Clinically significant subjective features of highly qualified athletes with different types of cardiac rhythm regulation

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

The aim of the study is to identify the characteristic subjective features of highly qualified athletes with different types of cardiac rhythm regulation.

Materials and methods. 202 highly qualified male athletes aged 22.6 ± 2.8 years and engaged in acyclic sports were examined. According to the designed survey protocol, all athletes were interviewed using a specifically designed questionnaire, which included 4 questions pools, each of them characterized certain components of athletes’ subjective assessment of their condition and attitude to it during the previous week, as well as studies using spiroarteriocardiorhythmography (SACR).

Results. The SACR study allowed to divide athletes, taking into account heart rate variability (HRV) parameters, into 4 groups according to the types of their cardiac rhythm regulation. Subjective signs that might have clinical significance in the development of cardiovascular overexertion were uncomfortable sensations in the heart, feeling of interruption in the heart work, perspiration at rest, headache after sleep, perspiration at low loads, feeling of fatigue after sleep and night perspiration. Uncomfortable sensations in the heart occurred frequently in 1 % of cases and periodically in 15.3 % of cases, and feeling of interruption in the heart work occurred frequently in 0.5 % of cases and periodically in 14.9 % of cases. These indications were typical of people with cardiac rhythm regulations type I and II. In type III the least number of clinically significant features was noted. In type IV the number of significant features was less than in types I and II; however, this is nonsignificant. Probable differences in the features of perspiration at rest were noticed in athletes with type IV in comparison with type III.

Conclusions. Subjective indications can be employed to verify the regulatory features of the cardiovascular system, which are associated with the centralization of effects. Questionnaires can be useful in differentiating states of overexertion according to parasympathetic type and a state of high training level in type IV cardiac rhythm regulation.

Key words: data collection, medical history taking, heart rate, athlete.
The problem of routine monitoring of athletes is related to the individual assessment of the effect of training and competitive loads, as well as recovery after them [1–4]. It is important to consider not only objective but also subjective features that would allow to standardize a comprehensive assessment of athletes’ condition [1–3,5,6].

At the level of determining the physiological parameters that reflect the body’s response to exercise, according to changes in energy supply [7–9], in cardiovascular [1–14], respiratory [15,16], sensorimotor systems [17–19], in metabolic processes [20–22], accompanied by changes in the immune response [20], endocrine regulation [23], methods of determining the subjective assessment of load perception, as well as psychophysical changes in the athlete’s body are essential [24–26]. Some authors emphasize certain advantages of their use in the training process [27].

In recent years, a significant number of questionnaires and their modifications, providing a meticulous assessment of the effect of sports, as well as external factors on the recovery of an athlete, have appeared [6,28]. Their use in determining or regulating non-functional overstrain has been tested [29–33].

Within microcycles, it is proposed to use the Acute Recovery and Stress Quick (ARSQ), which has 8 scales for assessing physical, mental, emotional and general recovery, as well as stress [29,30]. A short version (SRSS) is also used; it is suitable for multiple measurements at short intervals, for example, in experimental conditions to evaluate recovery strategies [31], as well as in long-term monitoring [32]. The developers emphasize that the effectiveness of questionnaires depends on the responsibility and diligence of athletes, so it is important to ensure the confidentiality, proper use and estimation of data provided by athletes [34,35]. When examining a large number of athletes, the survey allows to quickly and economically collect data on their condition, especially after intense training or competition. This helps develop and adjust individual training schemes, taking into account the characteristics of the sport, as well as the psychophysiological state of athletes after competitions or training. At the same time, it is emphasized that survey data will be the most informative in combination with possible physiological research methods [6,36,37].

The method of spiroarteriocardiorhythmography (SACR) [38] has been tested by us in numerous field studies of athletes [39–42]. This allowed us to use the mentioned method in a comprehensive monitoring survey of athletes during the pre-competition period of the annual training cycle in combination with questionnaires.

**Aim**

The purpose of the work is to identify typical subjective characteristics of highly qualified athletes with different types of cardiac rhythm regulation.
Materials and methods

Using spiroarteriocardiorhythmography (SACR), 202 highly qualified male athletes aged 22.6 ± 2.8 years and engaged in acyclic sports, namely various martial arts (karate, taekwondo, kickboxing, boxing, judo, sambo, wrestling) and sport games (water polo, football), were examined. Their experience of sports training was 10.3 ± 3.1 years. All studies were conducted in the pre-competition period. The SACR study was performed in the morning, on an empty stomach, in a sitting position. Registration lasted for 2 minutes. Before SACR study, questionnaires, morphometric examinations, and standard methods of measuring arterial systolic (SPB) and diastolic pressure (DPB) were performed [43].

According to the developed survey protocol, all athletes were interviewed using a specifically designed questionnaire, which included 4 questions pools. Each of them characterized certain components of athletes’ subjective estimation of their own condition and attitude to it during the previous week. Each question was evaluated on a three-point scale, which provided an opportunity to characterize various features as non-occurring (scoring “0” points), occurring periodically (scoring “1” point) or often (scoring “2” points).

The first pool included questions that characterized the subjective signs of the general condition of an athlete at the time of the examination: psycho-emotional state, appetite, body weight dynamics, the presence of cardiovascular system complaints, headache, sweating and more. The second pool included questions related to characteristics and sensations during and after sleep, such as falling asleep, dreaming, waking up, the presence of fatigue after waking up, sweating in sleep, and so on. The third pool included questions related to sensations and manifestations during training loads. The fourth pool of questions was formed to understand the attitude of athletes to the recovery procedures used in the training process. However, the analysis of the results of the latter was not conducted in this study.

The type of autonomous regulation of the cardiac rhythm of athletes was determined according to the approach proposed by N. I. Shlyk [44,45], which grounds the classification of HRV on the data with the definition of TP (ms²), SI (c. u.) and VLF (ms²). There are 4 Types of autonomic regulation of cardiac rhythm: Type I shows moderate stress, Type II shows a decrease in the functional state of regulatory systems, the development of fatigue, Type III shows the optimal state of regulation, Type IV shows overstrain of autonomic regulation, or high fitness.

The principles of types classification, taking into account the above mentioned criteria, are presented in Table 1.

Statistical analysis of the physiological study results was performed to determine the differences between the groups using Mann–Whitney test. Subjective parameters were analyzed using the percentile method.

Results

According to the survey of athletes, the information on the peculiarities of classes and recreation organization in the pre-competition period was provided. It was related to the number of trainings (per week) – 6.0 ± 2.2, the average duration of one training (min.) – 121.0 ± 24.0, the average duration of training (min. per week) – 726 ± 314 and the average duration of sleep (hours) – 7.8 ± 1.1.

Analyzing the survey data in the whole group of athletes (Table 2), we will focus on the questions of each pool. According to the answers to the question about the general condition, it should be noted that in the vast majority of athletes, negative symptoms associated with discomfort in the heart, a feeling of heart failure, sweating at rest are not frequent, but occur periodically in 13.9–15.8 % of cases. Very rarely (up to 5 %) athletes report loss of appetite, variability in body weight, headache, and persistent reluctance to train. Feelings of lethargy, apathy, lack of vigor are within the expected range (5.0–5.9 %), while 8.9 % of athletes report frequent irritability and 12.9 % of them report increased excitability. Periodically, the above symptoms are observed between 21.8 % (for loss of appetite) and 57.9 % (for a feeling of increased excitability). The exception is the question on the feeling of reduced efficiency, which appears periodically in 72.8 % of cases. And only 11.4 % of athletes report it as frequent.

Analyzing the answers to the questions pool “Sleep”, it should be noted that frequent sleep disorders in the studied group of athletes are quite rare (up to 5 %). However, a number of athletes (7.9 %) often report the presence of shallow sleep, and a certain number (5 %) often have a feeling of fatigue after sleep. This sign is most often defined by athletes as recurrent (48.5 % of cases). Slightly less often (35.6 % of cases), athletes notice periodically occurring poor sleep. All other subjective signs of recurrent sleep disorders occur in 10.0 % to 25.0 % of cases, which can be considered as expected. Among the characteristics of this question pool, there are the answers about poor sleep, the presence of a feeling of fatigue after sleep, as well as shallow sleep.
Table 2. The distribution of answers to the questionnaire by pools and their average scores in the studied group of athletes, n (%)
Table 3. Average values of HRV indicators, which were the basis for the differentiation of athletes by types of cardiac rhythm regulation

<table>
<thead>
<tr>
<th>Type of regulation</th>
<th>n</th>
<th>TP, ms</th>
<th>VLF, ms</th>
<th>SI, c.u.</th>
</tr>
</thead>
<tbody>
<tr>
<td>І type</td>
<td>42</td>
<td>2490 (1632; 3844)</td>
<td>610 (331; 1406)</td>
<td>143.4 (122.9; 214.5)</td>
</tr>
<tr>
<td>ІІ type</td>
<td>28</td>
<td>1475 (1163; 2314)</td>
<td>161 (144; 188)</td>
<td>222.1 (150.8; 282.8)</td>
</tr>
<tr>
<td>ІІІ type</td>
<td>88</td>
<td>5686 (4186; 12679)</td>
<td>770 (471; 1600)</td>
<td>57.7 (38.5; 70.3)</td>
</tr>
<tr>
<td>ІV type</td>
<td>44</td>
<td>18540 (12645; 26392)</td>
<td>1490 (992; 2061)</td>
<td>17.4 (13.3; 19.9)</td>
</tr>
</tbody>
</table>

Table 4. Comparative characteristics of morphometric and routine parameters of athletes with different types of cardiac rhythm regulation, M (Q1; Q3)

<table>
<thead>
<tr>
<th>Indicators</th>
<th>І type</th>
<th>ІІ type</th>
<th>ІІІ type</th>
<th>ІV type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass, kg</td>
<td>75.0 (62.0; 84.0)</td>
<td>75.0 (70.0; 87.0)</td>
<td>73.0 (64.0; 79.5)</td>
<td>70.7 (58.5; 82.5)</td>
</tr>
<tr>
<td>Body length, cm</td>
<td>181 (169; 188)</td>
<td>181 (172; 190)</td>
<td>175 (170; 186)</td>
<td>175 (170; 185)</td>
</tr>
<tr>
<td>BMI, kg·m⁻²</td>
<td>23.1 (21.1; 25.2)</td>
<td>22.2 (21.4; 26.7)</td>
<td>22.5 (20.9; 24.7)</td>
<td>20.9 (20.0; 26.2)</td>
</tr>
<tr>
<td>HR, m⁻¹</td>
<td>70.3 (62.9; 74.4)</td>
<td>66.2 (62.5; 71.8)</td>
<td>59.2 (54.0; 65.4)</td>
<td>54.1 (49.9; 61.2)</td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>120 (110; 130)</td>
<td>120 (116; 130)</td>
<td>120 (110; 130)</td>
<td>110 (106; 120)</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>76 (70; 80)</td>
<td>76 (70; 80)</td>
<td>76 (70; 80)</td>
<td>76 (70; 80)</td>
</tr>
<tr>
<td>PBP, mmHg</td>
<td>50 (40; 54)</td>
<td>54 (40; 60)</td>
<td>42 (40; 50)</td>
<td>40 (35; 47)</td>
</tr>
<tr>
<td>Vegetative index</td>
<td>-0.08 (-0.19; 0.06)</td>
<td>-0.11 (-0.22; 0.01)</td>
<td>-0.23 (-0.33; -0.07)</td>
<td>-0.34 (-0.57; -0.18)</td>
</tr>
<tr>
<td>Robinson index</td>
<td>82.4 (69.6; 94.8)</td>
<td>79.4 (77.4; 94.1)</td>
<td>72.0 (62.4; 79.4)</td>
<td>61.5 (56.5; 71.0)</td>
</tr>
<tr>
<td>Baevsky’s AP</td>
<td>2.26 (1.88; 2.40)</td>
<td>2.21 (2.06; 2.27)</td>
<td>2.01 (1.82; 2.19)</td>
<td>1.89 (1.72; 2.02)</td>
</tr>
<tr>
<td>LFS by Pirogova</td>
<td>0.67 (0.55; 0.78)</td>
<td>0.69 (0.63; 0.70)</td>
<td>0.75 (0.68; 0.83)</td>
<td>0.81 (0.75; 0.90)</td>
</tr>
</tbody>
</table>

Table 5. The comparison of distributions of clinically significant subjective features of athletes with different types of regulatory support of the cardiovascular system

<table>
<thead>
<tr>
<th>Features</th>
<th>І type</th>
<th>ІІ type</th>
<th>ІІІ type</th>
<th>ІV type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncomfortable sensations in the heart</td>
<td>31</td>
<td>10</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>%</td>
<td>73.8</td>
<td>23.8</td>
<td>2.4</td>
<td>60.7</td>
</tr>
<tr>
<td>Feeling of interruption in the heart work</td>
<td>31</td>
<td>11</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>%</td>
<td>73.8</td>
<td>26.2</td>
<td>0.0</td>
<td>60.7</td>
</tr>
<tr>
<td>Sweating at rest</td>
<td>31</td>
<td>8</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>%</td>
<td>73.8</td>
<td>19.0</td>
<td>7.1</td>
<td>67.9</td>
</tr>
<tr>
<td>Sweating at night</td>
<td>30</td>
<td>11</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>%</td>
<td>71.4</td>
<td>26.2</td>
<td>2.4</td>
<td>75.0</td>
</tr>
<tr>
<td>The feeling of fatigue after sleep</td>
<td>21</td>
<td>18</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>%</td>
<td>50.0</td>
<td>42.9</td>
<td>7.1</td>
<td>39.3</td>
</tr>
<tr>
<td>Headache after sleep</td>
<td>39</td>
<td>2</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>%</td>
<td>92.9</td>
<td>4.8</td>
<td>2.4</td>
<td>75.0</td>
</tr>
<tr>
<td>Sweating at low loads</td>
<td>2</td>
<td>26</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>%</td>
<td>4.8</td>
<td>61.9</td>
<td>33.3</td>
<td>7.1</td>
</tr>
</tbody>
</table>
Discussion

The analysis of subjective signs that characterize the general condition, sleep and feelings during training revealed that most changes in athlete’s feelings determine the nature of the adaptive reactions of the body that occur in the training process. Symptoms that are rare and may be of clinical significance in the development of cardiovascular overstrains have been identified. These included: uncomfortable sensations in the heart, a feeling of heart failure, sweating at rest, headache after sleep, sweating at low loads, the presence of fatigue after sleep and the activity of the activation of autonomous mechanisms of thermoregulation, as well as autonomic dysregulation (according to sweating).

Discomfort in the heart is a non-specific symptom that can occur in various conditions related to heart function, such as myocardial ischemia with excessive stretching of the heart chambers, which can occur with increasing end-diastolic size, a number of inflammatory diseases of different layers of the heart, aortic lesions, etc. [47–50]. These sensations can also have reflexive nature and be associated with the condition of the spine or excessive activation of the branches of the sympathetic ANS [51–53]. Despite the fact that this feature is quite rare in the surveyed group of athletes (often in 1 % of cases and periodically in 15.3 % of cases), it deserved a meticulous analysis, which showed its significant predominance in the centralization of regulatory effects on heart rate. However, in some cases, it can occur with the predominance of autonomous influences.

Feeling of heart failure is also a non-specific symptom; however, it has a clear connection with heart function, namely arrhythmia. This feature in the studied group of athletes is also quite rare (often in 0.5 % of cases and periodically in 14.9 % of cases). Its presence, as a rule, may indicate the appearance of an extrasystolic form of arrhythmia, and, most likely, ventricular [47,49]. However, it can be variably present as sinus node weakness, when one or more heart contractions may occur [54]. Other forms of arrhythmic disorders usually have a more stable course. The same forms such as sinus arrhythmia, which is characteristic of athletes, or atrial extrasystole, usually do not cause subjective sensations. Thus, in athletes belonging to Type IV, who have very pronounced sinus arrhythmia, the feeling of interruption in work was noted in only 2.3 % and only periodically.

Sweating at rest in the absence of other symptoms is a sign of adjustment of thermoregulatory processes and stress of the autonomic nervous system in ensuring metabolism. In the whole group of surveyed athletes, this symptom is often present in 4.5 % of cases, and periodically – in 14.9 % of cases. Taking into account the type of cardiac rhythm regulation, it was the least often (in 8 % of cases) in optimal (Type III), most often in 32.1 % and 27.3 % of cases in autonomic dysregulation, as well as autonomic dysregulation (according to sweating).

Sweating at low loads, which is registered in the vast majority of athletes (95.2 % and 92.9 % of cases, respectively) was quite characteristic for Types I and II. In others it ranges from 22.7 % to 28.6 %, which also does not allow to characterize as specific for any of the Types.

Athletes of Type II complain of sleep fatigue more often – 50.0 % periodically and 10.7 % often. However, in other Types it occurs in 50.0 % to 54.4 % of athletes and is less often – from 2.3 % in type IV to 7.1 % in Type I. The symptom associated with post-sleep headache is in some way different. Most often (in every fourth athlete) it is observed in Type II. It is rarely fixed (2.3 %) in Type IV. On the other hand, it occurs in every seventh athlete with optimal (Type III) regulation. A sign of sweating at low loads, which is associated with the feeling of interrup
processes, aimed at restoring the structures and functions of the body after daytime stress of catalytic mechanisms associated with life, take place [22]. Usually, sweating during sleep is accompanied by lytic processes of thermoregulation, which implement the return of accumulated heat, as in case of a number of inflammatory diseases [23]. In athletes, sweating during sleep can characterize the processes of hypothalamic-pituitary and autonomic dysfunction and indicate the tension of adaptive mechanisms in the body [10]. In our study, night sweats occur frequently and periodically in one of five athletes (only 20.8% of cases).

Signs of fatigue after sleep and sweating at low physical loads have a certain pre-nosological significance. These symptoms are quite common: in 53.5% and 66.3%, respectively. The presence of fatigue after sleep is a characteristic sign of insufficient recovery, but it can occur with excessive stress of the previous day, when the body has little time to fully recover, and the presence of sweating at low physical loads, usually characterizes the stress of adaptive mechanisms [10]. Certainly, these signs are significant with frequent registration.

Conclusion
Subjective features can be used to verify the regulatory features of the cardiovascular system, which are associated with the centralization of effects (for the majority of signs). However, their intertype individual differentiation is difficult. On the other hand, the autonomy of influences can be determined as a manifestation of optimal regulatory support (Type III) only in the absence of most subjective features, and not always. An even bigger problem is the definition of Type IV, which is differentiated from Type III, only on the basis of sweating at rest (27.3% vs. 8%), which is not a clear subjective feature, although it can help distinguish between states of high fitness and overexertion according to parasympathetic type.

So, taking into account the types of heart rate regulation, the questionnaire can be helpful in determining the condition of the athlete. It is most likely that it can be effective in differentiating states of overstrain by parasympathetic type and state of high fitness.

Conflicts of Interest: authors have no conflict of interest to declare.

References
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Pre-season training camp in elite football players. Journal of science and medicine in sport, 16(6), 550-555. https://doi.org/10.1016/j.jsams.2012.12.003


Shepherdson, A., & Ferguson, L. (2014). Training distress and perfor...
[44] Shlyk, N. I. (2020). Variabel’nost’ serdechnogo ritma v pokoe i orto-
staze pri raznykh diapazonakh znachenii MxDMn u lyzhnits-gonshchits v trenirovchnom protsesse [Heart rate variability at rest and during an orthostatic challenge at different ranges of MxDMn values in female skiers in the training process]. Nauka i sport: sovremennye tendentsii, 1(8), 83-86. [in Russian].

vantazhuvalna dynamika pokaznykiv variabelnosti sertsevoho rytmu u voskokokvalifikovanych sportsmeniv pri formuvannii perenapruzhen za sympatheticnym ta parasympatychnym typany [Post-Loading Dyna-
mics of Heart Rate Variability Indices in Highly Qualified Athletes in the Formation of Overstains by Sympathetic and Parasympathetic Types]. Art of Medicine, (4), 28-36. [in Ukrainian]. https://doi.org/10.21802/artm.2020.4.16.28

a for electrocardiographic interpretation in athletes: Consensus statement. British journal of sports medicine, 51(9), 704-731. https://doi.org/10.1136/bjsports-2016-097331

[47] Mykhaliuk, Ye. L., & Syvolap, V. V. (2019). Osoblyvosti elektrokar-
diohramy osib, yaki zaimaiutsia sportom. Povidomlennia I (ohliad


