

Assessment of the relationship between psychophysiological compatibility and sports qualifications in rhythmic gymnastics

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Abstract. The aim of this study was to determine the relationship between the level of psychophysiological compatibility (PPC) and sports qualifications in group rhythmic gymnastics. 20 girls from 4 rhythmic gymnastics sports teams of various sports qualifications participated in this study: one team consisted of athletes of the first adult sports category, two teams – of candidates for master of sports, one – of masters of sports. The level of PPC in the teams was assessed using the hardware and software complex SIGVET-TEAM and the Pearson correlation coefficient (r). The positive relationship between the growth of PPC and sports qualifications was revealed as a result of the study. At the same time, the analysis of the individual result of athletes demonstrates a great variability in the specific contribution within the groups. This fact raises new questions about the importance of PPC at various stages of athletic training in group rhythmic gymnastics.

1 Introduction

The result of a successful performance of a sports team in competitions depends not only on the level of physical, psychological, technical and tactical training, but also on effective interaction between its members [1].

The ability to coordinate their actions, adapt to external stimuli and the actions of other athletes is necessary for the successful performance of motor tasks in competition conditions [2]. In addition to motor control, such psychophysiological mechanisms as memory, attention, reaction time, anticipation, cognitive performance, etc. are also important components in the development of motor behavior consistent with sensory signals [3]. All these mechanisms are considered as components of psychophysiological compatibility.

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Psychophysiological compatibility (PPC) refers to the similarity and consistency of sensorimotor reactions, psychophysiological and tempo-rhythmic characteristics of joint activities that ensure the effective performance of the task [3].

The issue of PPC in team and group sports is considered quite well in modern scientific research literature [4-8].

For rhythmic gymnastics, the assessment of PPC plays an important role at all stages of sports training, since the main goal in this sport is to perform dance and complex coordination gymnastic exercises of various complexity levels [9] using various items in synchronous or partially asynchronous mode, accompanied by music [10]. In addition, there may be joint actions with a partner with one or more items without exchanging them [11]. This requires both the formation of specific motor skills at the initial stages and their improvement at later stages of sports training, as well as high teamwork of the members interpersonal coordination [12] provided by high PPC within the team.

One of the central issues in the study of PPC in team and group sports is its relationship with the level of sports qualifications. Unfortunately, to date we have not found any works dedicated to this area. This fact was a prerequisite for our study.

The lack of research in this area is due to a number of problems in the assessment of PPC.

The main problem is the collective nature of the work. This means that the effectiveness of an individual athlete cannot be reduced either to her level of athletic qualification or to her level of functional condition [13]. It should reflect the athlete's contribution to the overall result and thus ensure the success of her team, at the same time taking into account the effectiveness of all team members. This requires monitoring the actual success of the team in the absence of a specific athlete, which is impossible in real life.

This leads to another problem of systematically evaluating an athlete's performance based on the success of her team — that is, based on work done not only by her [14].

Another problem is the fact that in modern works PPC is not considered as the main factor of an integrated approach to assessing the technical and physical condition of athletes, their morphofunctional indicators, the ability to work in groups and coordinate their actions with partners [15].

In many ways, the above-described problems come down to the lack of appropriate research methods that allow to negate them.

For this purpose, the hardware and software complex (HSC) SIGVET-TEAM was developed, which allows evaluating various components of the PPC when performing joint activities [16].

The aim of this work was to determine the relationship between the level of psychophysiological compatibility and sports qualifications in group rhythmic gymnastics.

In this article, we hypothesized the existence of a link between the level of psychophysiological compatibility and athletic qualifications in group rhythmic gymnastics.

To fulfill the purpose of the study, the following tasks were set:

1. To assess the level of psychophysiological compatibility among rhythmic gymnastics teams of various sports qualifications.
2. To assess the individual (intragroup) level of psychophysiological compatibility in rhythmic gymnastics for teams of various sports qualifications.
3. To identify the link between the level of psychophysiological compatibility and the athletic qualifications of rhythmic gymnastics sports teams.

2 Materials and methods

The study was conducted on the basis of the Lesgaft National State University of Physical Culture, Sports and Health. 20 girls from 4 rhythmic gymnastics sports teams of various

sports qualifications participated in this study. The characteristics of the participating groups are shown in table 1. All gymnasts were right-handed. For further analysis, all participants in each group were assigned a corresponding indicator marked with letters: A, B, C, D, E.

Table 1. Characteristics of the study participants (Compiled by the authors).

Group	n	Age (years)	The level of sportsmanship
No. 1	5	9-10	1 adult sports category
No. 2	5	13-14	Candidates for the Master of Sports
No. 3	5	15-16	Candidates for the Master of Sports
No. 4	5	18-19	Masters of Sports

Notes: n – number of participants

The HCS SIGVET-TEAM was used to assess and analyze the intergroup and intragroup level of the PPC [16] (St. Petersburg, Russia). This complex (Figure 1) allows for group ergometry (up to 10 people) using wrist dynamometers with calibrated springs, allowing to vary and develop a force of up to 20 kg. The forces are displayed in conventional units (units), which were automatically calculated by the program during calibration, taking into account the vertical dimension of the graphic window. The sampling rate was 100 Hz.

In this study, the image was displayed on a Samsung Odyssey G5 27” VA black C27G55TQBI liquid crystal monitor, with a size of 1080x1440 pixels.

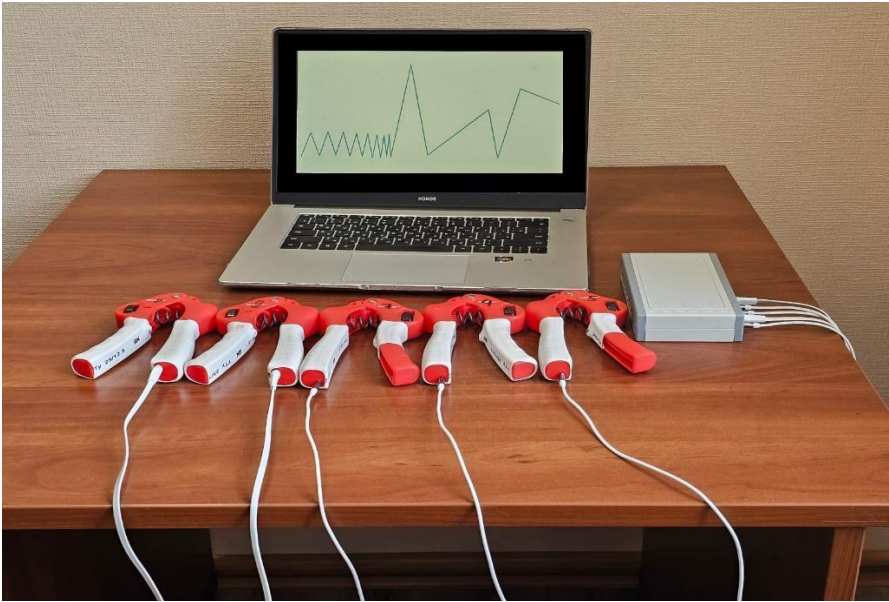


Fig. 1. Hardware and software complex SIGVET-TEAM (compiled by the authors).

The study took place 20 minutes before the workout. Before it began, the researcher explained the task of testing, conducted instructions on the procedure for completing the task and, if necessary, answered the questions that the athletes had. The task of the test subjects was to track and form the cursor position on the screen by dosed compression of the wrist ergometers, repeating the movement of the leader line along the trajectory set by the program (Figure 2).

Previously, each athlete of the group was individually given two trial attempts to reproduce the movement of the leader line. If the participant was missing two attempts, she was given additional attempts until the movement was played correctly. After completing

the trial attempts, the group performed a control test, where the task and the trajectory of the leader line were the same as during the trial attempts, however, a diagram of the total contribution of all team members was displayed on the screen.

The individual result of each participant was shown on the screen during the trial attempts. The result of the joint effort was shown on the screen during the control task, while the specific contribution of each athlete during the test was not displayed. After completing the task, the participants were shown the total result and the result of each athlete’s individual contribution.

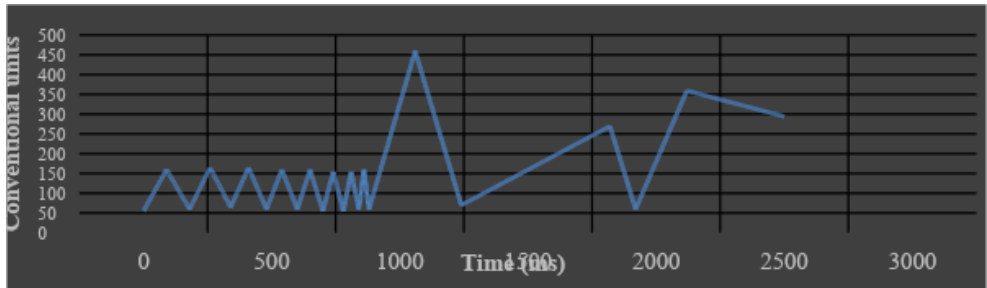


Fig. 2. An example of the leader line movement along a trajectory set by the program (compiled by the authors).

All groups were tested under the same conditions in the same room, in a sitting position, at a distance of 50-60 cm from the monitor.

The statistical analysis included the following: checking the data obtained for compliance with the normal distribution using the Shapiro-Wilk test and correlation analysis using the Pearson correlation coefficient (r) to calculate the correlation of the result of each participant with the model diagram (leader line). The magnitude of the correlation effect was established in accordance with Hopkins’ description: insignificant (0 – 0.1), very low (0.1 0.3) low (0.3 0.5), moderate (0.5 0.7), high (0.7 0.9), very high (0.9 – 1.0) and negative: insignificant (0 – -0.1), very low (-0.1 – -0.3) low (-0.3 – -0.5), moderate (-0.5 – -0.7), high (-0.7 – -0.9), very high (-0,9 – -1,0).

The following formula was used to assess the level of psychophysiological compatibility (y) of the teams:

$$y = \frac{A+B+C+D+F}{5},$$

where A, B, C, D, F are the results of the specific contribution correlation effect with the model value of each participant’s diagram.

“1” was assumed to be the maximum ratio of the test subjects’ diagram to the model diagram and defined as the best value of the PPC.

The data was analyzed using Microsoft Excel 2021 and JASP software (version 0.17.3.0) (University of Amsterdam, Amsterdam, the Netherlands).

3 Results

For groups No. 2, 3, 4, it took an average of one trial attempt to complete the task correctly. It took from 2 to 4 attempts for group No. 1.

Figure 3 shows a diagram representing the total result of the teamwork of each group in completing the target task.

Figure 4 shows a diagram representing the result of athletes' individual contribution within their group to the overall performance of the task.

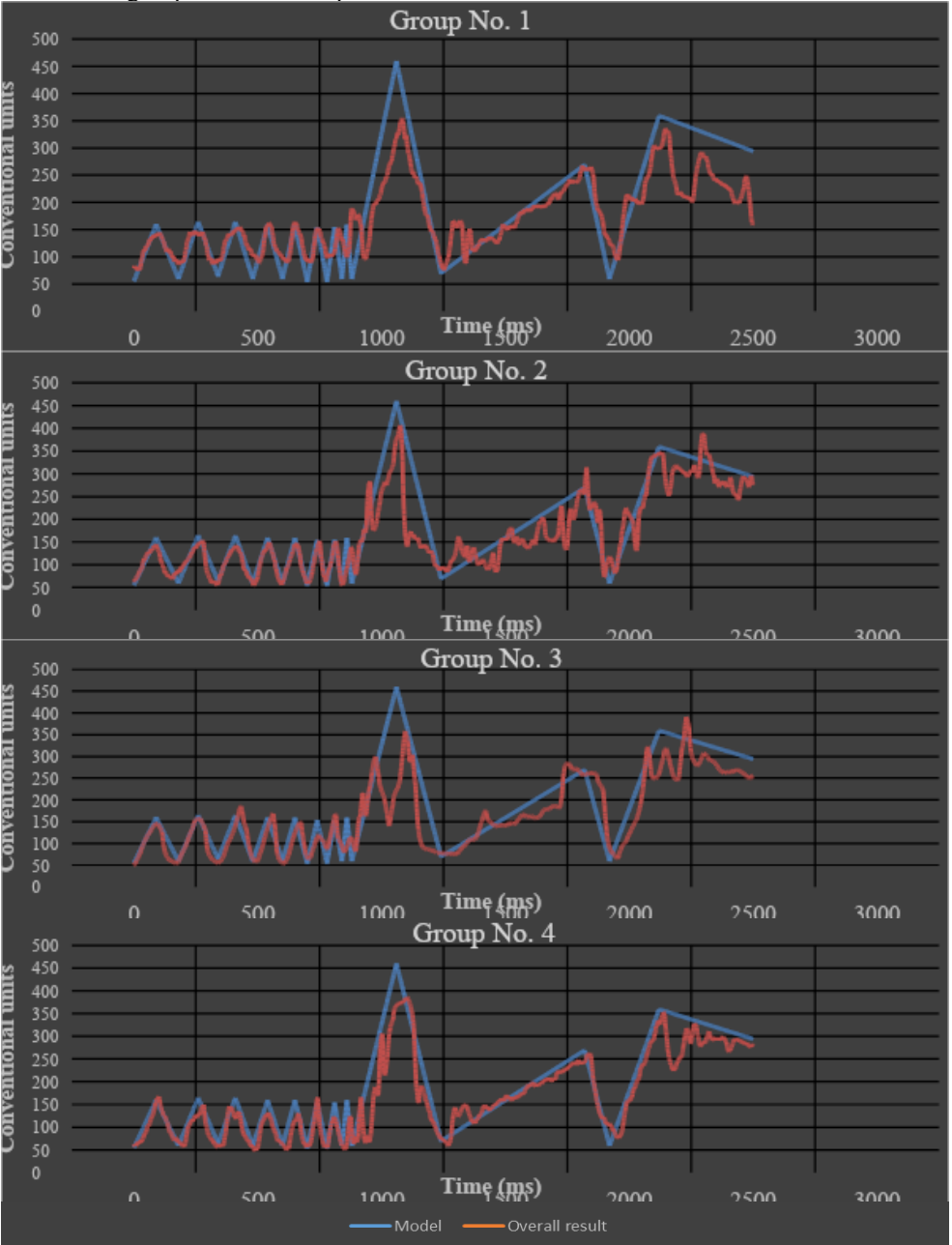


Fig. 3. The overall result of completing the task for groups of rhythmic gymnastics athletes of various sports qualifications (compiled by the authors).

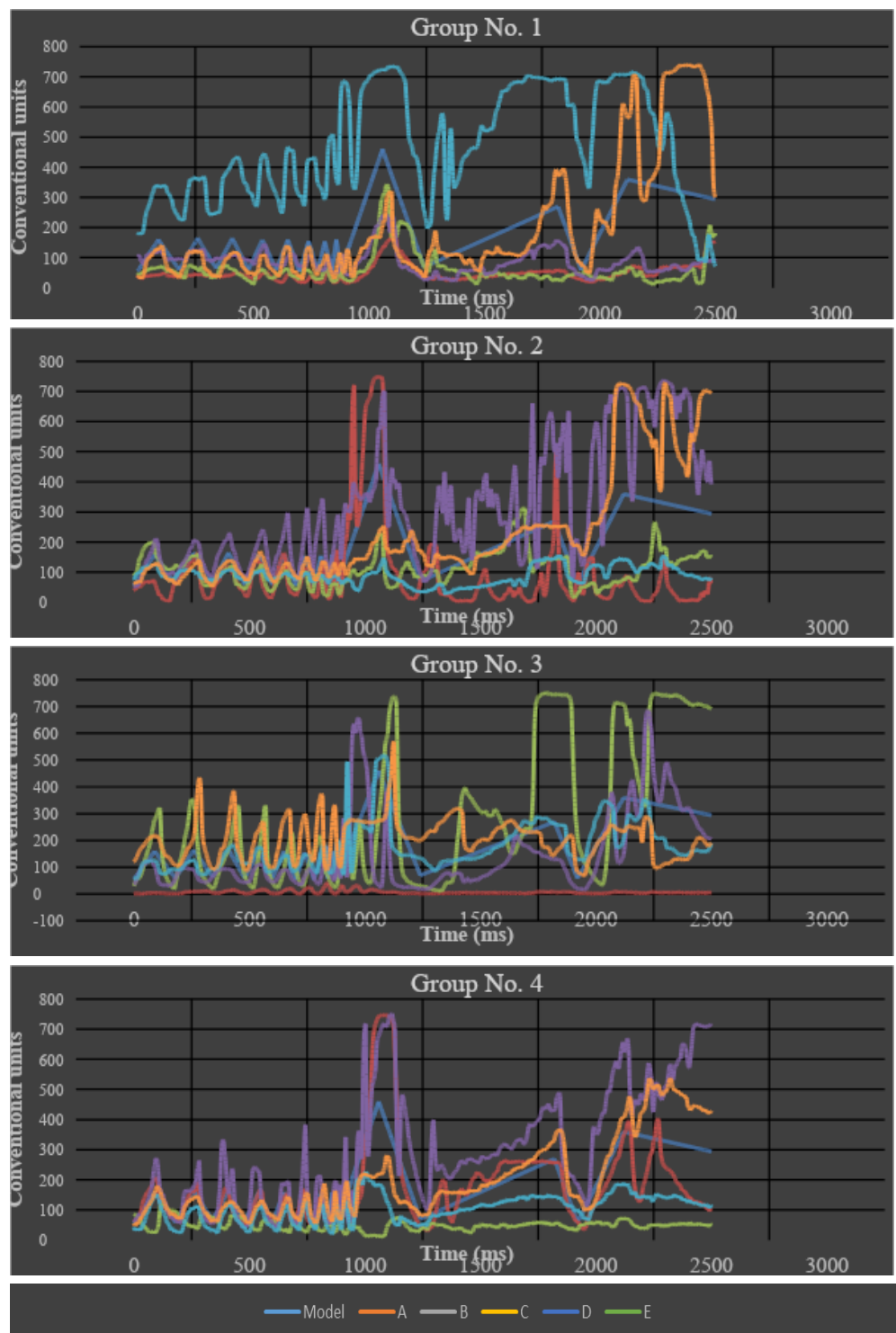


Fig. 4. The individual contribution of athletes within their group to the overall effectiveness of the task (compiled by the authors).

When considering all groups, the correlation analysis showed that the highest level of PPC was observed in group No. 4. Moderate correlation significance was observed in this group. Moderate correlation significance was also observed in groups No. 2 and No. 3, but it was significantly less than in group No. 4. Low correlation significance was observed in group No. 1.

The analysis of the individual contribution of the participants (Table 2) showed that in group No. 1 there was a high (2 people), moderate (1 participant), low (1 person) and insignificant (1 person) positive correlation significance. In group No. 2, there was a high (1 participant), moderate (2 participants), low (1 participant) and very low (1 participant) positive correlation significance. In group No. 3, there was a high (2 participants), low (2 people) and insignificant (1 person) positive correlation significance. In group No. 4, there was a high positive (4 people) and low negative (1 person) correlation significance.

Table 2. The results of the correlation analysis (compiled by the authors).

No. of participant	Group			
	No. 1	No. 2	No. 3	No. 4
A	0.705	0.060	0.286	0.817
B	0.014	0.443	0.669	-0.133
C	0.278	0.837	0.669	0.891
D	0.585	0.477	0.797	0.832
E	0.817	0.805	0.365	0.851
The level of psychophysiological compatibility	0.480	0.524	0.557	0.651

4 Discussion

The results of the study demonstrate a positive correlation between the level of PPC and sports qualifications in rhythmic gymnastics. At the same time, a significant individual variability of each participant’s contribution was revealed within each group to the effectiveness of the task.

For example, an interesting result was observed in the group of masters of sports (No. 4), where the athlete “B” had a low negative correlation, compared with a high positive correlation among the rest of the team members. In Figure 3, this athlete has a low specific contribution to the overall performance of the task, which can also affect the performance of the other team members. However, despite her contribution, this group showed the highest level of PPC, which allowed to neutralize the negative value of the athlete “B”.

In group No. 1, 2, 3, there was a large variability in the specific contribution of each participant to the result of the performance. At the same time, the variability became less due to the increase in the qualifications of sports teams.

So, on the one hand, it can be assumed that PPC is an individual parameter and probably changes slightly during ontogenesis. On the other hand, with the increase in the qualification of teams, there is a decrease in the variability of specific contribution indicators. This trend can be explained by the long-term systematic and phased sports selection in rhythmic gymnastics, as well as a better application of a differentiated approach to the formation of groups at the stage of sports improvement and higher sports skills. These ideas correlate with the work of other authors in the field [8, 13, 16].

In addition, at the stage of preparation for the test task, the difference between the groups of athletes in the number of test attempts was revealed. It was found that groups of highly qualified athletes needed significantly fewer attempts to master the task. This observation indicates that sports qualification as a result of high-quality group motor experience determines the speed of solving a new motor task by a team.

McEwan D. et al. [15] describe the challenges of evaluating individual performance in team sports. McEwan believes that quantifying individual performance is impossible in the absence of information about individual contribution; conversely, quantifying individual contribution is impossible in the absence of information about individual performance.

In addition to the main result, our study demonstrates the effectiveness of the HCS SIGVET-TEAM for evaluating the PPC and individual performance of sports teams.

A promising area for future research may be to establish the relationship between the level of PPC (as well as individual contribution) and the effectiveness of performance at competitions. These results may have practical significance in the selection and formation of sports teams in rhythmic gymnastics at various stages of sports training.

Our study had some limitations. Firstly, only 4 teams of different ages and levels of sports qualifications took part in it, which does not allow extrapolating the data obtained to large samples in this sport. The solution to this problem involves the participation of more sports teams in future research. Longitudinal study can also show the stability of PPC in various periods of athletic training.

Secondly, we believe that performing only a visual-motor task may not be enough to describe all the components of PPC in rhythmic gymnastics. The HCS SIGVET-TEAM allows to evaluate various components of PPC (short-term memory, distribution and concentration of attention, speed of sensorimotor reactions, anticipation and some others) and physiological reactions of the body (galvanic skin reaction). Such an approach will allow to determine the relationship with the level of sports qualifications in this sport more accurately.

5 Conclusion

In this paper, we present results of the study of the relationship between the PPC level and the level of athletic qualifications among rhythmic gymnastics teams. The positive relationship between the growth of the PPC and sports qualifications has been revealed. At the same time, the analysis of the athletes' individual result demonstrates a great variability in the specific contribution within the groups. This raises new questions about the importance of PPC at various stages of athletic training in group rhythmic gymnastics. Further research is needed to study the relationship between the general and individual level of PPC and the effectiveness of performance at competitions.

References

1. A. T. Pescosolido, R. Saavedra, *Small Group Res.* **43**(6), 744-758 (2012)
<https://doi.org/10.1177/1046496412465020>
2. M. Gerber, *Soc. Work Groups* **21**(3), 35-48 (1999)
https://doi.org/10.1300/J009v21n03_04
3. S. V. Krutkin, *Psychological compatibility as a factor in optimizing the recruitment of primary military units*. PhD Thesis in Psychology (Moscow, 2004)
4. H. Folgado, R. Duarte, P. Marques, B. Gonçalves, J. Sampaio, *Sci. Med. Football* **2**(2), 101-107 (2018) <https://doi.org/10.1080/24733938.2018.1431399>
5. A. Tomassini, J. Laroche, M. Emanuele, G. Nazzaro, N. Petrone, L. Fadiga, A. D'Ausilio, *iSci.* **25**(4) (2022) <https://doi.org/10.1016/j.isci.%202022.104096>
6. D. McEwan, *Sport, Exer. Perf. Psych.* **9**(1), 1 (2020)
<https://doi.org/10.1037/spy0000166>

7. A. M. Bird, *J. Soc. Psych.* **103(2)**, 217-223 (1977)
<https://doi.org/10.1080/00224545.1977.9713320>
8. K. Flores-Szwagrzak, R. Treibich, *Manag. Sci.* **66(6)**, 2523-2544 (2020)
<https://doi.org/10.1287/mnsc.2019.3305>
9. C. Armada Martínez, F. Cavas-García, A. Díaz-Suárez, A. Martínez-Moreno, *Front. Sports Act. Liv.* **3**, 625944 (2021) <https://doi.org/10.3389/fspor.2021.625944>
10. E. N. Medvedeva, A. Yu. Davydova, G. V. Zarodnyuk, *Theory Prac. Phys. Cult.* **12**, 85-87 (2020) <https://doi.org/10.54702/msj.2021.20.2.0073>
11. H. E. Mohammed, R. F. Mohammed, *Mod. Sport* **20(2)**, 0073-0081 (2021)
<https://doi.org/10.54702/msj.2021.20.2.0073>
12. M. Manos, L. Popescu, *Discobolul–Phys. Edu., Sport Kinetother. J.* 118-125 (2019)
<https://doi.org/10.35189/iphm.icpesk.2019.19>
13. D. McEwan, B. D. Zumbo, M. A. Eys, M. R. Beauchamp, *J. Sport Exer. Psych.* **40(2)**, 60-72 (2018) <https://doi.org/10.1123/jsep.2017-0193>
14. D. McEwan, G. R. Ruissen, M. A. Eys, B. D. Zumbo, M. R. Beauchamp, *PloS one* **12(1)**, e0169604 (2017) <https://doi.org/10.1371/journal.pone.0169604>
15. D. McEwan, E. J. Shah, K. L. Crawford, P. C. Jackman, M. D. Hoffmann, E. Cardinal, A. J. Benson, *J. Sport Exer. Psych.* **1**, 1-12 (2023)
<https://doi.org/10.1123/jsep.2023-0147>
16. Ya. V. Golub, G. Ya. Golub, A method for assessing psychophysiological readiness for professional activity. RU 2661726 C2 (2018)