DOI 10.25789/YMJ.2021.73.21

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TYPOLOGICAL FEATURES OF HEART RATE VARIABILITY IN ATHLETES INVOLVED IN MARTIAL ARTS

The aim of the study is to determine typological features of the heart rate autonomic regulation in adolescents and young men who are systematically engaged in martial arts.

Materials and methods of research. In total 60 martial arts athletes of Magadan region aged on average 16.1±0.16, all indigenes of the North (Evens, Koryaks), were involved in the screening surveys of 2007-2019. All the subjects exercised 18 hours a week. The VK 2.5 Varikard and Iskim-6 (LLC Ramena) program were used in the orthotest mode to register the HRV followed by analyzing the obtained indices. The classification by N.I. Shlyk was applied to ascertain the predominant type of autonomic regulation.

Results. Among all the examinees, 50.0% demonstrated a moderate predominance of autonomic regulation, which indicates their good reserves in heart rate regulation (group III) while moderate and pronounced prevalence of central regulation (41.6% of athletes) is considered an unfavorable indicator for doing sports (groups I and II). They experience a tension in the body regulatory systems, unlike students from group III. The predominance of centralization in the heart rate regulation makes the Amo, SDNN, MxDMn, TP, HF, LF, and VLF values decrease while the HR, AMo50 and SI indices tend to increase. After the active orthostatic test (AOT), the optimum functional response got to prevail in group III (with sympathetic activity becoming higher and parasympathetic activity becoming lower). In groups I and II, the subjects showed reduced versions of changes in HRV indicators as compared to their initial values indicating low functional capabilities. In group IV, a pronounced functional response to AOT was observed that requires dynamic monitoring of the young athletes to determine the causes of such a reaction.

Conclusion. Specifying the type of autonomic regulation makes it possible to determine the adaptive and regulatory capabilities of the body of young athletes and take a proper model of physical exercise, which can help preserve the health of the younger generation.

Keywords: Russia’ Northeast, indigenous peoples of the North, sports, heart rate variability, initial type of autonomic regulation.

Introduction. Martial arts refer to sports (all sorts of wrestling and boxing) which suggest dynamic changes in the competitive situation. The athlete needs to quickly assess the situation and correctly respond to it with effective and accurate actions. For doing that significant morphofunctional reserves of the body are necessary. In northern regions, low comfort climatic environments additionally affect the processes of adaptation to physical exercises [3, 4]. Proper physical activity contributes to the formation of the body general resistance while excessive exercise breaks down the adaptation [2, 5]. Moreover, the problem of more frequent cardiac pathologies and sudden deaths from cardiovascular diseases in young athletes remains common [7]. One of the reasons for the rapid onset of dysregulation and overtraining among younger beginners may be the initial functional state of the body regulatory systems that is not considered by physicians and coachers prior to accepting children for training [5].

Indicators of heart rate variability (HRV) are known to be informative criteria for assessing mechanisms of autonomic regulation [1]. The regulation has individual characteristics and depends on the age, gender, and fitness of the body. Each athlete has their own physiological capabilities which can be used to assess their functional readiness to perform exercises [5]. An active orthostatic test has proved to be one of the highly informative methods for determining the body adaptabilities as well as early and hidden changes in the heart regulation. For a practically healthy person, the test does not bring any pronounced stress but suggests a working tension to the body regulatory systems, unlike people with autonomic disorders [2, 8].

The aim of the study was to determine typological features of the heart rate autonomic regulation in adolescents and young men regularly involved in martial arts.

Materials and methods of research. Screening studies of 2007-2019 involved 60 students from secondary schools of Magadan region, Evens and Koryaks by origin. The average age of the subjects was 16.1±0.16 years old. Four people responded going in for boxing, six people – for freestyle wrestling, and 50 – for Greco-Roman wrestling. Training sessions were held for 18 hours a week. The level of sports qualification was different: from the youth category to the candidate for master of sports. Prior to the study, all students and their authorized representatives gave their informed consent.

General HRV indicators were recorded using the VK 2.5 Varicard hardware complex and the Iskim-6 program (Ryazan city, Ramena LLC) in the Ortho Test mode (11 min.) [1]. A predominant type of autonomic regulation was determined according to the classification proposed by N.I. Shlyk: moderate and pronounced predominance of sympathetic and central regulation of the heart rate (group I and II), and moderate and pronounced predominance of the autonomic regulation (group III and IV) [5]. After Doctor of Medical Sciences, Professor, Honored Scientist of the Russian Federation R.M. Baevsky “... these groups of regulation correspond to the generally accepted division into sympathotonic, normotonic and vagotonic types. At the same time, the normotonic type is considered in two versions: sympatho-normotonic (group I) and vago-normotonic (group III)” [5].

Statistical analysis of the data was performed with the Statistica 6 program using nonparametric methods: Kruskal-Wallis one-way analysis of variance (Kruskal-Wallis test), and Wilcoxon criterion. The values are presented as the median (Me) and the 25th and 75th percentiles (C25; C75). The critical significance level was taken at $p<0.05$.

Results and discussion. In the sample of subjects, their initial types of autonomic regulation were determined. We observed moderate (group I) and pronounced (group II) predominance of central regulation in 11 (18.3%) and 14 (23.3%) students, and moderate (group III) and pronounced (group IV) predominance of autonomous regulation in 30 (50.0%) and 5 (8.4%) subjects, respec-

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Heart rate indicators in athletes with different types of autonomic regulation at active orthostatic test. Me (25th; 75th percentile)

Indicator	Group I. n = 11		Group II. n = 14		Group III. n = 30		Group IV. n = 5		Difference significance level Kruskal-Wallis test	
	Baseline	Orthostatic test	Baseline	Orthostatic test	Baseline	Orthostatic test	Baseline	Orthostatic test	Baseline	Orthostatic test
HR. beats per min	75 (71; 83)	96 (85; 103)	83 (75; 85)	99 (91; 106)	69 (62; 75)	84 (79; 93)	60 (56; 64)	90 (83; 93)	p<0.001	p=0.011
Mo. ms	807 (732; 831)	623 (572; 667)	714 (698; 823)	592 (558; 644)	868 (796; 960)	712 (624; 764)	876 (871; 1128)	680 (589; 705)	p<0.01	p=0.011
AMo_{50}. %	55 (50; 60)	50 (43; 74)	56 (47; 62)	63 (52; 84)	35 (31; 42)	45 (38; 54)	20 (19; 21)	46 (42; 48)	p<0.001	p=0.002
MxDMn. мс	221 (193; 245)	206 (154; 251)	170 (151; 202)	150 (130; 207)	315 (278; 345)	240 (195; 273)	480 (471; 499)	250 (228; 250)	p<0.001	p=0.003
SDNN. мс	43 (36; 45)	39 (28; 45)	34 (29; 37)	31 (26; 37)	60 (51; 67)	44 (39; 53)	100 (92; 111)	51 (44; 52)	p<0.001	p<0.001
SI. arb. units	150 (142; 189)	180 (142; 363)	223 (186; 273)	374 (195; 527)	62 (52; 84)	137 (105; 193)	20 (20; 25)	155 (131; 158)	p<0.001	p=0.002
TP. ms^2	1809 (1618; 2253)	1651 (684; 2044)	1142 (967;1485)	796 (464; 1760)	3304 (2422; 4476)	1742 (1468; 2216)	8376 (8261; 9118)	2335 (2319; 2715)	p<0.001	p=0.010
HF. ms^2	438 (251; 664)	200 (57; 567)	408 (290; 586)	125 (71; 246)	1197 (783; 1730)	258 (190; 393)	3273 (3000; 3832)	296 (198; 309)	p<0.001	p=0.076
LF. ms^2	492 (377; 861)	498 (258; 1351)	295 (167; 495)	399 (155; 540)	1085 (610; 1383)	857 (496; 1086)	2856 (1616; 3162)	1174 (938; 1185)	p<0.001	p=0.024
VLF. ms^2	325 (291; 412)	252 (137; 546)	135 (111; 171)	183 (114; 295)	425 (326; 629)	420 (344; 675)	1798 (1273; 1817)	425 (396; 666)	p<0.001	p=0.004

Note: In the table and in the figure presented on the abscissa axis is the indices of heart rate variability: HR heart rate; Mo is Mode; AMo50 is the amplitude of Mode; MxDMn is the difference between maximum and minimum values of cardiointervals; SDNN is standard deviation of cardiointervals; SI is Stress Index; TP – Total Power; HF is High Frequency; LF is Low Frequency; VLF is for Very Low Frequency

tively (Table). The categorized groups demonstrated changes of HRV indices with the running influence of the central regulation on the heart rhythm: the Mode (Mo), the standard deviation of the full array of cardiac intervals (SDNN), the variation range of the dynamic series of cardio intervals (MxDMn), the power of high-, low- and very low frequency spectral component (HF, LF, VLF, ms2) proved to become lower. Groups I and II tended to have a low-frequency component (LF > HF > VLF) to prevail in the total spectrum power. The growth of the LF component at rest was associated with the pronounced activity of cardiovascular system which resulted in an emergency mechanism for increasing myocardial contractility that contributed to the formation of negative metabolic and rheological abnormalities [2]. Groups III and IV showed respiratory waves (HF > LF > VLF) to predominate which reflected physiological respiratory arrhythmia in healthy individuals. However, despite the similar ratio of spectral components, subjects from group IV were high in the SDNN index that exceeded the standard values of 40-80 ms [1, 5]. The MxDMn values in these athletes were combined with high values of the total power of the spectrum (TR > 8000 ms2), which may have indicated a multifactorial nature of the effects on the heart rhythm. That is often observed in various sinus node dysfunctions. To find out whether these HRV changes correspond to physiological or pathological autonomic regulation of the heart rate is only possible by making dynamic analyses of the cardiorhythm parameters and doing functional tests [5].

It was found that the perfect response to orthostatic exposure was characterized by moderate activation of the central regulation and a decrease in parasympathetic effects. That was reflected in the following changes of the HRV indicators: along with the running HR, SI, and AMo50, there was a decrease in Mo, MxDMn, SDNN, and the spectral components of HRV – TP, HF, LF, and VLF [5]. We could see differences between the categorized groups in the analyzed HRV parameters at orthostasis to remain, with the exception for the HF-wave index (Table), which may have indicated a different level of reactivity of the autonomic regulation in maintaining

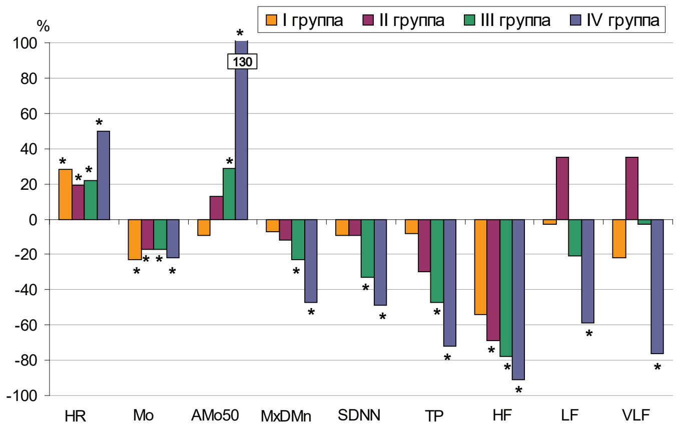

Fig. Changes in the median of heart rate variability indicators during orthotest as compared to the baseline (initial) level
Note:
* is for statistical reliability between the indicators in the lying and standing positions

the activity of the heart. The examinees differed in functional reserves of the heart regulation and autonomic responses to stress (Fig.). In group III, changes in HRV statistical indicators corresponded to the optimum response to orthostatic exposure, with an increase in the SI index median by 2.2 times from the initial values, $p<0.05$. The total power of the spectrum changed at the expense of the HF waves that had been the only to significantly decrease reflecting the inhibition of vagotonic influences [4]. We found no reliable changes in LF- and VLF-wave parameters which indicated insignificant reactivity of vasomotor and ergotropic suprasegmental centers, respectively.

In group IV, the orthostasis test resulted in pronounced changes in all the considered HRV indicators with an increase in SI by 7.8 times from the initial values at $p<0.05$. Such a functional response to AOT was typical for highly trained or overtrained athletes. That can be considered a hyperreaction with the overtrained athletes. With young athletes, it may indicate an accelerated, irrational way of a rise in the heart adaptation and its overload to training [5]. It remains unclear whether the identified changes occurred before starting sports or occurred during the course of training. Therefore, for subjects of that group, explanation of the changes observed in their heart rate regulation is still to be made.

We observed a different reaction to the orthostatic test in the central regulation groups: no changes in most HRV indicators were found as compared to their background values, and the diametrically opposite reaction of the low-frequency components (LF and VLF) of the spectrum in group II (Fig.). Examinees from groups I and II were 1.2 and 1.7 times as high in SI index in comparison with the initial values. It has been proved that the more pronounced is the stress of the central regulation structures, the greater is growth in SI, and LF and VLF values. This may indicate the predominance of low reactivity of the ANS and a decrease in its adaptabilities. Such changes in HRV are most often found at severe fatigue as well as at prenosological conditions and pathologies [2, 5].

According to researchers, for doing sports it is necessary to select individuals with moderate predominance of autonomic regulation since they have a ready physiological “platform”. Such athletes have a normal level of the sinus node functioning, economical type of respiratory and cardiovascular systems in the initial state, and they demonstrate a quick recovery rate after physical exercises. With the central control getting involved in the regulation process, the body system to be controlled is destabilized, which completely suppresses self-regulation [5]. The sympathicotonic type of autonomic regulation does not agree with the concepts of fitness and adaptability in sports [2]. When planning exercising, it is necessary to consider the initial type of autonomic regulation of the athlete since the same physical activity can cause different adaptive reactions in the body. Special attention should be paid to individuals with both autonomic and central parts of the ANS strongly influencing their heart rate (group II and IV) [5]. As shown by N.I. Shlyk [6] these types of autonomic regulation are acquired as a result of various long-term stress states. Individuals with these types of regulation often have pronounced or low variants of autonomic reactivity considered unfavorable for the body [2, 5, 8].

Conclusion. Among the examinees, moderate (group III) and pronounced (group IV) predominance of the autonomic regulation was found in 50.0% and 8.4%, respectively. Moderate (18.3%) and pronounced (23.3%) predominance of central and sympathetic regulation of heart rhythm (groups I and II, 41.6% in total) has been an unfavorable indicator for doing sports. These subjects prove to have a strain within the body regulatory systems, compared to group III. With the centralization prevailing in the heart rhythm regulation, there was a directed decrease in Mo, SDNN, MxDMn, TP, HF, LF, VLF and an increase in the HR, AMo50 and SI indices, which was consistent with the physiological approaches to their interpretation of other authors. In group III, the optimum functional response (moderate increase in sympathetic activity and decrease in parasympathetic activity) could be seen. In groups I and II, changes in heart rate control were less expressed as related to the baseline values indicating low functional capabilities of the body. Athletes of group IV require more dynamic observation to make clear the causes of their pronounced functional response to AOT and prevent possible prenosological states or even adaptation failure. Specifying the initial type of autonomic regulation allows avoiding overload in young athletes’ regulatory capabilities and taking a proper model of physical exercise.

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