

On the relation of individual-typological features of wrestlers' nervous system with the success of their competitive activity

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Abstract. The purpose of the article is to study the dynamics of indicators of electro-skin resistance (ESR) in the pre-start, competitive and post-competitive period, depending on the outcome of the wrestling match. For 26 wrestlers of 19.26 ± 0.3 years old we studied the indicators of ESR during weighing (background), before and after the fight. Intergroup features of the dynamics of mental states were analyzed in connection with victory or defeat. For the winners, ESR on the day of weighing was 12.97 kOhm, for the losers it was 14.65 kOhm. Before entering the mat, mental stress increases in all wrestlers, however, in those who subsequently lose the fight, it is more pronounced. Pre-competitive emotional arousal among the winners develops in a timely manner and among the losers prematurely: difference between the results was 16.21% ($p < 0.01$). The psycho-emotional stress of the winners does not decrease after the competition, ESR increases by 19% ($p < 0.05$), which indicates the need for additional health and rehabilitation measures. Manifestations of individual-typological properties of the nervous system in states of mental tension are a prognostic factor in the effectiveness of competitive activity in wrestling.

1 Introduction

The development and maintenance of sports-important mental properties at the necessary level is one of the most important aspects of the formation of the athlete's individuality [1]. In sports wrestling, in the course of many years of sports training, athletes form a peculiar structure of mental processes and mental states, which ensures the effectiveness of their activities. A harmoniously developed structure of sports important mental properties of wrestlers in states of mental tension, in competitions and training sessions, ensures the emergence of an adequate situation of the athlete's working condition, which, in turn, determines the necessary level of organization of mental processes and states included in his activity [1, 2].

An inverse interaction has also been found, when long-term sports training based on repeated mental processes and states has a powerful influence on the development of sports important mental properties of an athlete, which he needs to achieve high sports results [3,4].

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Well-coordinated work of all links of such a structure is the most important condition for high efficiency and reliability of a wrestler's activity. Therefore, at present, special attention is paid to the study of mental processes and states of athletes [4].

One of the indirect indicators of the strengthening of the sympathetic circuit of the regulation of the autonomic nervous system to various stimuli is the indicators of skin electrodermal activity (EDA) [1, 5].

EDA phenomenon is carried out mainly by the activation of the endocrine sweat glands, since the sweat glands are innervated by efferent sympathetic nerve fibers. Thus, under all types of stimulations and reflex states that increase sympathetic tone and sympathetic sweating activity, EDA parameters seem to change [5].

Since the tonic activity of sympathetic nerve fibers and the barrier layer of the skin form the basal (tonic) level of EDA, increased discharges of sympathetic efferent fibers innervating sweating (as a result of activation of the sympathetic nervous system) cause phasic changes in EDA [6]. According to U.T. Turaçlar (1999) potential skin response, response and skin conductance response (ESR) are three EDA parameters that are produced in response to deep inspiration, emotional stimuli such as arousal and mental stress, sensory stimuli such as heat or cold, noise, pain, as well as electrical incentives [7].

It is known that sweat endocrine glands are located mainly in the palmar and plantar regions of the body, and their main function is thermoregulation. However, according to modern data, sweat glands secrete not only with an increase in body temperature, but also with emotional stress, as they receive impulses from the cerebral cortex, reticular formation, and hypothalamus, and are also activated during exercise [8].

A number of studies have shown that with high mental load and / or stress there is an increased ESR [9], Namazi H. et al. studied the change in ESR when listening to music of various genres [10], Akane Sano and H.F. Posada-Quintero studied EDA during sleep and sleep deprivation [11, 12]. In a sports context, ESR is mainly considered directly during physical exercises [13], in conjunction with other autonomic indicators, such as heart rate variability and QT variability [14, 15], when modeling a virtual image of motor acts in volleyball [15] and sports gymnastics [16]. However, in the available literature, we did not find works showing the relation between ESR parameters, which are active electrical characteristics of the skin, with the effectiveness of a wrestling match in different periods of sports training.

The purpose of the article is to study the dynamics of indicators of ESR in the pre-start, competitive and post-competitive period, depending on the outcome of the wrestling match.

2 Materials and methods

2.1 Members

The contingent of the examined consisted of 26 young men of 19.26 ± 0.3 years old (weight: 75.6 ± 0.3 kg, height: 1.82 ± 0.2 m), engaged in wrestling on the basis of the sports club of Moscow Aviation Institute (National Research University) (SC MAI) less than 6-7 years old, with a sports qualification of the first category and a candidate for master of sports.

Inclusion criteria are the following:

- active athletes with a total number of training sessions of at least 21 academic hours / 11 sessions per week.

Exclusion criteria are the following:

- surveyed, taking medicines and dietary supplements;
- surveyed with somatic diseases;
- surveyed with acute respiratory diseases, acute respiratory viral infections.

All participants were informed about the purpose and risks of the study before they signed the written consent, and the studies were carried out in conformity with the Declaration of Helsinki.

2.2 Procedures

The study was carried out in two stages. At the first stage were studied the indicators of the level of psycho-emotional stress by changing ESR on the back of the hand in wrestling competitions in connection with victory or defeat (series-1) and in connection with the dynamics of ESR on the day of weighing and immediately before and after the fight (series-2) (Figure 1).

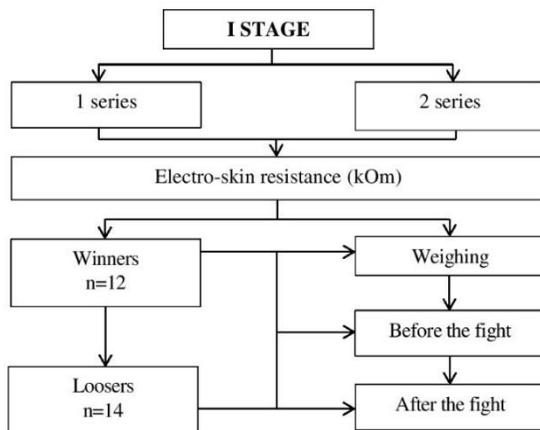


Fig. 1. Design of the first stage of research

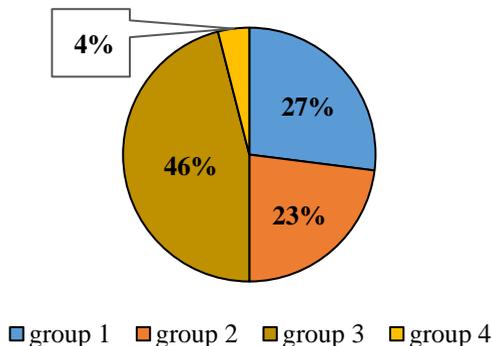


Fig. 2. Distribution of the examined into subgroups in accordance with the individual typological features of self-regulation of mental functions

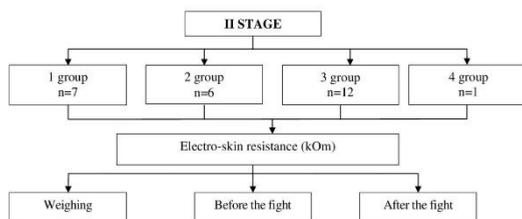


Fig. 3. Design of the second stage of research

At the second stage, all athletes were divided into 4 groups (Figure 2, Figure 3):

- group 1 (n=7) with wrestlers whose ESR increased compared to the background before the fight and even more after it;
- group 2 (n=6) with wrestlers whose ESR goes down at each stage of the examination;
- group 3 (n=12) with wrestlers who had fluctuations in their ESR: an increase in indicators before the fight and a decrease after the fight;
- group 4 (n=1) with wrestlers whose ESR decreased before the fight and increased after the fight.

Since only one person entered group 4, this group was not considered further. Then, intergroup features of the dynamics of mental states were analyzed.

2.3 Method of registration of electrical skin resistance

Testing was carried out using the BioMouse professional diagnostic complex (KPF-01) according to a special program. After applying electrodes to two different fingers of the right hand and turning on the device, a calibration setup was carried out for 1 minute, including a period for diagnosing transients and stabilizing the ESR index. Then, over the next 2 minutes, the true value of ESR was recorded. The obtained indicators were mathematically processed using statistical methods.

2.4 Statistical analysis

Statistical processing was performed using Microsoft Excel program and software package "STATISTICA 10.0". The parametric Student's t-test was used in the study. Differences were significant at $p < 0.05$ [17]. The choice of a criterion for testing statistical hypotheses and measures of central trends used to describe data was carried out depending on the results of distribution testing, which was carried out using Shapiro-Wilk test [17].

To test the null hypothesis about the absence of differences between three related groups with a normally distributed trait, we first used the procedures of one-way analysis of variance repeated observations (Repeated Measures ANOVA). Next, we checked the normality of the distribution of the difference between the values of the attribute for the paired Student's t-test and the sphericity condition for the analysis of variance of repeated observations. Then, in cases where an alternative statistical hypothesis was accepted, a pairwise comparison of groups was performed using Student's parametric test. In this case, the arithmetic mean (M) was used as a measure of the central tendency, and the standard error of the arithmetic mean (m) was used as a measure of dispersion.

3 Results

The results of the research show that the wrestlers who lost the fight develop pre-start excitement already on the day of weighing, when there are still 1-2 days left before the fight, the winning athletes have a pre-start reaction by 13% ($p < 0.05$) lower than losers. ESR on the day of weighing for the winners is 12.97 kOhm, for the losers it is 14.65 kOhm, and in some cases for the losers it reaches 25-29 kOhm, which indicates extreme mental tension (stress) and the data of pedagogical observations confirm this (Table 1). Wrestlers tend to be realistic about their capabilities, and future winners believe in their strength, unlike losers, who think more about the likelihood of defeat. The first is characterized by a state of mental readiness with a typical setting for him to achieve the highest possible result. Therefore, they do not have so high mental tension [18].

Immediately before entering the mat, the state of mental tension intensifies in all wrestlers without exception, however, in those who subsequently lost the fight, it is more pronounced. Immediately before the fight, it increased to 18.0 kOhm for the winners (by 42.63%) ($p < 0.05$), for the losers it increased to 21.5 kOhm (by 46.75%) ($p < 0.01$). Changes in ESR before and after intense activity indicate the dynamics of nervous processes; at the same time, it reflects the pre-setting for the performance of activities [19].

Analysis of post-competitive data suggests that after a fight, the losers' ESR significantly decreases by 6.23 kOhm ($p < 0.01$), almost to the pre-competitive level, which is 40%. It is interesting to note that after the fight, ESR not only does not decrease in the winners, but, on the contrary, increases by 19% ($p < 0.05$), which can be interpreted as an indicator of the inability to independently “relieve” mental tension [20] (Figure 4). This is also confirmed by the data of clinical studies by the following authors: Minina, E.N., Bobrik, Y.V., Ponomarev, V.A. (2021) [1].

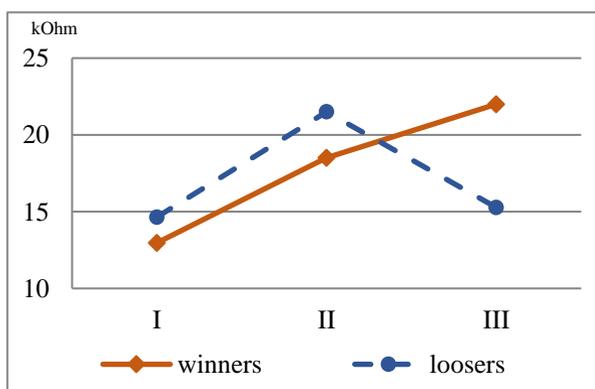


Fig. 4. Dynamics of indicators of ESR for wrestlers who lost or won the fight (I - during weighing, II - immediately before the fight, III - after the fight)

Table 1. Changes in ESR for wrestlers due to victory or defeat (n=26).

Conditions and units	Winners	Losers	Difference of indicators (%)
Weighing (kOhm)	12.97±0.5	14.65±0.4	12.95*
Before the fight (kOhm)	18.50±0.3	21.50±0.3	16.21**
After the fight (kOhm)	22.00±0.3	15.27±0.4	30.59*

Notes: * - differences statistically significant at $P \leq 0.05$, ** - differences statistically significant at $P \leq 0.01$, t - Student's t-test.

Figure 5 shows the difference in ESR indicators for wrestlers before bouts of different intensity in relation to the outcome of the fight. First of all, attention is drawn to the fact that, compared with the initial values, before a more responsible fight, the indicators change more strongly than before training sparring. So, for those who lose the fight, ESR increases by 9% in a normal training session, and for the winners by 10%, the difference between these groups was not significant ($p > 0.05$). Before a responsible competition, ESR of the losers decreases by 23%, ESR of the winners decreases by 14%, and the difference was 9% ($p < 0.05$).

Consequently, EDA indicators turned out to be sensitive to the factor of mental tension, and therefore they can be considered prognostically valuable for assessing the dynamics of the wrestlers' mental states. The winners' ESR indicators are less dynamic, the losers are more reactive to stress.

In general, the dynamic indicators EDA and ESR, in particular, reflect the degree of responsibility of the athlete before the fight and therefore can be used to assess the state of wrestlers at different training and competitive stages.

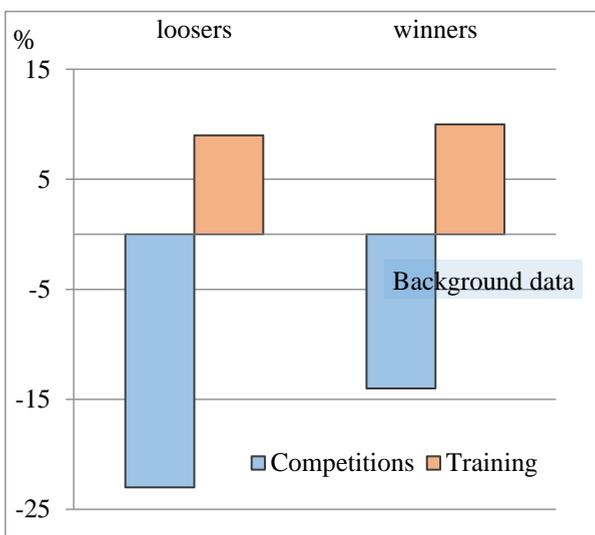


Fig. 5. Difference of indicators of electrical skin resistance in wrestlers before a training bout and before a responsible start, depending on the outcome of the fight

To study individual typological differences among wrestlers in the dynamics of mental states, we analyzed ESR in three groups, differentiated in connection with the outcome of the fight (Figure 2).

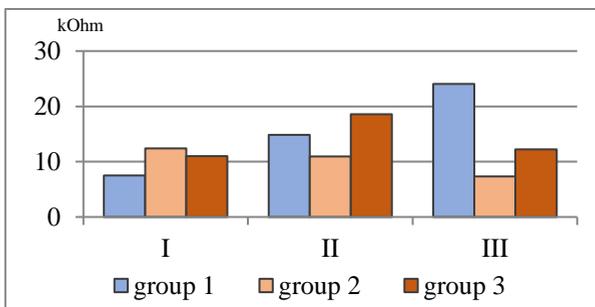


Fig. 6. Dynamics of indicators of ESR in connection with the measurement conditions and individual typological characteristics of wrestlers: I - during weighing, II - before the fight, III - after the fight

Table 2. Difference of indicators of ESR for wrestlers for different measurement conditions in connection with victory or defeat (n=26).

Test groups	Outcome of the fight	Difference of indicators (%)		
		weighing - before the fight	before the fight - after the fight	weighing - after the fight
Group I	Victory	–	–	–
	Defeat	97.5*	61.8*	219.5*
Group II	Victory	–11.76*	–49.38**	–60.75**
	Defeat	–15.38*	–82.75*	–173.7*
Group III	Victory	+69.1**	–34.4**	–10.9**
	Defeat	+89.5*	–74.5±0.3*	+16.5*

Notes: * - differences statistically significant at $P \leq 0.05$, ** - differences statistically significant at $P \leq 0.01$, t - Student's t-test.

As it is shown in the Figure 6, the wrestlers of the first group are characterized by a pronounced pre-start excitement, which continues to increase during the fight and reaches a maximum by the end of the fight. The representatives of this group lost all the fights, ESR during the weighing was 7.53 kOhm ($p < 0.05$), before the fight it increased by 97.5% ($p < 0.05$), and after the fight it continued to grow to the level of 24.06 kOhm ($p < 0.05$), which is almost three times higher than the background values. Since there were no winners among the representatives of this group, such a shift in mental functions cannot be considered optimal for achieving high results for wrestlers.

For wrestlers of the second group, the state of mental tension decreased before entering the mat and even more after the fight. ESR during the weighing was 12.41 kOhm ($p < 0.05$), before the fight it decreased to 10.95 ($p < 0.05$), and after the fight it decreased by another 49.38% ($p < 0.05$) (Figure 6, Table 2). It should be noted that in the second group, the winners significantly prevail over the losers: the latter are more distinguished by strong mental tension during the weighing and after the fight. At the most crucial moment (before entering the mat), the direction of the shifts in the mental state of the losers is almost the same as that of the winners.

The third group was the most numerous. The wrestlers included in it are characterized by the most typical dynamics of mental states: an increase in tension before entering the mat was from 70 to 89% ($p < 0.01$), and its decrease after the end of the fight to a minimum for the winners, and a prolonged increase by 16.5% for the losers (Figure 6, Table 2).

Thus, it can be assumed that for the successful completion of the fight of wrestlers, two options for the dynamics of mental states seem to be optimal:

1. slight (within 10%) decrease in mental tension before the fight and a significant decrease after the fight;
2. increase in mental tension before the fight and "withdrawal" after the fight.

4 Discussion

When evaluating the psychological factors of the effectiveness of sports activities, many studies talk about the dynamic characteristics of mental states that directly affect this activity. This provision also applies to the so-called pre-start conditions and to the conditions experienced by the athlete during and after the competition. The mental state of an athlete depends not only on the responsibility of the competition, but also on the individual characteristics of the athlete. In the same stressful situation, different athletes experience different mental states. The less discoordination of activity they cause, the more "reliable"

such an athlete can be considered, the more capable he is to act effectively with a high degree of mental tension.

According to E.A. Birukova, mental tension is a set of psychophysiological phenomena that provide a person's mental tone to perform a particular activity [18]. The presence of such a psychophysiological syndrome determined the choice of methods for studying the features of mental tension in various types of activity. The presented ESR methodology includes indicators of mental and autonomic functions [18-21].

O.N. Kuvshinov and A.A. Dzhililov studied the dynamics of sensorimotor reactions in boxers before fights of varying degrees of intensity. They concluded that the indicators of sensorimotor reactions in boxers before a responsible fight are better than before a training fight. This is especially true of the anticipatory reaction, which, in their opinion, is the most variable in relation to the factor of mental tension, and therefore they can be considered the most predictive for assessing the dynamics of the mental states of boxers [22].

As a result of our study, it was shown that with all types of stimulations and reflex states that increase sympathetic tone, including physical activity and precompetitive psycho-emotional stress, ESR parameters change.

Such changes before and after intense activity testify to the dynamics of nervous processes; at the same time, they reflect the pre-setting for the performance of the activity. As it was shown in the study of Lelard T., ESR changes dramatically already during the presentation of unfavorable competitive situations [15].

To assess autonomic indicators of changes in mental states, researchers usually use indicators of a calm state as a background [19, 20]. In the present experiment, the baseline values were obtained during the weigh-in, as the changes in vegetative parameters, occurring sequentially from the early pre-start state to the competitive and post-competitive state, were investigated. Obviously, in this case, it is possible to remove the influence of the artifact, which is almost inevitable when comparing individual measurements obtained in a calm state and in a state of mental tension.

E.Sh. Shayakhmetova assessed in her work the emotional state of athletes before and after a competitive fight, but the dynamics of the results obtained was not analyzed due to such a powerful emotional factor as victory or defeat. This was investigated in the present work [23].

Attention is drawn to the noticeable differences between the results of the examination obtained in the case of victory and in the event of defeat of the wrestlers. During the weigh-in, the losers had a more significant drop in ESR ($P < 0.05$) than the winners. Athletes tend to be realistic about their abilities, and future winners believe in their strength, unlike losers, who think more about the likelihood of defeat. The first is characterized by a state of mental readiness with a typical setting for him to achieve the highest possible result. Therefore, they experience a state of mental tension to a lesser extent.

Summing up, it is quite obvious that the psychological complexity of the competitive situation cannot be fully assessed either by exclusively "external" characteristics (scale of the competition, tasks assigned to the athlete, preparedness, etc.), or only by "internal" ones (for example, shifts in vegetative terms). It is necessary to consider a complex set of mutually influencing factors of an objective and subjective nature. However, the trend found in the experiments described above indicates the general and group dynamics of the reliability of the competitive actions of athletes. This dynamic is due, first of all, to the influence of special preparedness and the resultant subjective confidence of the athlete in his abilities. Although these two points are interrelated, there is no strictly unambiguous relationship between them. This state of affairs gives great opportunities to a practicing psychologist in choosing the means of diagnosing the reliability of an athlete's competitive activity.

5 Conclusions

As a result of the study, it was shown that ESR undergoes significant changes in the state of mental tension, so it can serve as an indicator of the assessment of the state of all higher mental functions. In the course of the study, it was determined that the winners' pre-launch reaction develops in a timely manner, and the losers develop it prematurely. To achieve highly competitive results, the most favorable individual typological pattern of an athlete is a slight (within 10%) pre-start reaction, competitive psychophysiological stress and a significant decrease in autonomic reactions after the fight. However, as it was shown in the study, the winners' psycho-emotional shift after the competition has an increasing prolonged character, which indicates the need for additional relaxing health-improving and recovery measures, as well as further sports and psychological support for the athlete.

References

1. E.N. Minina, Y.V. Bobrik, V.A. Ponomarev, IOP Conf. Ser.: Earth and Env. Sci. **853**(1), 012031 (2021). <https://doi.org/10.1088/1755-1315/853/1/012031>
2. D. Darby, J. Moriarity, R. Pietrzak, J. Kutcher, K. McAward, P. McCrory, The J. of Sports Med. and Phys. Fitn. **54**, 340-346 (2014).
3. H.-C. Huang, P.-Y. Lee, Y.-C. Lo, I.-S. Chen, C.-H. Hsu, Sust. **13**, 7199 (2021). <https://doi.org/10.3390/su13137199>
4. G. Polevoy, Int. J. of Ped. **9**(6), 13773-13779 (2021). <https://doi.org/10.22038/ijp.2021.57347.4500>
5. P.H. Venables, Electrodermal activity (Annals New York Academy of Sciences, New York, 1991)
6. M.J. Christie, P.H. Venables. J. of Psych. Res. **15**, 343-348 (1971).
7. U.T. Turaçlar, S. Erdal, A. Abdullah, A. Yildiz. Turkish J. of Med. Sci. **29**, 113-116 (1999).
8. S. Suominen, Athens J. of Sports. **8**(3), 201-214 (2021).
9. Epps J., Chen S. IEEE Syst., Man, and Cyb. Mag. **4**(4), 15-20 (2018).
10. H. Namazi, D. Baleanu, S. Omam, O. Krejcar. Fract. **29**(02), 2150124 (2021).
11. A. Sano, R.W. Picard, R. Stickgold. Int. J. of Psychophys. **94**(3), 382–389 (2014).
12. H.F. Posada-Quintero, J.B. Bolkhovsky, N. Reljin, Ki H. Chon. Front. in Phys. **8**, art 409 (2017).
13. H.F. Posada-Quintero. PloS one. **13**(6), e0198328 (2018).
14. S. Boettger, C. Puta, V.K. Yeragani, L. Donath, H. J. Mueller, H.H. Gabriel, K.J. Baer, Med. Sciio Sports Exerc. **42**(3), 443-448 (2010).
15. T. Lelard, O. Godefroy, S. Ahmaidi, P. Krystkowiaky, H. Mouras. Front. in Psych. **8**, 2012 (2017).
16. Knufinke M. The measurement of arousal by the means of electrodermal activity during an actually performed balance beam routine and observational learning of the same routine: dissertation. – University of Twente. – 2012. – 73p.
17. J. Oldham, Nurs. stand. **44**, 28-30, (1993).
18. N. Vysochina, Sport Sci. **4**, 2-9 (2016). <https://doi.org/10.15823/sm.2016.36>.
19. E.A. Birukova, Y.O. Dyagileva, N.S. Yarmolyuk, E.I. Nagaeva, E. Ukalo. Eur. J. Clin. Invest. **51**(1) (2021). <https://doi.org/10.1111/eci.13564>

20. E. Birukova, E.R. Dzheldubaeva, N.S. Yarmolyuk, E.I. Nagaeva, Eur. J. Clin. Invest. **51**(1) (2021). 55ASM-0006 FT. <https://doi.org/10.1111/eci.13564>
21. E. Birukova, N.S. Yarmolyuk, E.R. Dzheldubaeva, E.I. Nagaeva, E.N. Chuyan, Eur. J. Clin. Invest. **51**(1) (2021). 55ASM-0005 FT. <https://doi.org/10.1111/eci.13564>
22. O.N. Kuvshinov, A.A. Dzhililov, West-Russia-East, **7**, 267–275 (2013).
23. E.Sh. Shayakhmetova. Psychoregulation in sports: textbook (Bashkir Institute of Physical Culture, Ufa, 2006).