RATE VARIABILITY DEPENDING ON THE TYPE OF VEGETATIVE REGULATION IN BOYS AGED 8-12 YEARS WHEN PLAYING SOCCER

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Key words: soccer, schoolchildren, age, physical activity, heart rate variability, types of regulation.

Annotation. The aim of the study is to examine the features of the formation of vegetative regulation of heart rate in male soccer players aged 8-12 years. The dominance of the central mechanism of regulation in beginner soccer players aged 8-9 years was revealed, which reflects the increased tension in the functioning of the growing organism. The number of young soccer players with the dominance of the central regulatory mechanism is 54% at the beginning and 60% at the end of the study. The activity of the autonomic mechanism of heart rate regulation increases in young soccer players aged 10-12 years. It is shown that compensatory and adaptive processes in young soccer players are formed against the background of certain anatomical and physiological features and heterochronism of the development of functional systems.

Introduction. Currently, there is a substantial number of theoretical works aimed at the development of children's soccer and its regulations [1-5]. In addition, there is not enough studies dedicated to an assessment of the state of functional systems that support to an adaptation of the organism to systematic physical loads, which gives a possibility to correct the structure of training young athletes. One of the systems that promptly react to adaptation changes is the blood circulation system. The heart rate variability (HRV) shown changes in the work of regulatory systems under the influence of environmental factors [6-7]. Typological features of the vegetative regulation in some degree are genetically inherited and are a personal characteristic of an individual, which is important to note when engaging in sports [4, 7]. Even in case of a sufficient number of studies on HRV in children and adolescents, we have not found works dedicated to studies of the heart rate regulation in young soccer players, considering individual and typological features of the vegetative regulation. Therefore, the aim of our study

was to examine the features of the formation of vegetative regulation of heart rhythm in male soccer players aged 8-12 years.

Methods and organization. Depending on age and experience, we divided young soccer players into 2 groups. The first group included children aged 8-9 years, second group – 10-12 years. 113 boys, who visit the soccer sports club, participated in the study. The study was conducted twice: at the beginning (61 participants) and the end (52 participants) of the 8-week long preparatory period. The rhythm cardiogram registration was carried out using the Varicard 2.51 device made by the LLC "Institute of Introduction of New Medical Technologies RAMENA" (Ryazan', Russia), which has a special program for analyzing electrocardiography (ECG). Registration in the sitting position took 5 minutes. We analyzed generally accepted HRV parameters. We also defined types of regulation according to the generally accepted method [9]. The statistical processing of the results obtained was made using the STATISTICA 6.0 software package. Mean sample values of quantitative signs were presented in the form of M±m, where M is a mean sample and m – a standard error of the mean. We evaluated significant differences using the parametric Student's criterion (for both groups). Critical level of significance of differences was $p<0,05$.

Results and discussion. In order to study an effect of engaging in soccer on typological features of vegetative regulation of the heart rate in 8-12 year old athletes, we defined regulation types, taking into account the dominant autonomic or central mechanism of regulation [7]. In each age-based group, we revealed three of four types: boys with a pronounced predomination of the central mechanism of regulation (II type); moderate predomination of the central type of regulation (I type) and moderate predomination of the autonomic type of regulation (III type). There were no soccer players with a pronounced predomination of the autonomic mechanism (IV type). This is logical and natural, since the IV type shows a pronounced predomination of the parasympathetic division of the vegetative nervous system, which is not typical for children aged 8-12 years. Regulation of the heart's chronotropic function in primary schoolchildren is made with a high activity of the sympathoadrenal system and central mechanisms [8]. A number of participants of each type appeared to be different and varied, considering age and the stage of the annual training cycle. Among beginner soccer players aged 8-9 years, at the beginning of the preparatory period, a number of participants with the I type amounted to 26%, with the II type – 29%, with the III type – 45%. 2 months after, when we conducted the repeat examination, a number of participants with the I type increased up to 32%, with the II type – did not change (28%), with the III type of vegetative regulation of the heart rhythm – reduced to 40%. Among young soccer players aged 10-12 years, a

number of participants with the I type amounted to 27% at the beginning of the preparatory period, with the II type – 20% and with the III type – 53% of children. After the repeat examination, a number of participants with the I type decreased to 22%, with the II type – to 15%, with the III type – increased up to 63%. According to changes in a number of 8-9-year old boys with various types of vegetative regulation of the heart rate, after 2 months of training, it was found that engaging in soccer increases stress of regulatory systems with increased activity of the central mechanism of regulation (I and II type) and reduced activity of the moderate autonomic mechanism (III type). With the increase in experience of 10-12 year old boys in soccer, a number of players with the III type of regulation increases against the background of a decrease in a number of players with the I and II types of regulation. Predominance of the III type of the HRV regulation in 11-12 years was registered in young hockey players [9]. This fact is considered as positive, directed towards an expansion of adaptive capabilities of the organism of 10-12 year old soccer players under the influence of engaging in soccer systematically. It was discovered that among 8-9-year old young soccer players with the II type of regulation, indicators of the power spectrum of LF, HF/LF, VLF in eight weeks of the preparatory period statistically increased by 89%, 69% and 84% ($p<0,05$) respectively (table 1).

Physical loads caused changes, adequate to the functional state of the organism, in regulatory mechanisms of 8-9-year old boys. However, the stress of regulatory systems remained increased. One of the other positive moments is an increase by 84% ($p<0,05$) of the indicator of the spectrum power of VLF-oscillations, showing growth of adaptation capabilities of the organism [7, 10]. The data obtained correspond with results of the study that noted strengthening of both sympathetic and parasympathetic influences on heart rate [11]. Activity of the autonomic mechanism of regulation significantly increased under the influence of systematic physical loads with a transition in the group of young soccer players with a moderate predomination of the central mechanism of regulation (I type). Suppression of the activity of sympathetic curve of regulation was accompanied by a reduction of AMo by 33% ($p<0,05$) and SI by 66% ($p<0,05$). Activity of the cardiovascular center of the medulla oblongata was preserved with an increase of the LF-spectrum's value by 107% ($p<0,05$). Therefore, a level of adaptability of the cardiovascular system was increasing in young soccer players with the I type under the influence of physical loads. This increase was more pronounced in comparison with soccer players with the II type of regulation. The analysis of examined indicators in participants with a moderate predomination of the autonomic type of regulation (III type) did not reveal statistically significant differences in time and spectrum indicators.

Table 1

Dynamics of HRV in 8-9 year old soccer players with different types of vegetative regulation

Study stage	HR, beats/ min	AMo, %	SI, c.u.	LF, ms	VLF, ms	RM SSD, m	HF, ms	TP, ms^2	MxDMn, ms	LF/HF, c.u.
I type										
1	89,63 ±1,54	39,93 ±2,70	132,8 ±16,6	557 ±61,7	329 ±32,3	49,23 ±5,05	1093 ±164	2416 ±298	233 ±27,66	0,53 ±0,11
2	85,21 ±2,08	29,70 ±2,15	79,83 ±8,04	1151 ±148	248 ±28,1	61,30 ±7,57	1699 ±308	3291 ±488	274 ±33,52	0,77 ±0,15
p<0,05	p>0,05	p<0,05	p<0,05	p<0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p<0,05
II type										
1	100,2 ±3,26	51,60 ±4,70	248,2 ±25,9	258 ±30,0	76 ±9,10	38,50 ±4,48	239 ±36,9	813 ±165	169 ±21,63	1,55 ±0,24
2	102,7 ±3,20	51,22 ±4,98	229,9 ±20,54	487 ±55,6	140 ±19,5	25,49 ±3,20	256 ±48,0	1067 ±189	199 ±23,01	2,62 ±0,41
p<0,05	p>0,05	p>0,05	p>0,05	p<0,05	p<0,05	p<0,05	p>0,05	p>0,05	p>0,05	p<0,05
III type										
1	85,70 ±2,32	27,83 ±1,71	60,60 ±7,67	1796 ±205	812 ±163	72,03 ±7,65	2061 ±272	5344 ±567	349 ±20,62	0,98 ±0,22
2	83,00 ±2,50	27,85 ±1,43	65,95 ±6,39	1728 ±221	694 ±96,1	69,48 ±6,52	1866 ±178	4594 ±433	319 ±25,42	1,00 ±0,18
p<0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05	p>0,05

Note: 1 – first study at the beginning of the preparatory period; 2 – second study at the end of the preparatory period; HR – heart rate, AMo – mode amplitude; SI – stress index; LF – spectrum power in low frequencies' band; VLF – spectrum power in very low frequencies' band; RMSSD – root mean square of the successive differences; HF – spectrum power in high frequencies' band; TP – total spectrum power; MxDMn – band of variation range of cardio intervals; LF/HF – vegetative balance coefficient

In the age group of 10-12-year old soccer players, during the preparatory period of the annual cycle, dynamics of indicators of autonomic and central mechanisms of the heart rate regulation differ from the group of 8-9 year old soccer players. Among participants with the II type of regulation, impact of the autonomic mechanism was enhanced by an increase in RMSSD by 26% ($p<0,05$) and a decrease in the integral indicator (SI) by 26% ($p<0,05$) (table 2). An increase by 88% ($p<0,05$) of the impact of the cardiovascular center (LF) of the medulla oblongata remained on a significantly high level.

Table 2

Dynamics of HRV in 10-12 year old soccer players with different types of vegetative regulation

Study stage	HR, beats/ min	AMo, %	SI, c.u.	LF, ms	VLF, ms	RM SSD, m	HF, ms	TP, ms^2	MxDM n, ms	LF/ HF, c.u.
I type										
1	90,02 ±4,88	40,30 ±1,84	137,7 ±7,71	820 ±53,0	395 ±46,2	36,00 ±1,34	410 ±27,1	1765 ±166	272 ±19,7	2,05 ±0,25
2	74,52 ±2,51	45,50 ±2,20	102,0 ±6,42	618 ±42,9	308 ±22,9	43,30 ±1,61	608 ±40,9	1811 ±207	214 ±12,0	1,24 ±0,16
p<0,05	p<0,05	p>0,05	p<0,05	p<0,05	p>0,05	p<0,05	p<0,05	p>0,05	p<0,05	p<0,05

Table 2 (continued)

II type										
1	91,16 ±4,25	39,98 ±2,40	136,9 ±8,22	513 ±35,0	142 ±21,3	37,65 ±1,99	565 ±31,1	1580 ±192	229 ±23,4	1,18 ±0,12
2	76,62 ±2,44	36,79 ±2,22	111,2 ±6,02	963 ±58,7	188 ±29,0	47,88 ±2,36	623 ±39,5	1891 ±222	264 ±31,0	1,52 ±0,13
p<0,05	p<0,05	p>0,05	p<0,05	p<0,05	p>0,05	p<0,05	p>0,05	p>0,05	p>0,05	p<0,05
III type										
1	82,12 ±2,50	33,24 ±2,49	59,74 ±4,14	2205 ±288	582 ±216	61,84 ±6,25	1912 ±181	5740 ±428	301 ±19,5	1,42 ±0,26
2	69,58 ±1,60	21,61 ±1,47	45,77 ±3,50	2098 ±285	1070 ±270	89,09 ±7,67	2657 ±293	6278 ±641	374 ±26,2	0,82 ±0,17
p<0,05	p<0,05	p<0,05	p<0,05	p>0,05	p<0,05	p<0,05	p<0,05	p>0,05	p<0,05	p<0,05

Note: 1 – first study at the beginning of the preparatory period; 2 – second study at the end of the preparatory period; HR – heart rate, AMo – mode amplitude; SI – stress index; LF – spectrum power in low frequencies' band; VLF – spectrum power in very low frequencies' band; RMSSD – root mean square of the successive differences; HF – spectrum power in high frequencies' band; TP – total spectrum power; MxDMn – band of variation range of cardio intervals; LF/HF – vegetative balance coefficient

Among soccer players with the I type of regulation, influence of the autonomic mechanism of regulation on heart rate remained enhanced. Against this background, an activity of the sympathetic division of the VNS was decreasing with a substantial reduction in LF and LF/HF indicators. As a result of enhancing an activity of stress limiting systems, stress of systems reliably decreased with a reduced SI indicator by 35% ($p<0,05$). Heart rate fall was registered. Among 10-12-year old soccer players with the III type of heart rate regulation, influence of the autonomic mechanism of regulation on heart rhythm was gradually enhancing. By the end of the preparatory period, a trophotropic effect of the VNS's parasympathetic division was also enhanced under the influence of physical loads. In addition, mean values of AMo, LF/HF and SI indicators, which characterize an activity of the VNS's sympathetic division, were reliably decreasing. Heart rate fall was also registered. Thus, among boys aged 10-12 years, an enhancement in activity of the VNS's parasympathetic division occurred against the background of the preserved and pronounced tone of the VNS's sympathetic division. This option of the heart rate regulation is optimal for the organism, since it contributes to an increase of its adaptive capabilities and a more effective use of functional reserves of the cardiovascular system [12].

Therefore, through the example of features of the heart rhythm regulation in 8-12-year old children who visit soccer sports clubs, it is shown that compensatory and adaptive processes in young soccer players are formed against the background of certain anatomical and physiological features and heterochronism of the development of functional systems

Conclusion.

1. Systematic soccer classes influence mechanisms of heart rate regulation, enhancing activity of the autonomic mechanism against the background of reduced central curve of regulation.

2. 10-12-year old soccer players compared to 8-9-year old soccer players possess higher adaptive potential as a response to training loads.

References

1. Al-Zaidi Basim K. Abbas. Developing skills of young soccer players / K. Abbas Al-Zaidi Basim // Young Scientist. – 2014. – № 9(68). – P. 66-70.

2. Gertner S.V. Effect of speed interval loads on the functional state of the cardiorespiratory system of soccer players // S.V. Gertner, T.B. Borisova, Ya.V. Latyushin, A.F. Popova, I.F. Kharina // Human. Sport. Medicine. – 2021. – Vol. 21. – № S1. – P. 7-12.

3. Zakharova A.V. Control of speed-power abilities of soccer players at the initial specialization stage / A.V. Zakharova, A.N. Berdnikova // Human. Sport. Medicine. – 2016. – Vol. 16. – № 4. – P. 64-74.

4. Kurdyukov B.F. Soccer classes in the preschool age: results of experimental studies // B.F. Kurdyukov, M.B. Bojkova, E.A. Kurdyukova // Theory and Methods of Physical Education. – 2018. – № 2. – P. 10-14.

5. Polovinkin N.A. Issues of children soccer in Russia / N.A. Polovinkin // Issues of Student Science. – 2019. – № 5(33). – P. 335-338.

6. Brooke T.M. Features of the functional state and special performance of elite athletes, taking into account the type of the heart rate's vegetative regulation / T.M. Brooke, F.B. Litvin, P.A. Terekhov, O.A. Tolstoj // Bulletin of the Russian Military Medical Academy. – 2018. – Vol. 2(62). – P. 28-32.

7. Shlyk N.I. Evaluating quality of the training process of ski racers and biathlonists according to results of everyday studies of the heart rate / N.I. Shlyk, E.S. Lebedev, O.S. Vershinina // Science and Spots: Modern Tendencies. – 2019. – Vol. 7. – № 2. – P. 92-105.

8. Litovchenko O.G. Functional changes in the heart of 10-12 year old children who live in conditions of the Khanty-Mansijsk Autonomous Okrug – Yugra / O.G. Litovchenko, A.A. Ukhanova // Journal of Biomedical Research. – 2019. – Vol. 7. – № 4. – P. 399-409.

9. Surina-Marysheva E.F. Heart rate variability and physical development of 9-16 year old hockey players / E.F. Surina-Marysheva, V.V. Erlikh, E.N. Ermolaeva // Human. Sport. Medicine. – 2021. – Vol. 21. – № 2. – P. 100-106.

10. Widmark C. Spectral analysis of heart rate variability during desflurane and isoflurane an aesthesia in patients undergoing arthroscopy / C. Widmark,

J. Olaison, B. Reftel, L.E. Jonsson, K. Lindecrantz // Acta Anaesthesiol Scand. – 1998. – Vol. 42. – № 2. – P. 204-210.

11. Korkushko O.V. Autonomic control of cardiac chronotropic function in man as a function of age: assessment by power spectral analysis of heart rate variability / O.V. Korkushko, V.B. Shatilo, Yu.I. Plachinda, T.V. Shatilo // Journal of the Autonomic Nervous System. – 1991. – Vol. 32. – P. 191-198.

12. Plews D.J. Training Adaptation and Heart Rate Variability in Elite Endurance Athletes: Opening the Door to Effective Monitoring / D.J. Plews, P.B. Laursen, J. Stanley, A.E. Kilding, M. Buchheit // Sports Med. – 2013. – Vol. 43. – № 9. – P. 773-781.

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