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Analysis of interrelations of psychophysiological and physiological indicators of martial arts athletes

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Vyacheslav Romanenko[1 ABCDEF], Sergii Iermakov[2 ABCDEF], Leonid Podrigalo[3 ABCDEF], Olga Rovnaya[3 ABDEG], Zhanna Sotnikova-Meleshkina[4 ABEG], Valeriy Goloha[1 ABEG], Larysa Ruban[5 ABEG]

[1] Department of Combat Arts, Kharkov State Academy of Physical Culture, Kharkov, Ukraine

[2] Department of Tourism and Recreation, Gdansk University of Physical Education and Sport, Gdansk, Poland

[3] Department of Hygiene and Human Physiology, Kharkov State Academy of Physical Culture, Kharkov, Ukraine

[4] Department of Hygiene and Social Medicine, V. N. Karazin Kharkov National University, Kharkov, Ukraine

[5] Department of Biochemistry, Anatomy and Sports Medicine, Kharkov State Academy of Physical Culture, Kharkov, Ukraine

abstract

Background: The article presents a comparative analysis of interrelations of psychophysiological and physiological indicators of martial art athletes while performing functional tests.

Material and methods: 63 martial art athletes were divided into groups: the 1st group – 34 athletes of "striking" martial arts (taekwondo ITF, WTF, karate, hand-to-hand fight), age (17.58 ±0.08) years; the 2nd group – 18 Greco-Roman and freestyle wrestlers, age (18.94 ±0.33) years; the 3rd group – 11 judo and sambo athletes, age (18.73 ±0.23) years. Participants performed a test to define the choice reaction time with parallel control of the heart rate for 3 minutes.

Results: Indicators of the 1st and the 3rd groups did not significantly differ. Relevant excess of specific weight of significant and confident correlations was found in the 2nd group. The synchronization labilization indicator in the 2nd group was twice as high as in the 1st and the 3rd groups. The mean correlation coefficient in all groups belonged to the average interval. The indicator values of system formation in the 2nd group were significantly higher than in the other groups.

Conclusions: Wrestlers are characterized by a higher degree of adaptation tension opportunities in comparison with other athletes.

Key words: martial arts, choice reaction time, functional state, interrelations.

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Corresponding author: Prof. Sergii Iermakov; Department of Tourism and Recreation, Gdansk University of Physical Education and Sport, Kazimierza Górskiego 1, 80-336 Gdańsk, Poland; e-mail: sportart@gmail.com

INTRODUCTION

Nowadays there is a high popularity of martial arts all around the world. Athletes and professional sportsmen pursue them both for sports and recreational purposes [1]. The current situation increases the relevance of the organization of functional state monitoring of the persons practicing martial arts.

A monitoring algorithm supposes a prognosis and design of the athletes' state on the basis of its analysis. In turn, an estimation of the athletes' status in single combats, exposure of intercommunications and dependences between indices are the basic ways of receiving information for monitoring.

The study of psychophysiological indicators allows evaluating the athletes' functional state. First of all, it is the state of sensory systems. The assessment of the speed of reaction to various stimuli is an integral indicator of the athletes' functional state. This indicator determines sports success among martial arts athletes.

The status analysis of martial arts athletes is the main way of obtaining information for monitoring. The essential role in this process is played by the study of athletes' efficiency and assessment of their adaptation opportunities. A need for the study of the dynamics of functional parameters in performing strikes by karate athletes is emphasized [2]. The importance of kinetic parameters of kicks is stressed for success in martial arts.

The state of the cardiovascular system as an indicator of adaptation possibilities predetermines the necessity of its research and analysis for monitoring of the state of athletes of single combats. The heart rate is a simple and accessible integral criterion, which reflects the athletes' reaction to loads and allows estimating the value of the adaptation potential.

A comparative analysis of the functional state of Muay Thai wrestlers and athletes during fights and the recovery period [3] was carried out. Muay Thai sparring had a more intense effect on the athletes. The use of the cardiovascular system parameters as a tool for monitoring the athletes' state was offered.

The analysis of the cardiovascular system indicators of Muay Thai athletes was conducted during performance of different types of strikes [4]. Changes of the heart rate and systolic pressure are estimated as a reflection to adaptation changes. Considering the heart rate at rest and its maximum value as the reaction indicator to competitive load in martial arts is offered [5]. The importance of the cardiovascular system parameters in kickboxing athletes state monitoring is confirmed [6]. Functional tests with the standardized loads estimate the subjects' optimum adaptation opportunities.

Reaction speed tests to various stimuli have to be considered as the most adequate among functional tests according to the specifics of martial arts. Demirkan [7] investigated reaction speed dynamics of young wrestlers depending on their age. He determined that an increase in age and training experience significantly improves this parameter.

Volodchenko et al. [8] applied the division of participants according to martial arts for comparison of psychophysiological features of wrestlers, kickboxing, karate, and taekwondo athletes.

Lyzohub et al. [9] noted that it is possible to improve the methods of control over footballers' training process and play activity in case individual typological features if the higher parts of the nervous system are taken into account. Functional mobility, strength, a balanced state of nervous processes and indicators of a sensorimotor reaction as genetically unchanged indicators may determine the effectiveness of football players' training. The obtained data has prognostic validity and can be used in the process of young players' selection and optimization of sports training of professional footballers.

The existence of an interrelation between physical activity and motor action skills of school pupils was investigated by Balaban [10]. The determined correlations are considered as a reflection of the children's functional state.

Petrov et al. [11] emphasize the importance of reaction speed for success in badminton. They offered to apply reaction speed tests for the selection of prospective athletes.

Gutierrez-Davila et al. [12] investigated a reaction speed to various stimuli in elite fencers. The results demonstrated that the choice reaction time to visual stimuli increases in dual-task states with respect to simple reaction time, whereas the mean horizontal force tends to decrease in dual tasks. Also, the obtained results demonstrated that perceptual and attentional processes play a major role in fencer performance in real competition.

Gierczuk and Sadowski [13] investigated changes in the levels of selected indices of coordination motor abilities (CMA) in freestyle wrestlers during a 4-year training process. The conclusion was drawn that oriented individualized development of CMA in competitors at every stage of training may positively affect the process of learning and improving sports technique and the selection of effective strategies in performance.

Zabrocka et al. [14] determined motor skills that significantly affect the level of technical preparation in dancesport at the early stage of training. They confirmed that at the early stage of practicing dancesport, the greatest impact on the special fitness is exerted by motor coordination, balance, flexibility, speed and strength skills, the body height and mass, the pelvis, torso, and chest indicators, and the BMI.

Cerrah et al. [15] emphasized the importance of interrelation studies between kinetic and biomechanical parameters of hits in football players. The obtained information allows improving players' technical training.

Thus, the available results confirm the relevance of the research aimed at studying interrelations between various indicators of athletes in performing functional tests. In our opinion, the analysis of martial arts athletes' state could not be limited by the analysis of indicators and their dynamics under the influence of various factors. This analysis should be completed by a study of correlations between the indicators. One of the most effective methods in this context is correlation analysis. Its effectiveness was confirmed in a comparative evaluation of levels of the state of different skills in arm wrestling athletes [16] and synchronized swimming athletes [17]. The correlation matrices illustrate changes in the athletes' functional state under the influence of various factors. It allows estimating the athletes' adaptation features, gives valuable information for their state monitoring and success prognosis.

The purpose of the research is a comparative analysis of interrelations of psychophysiological and physiological indicators of martial art athletes while performing functional tests.

MATERIAL AND METHOD

PARTICIPANTS

63 martial art athletes were divided into groups: the 1st group – 34 athletes of "striking" martial arts (taekwondo ITF, WTF, karate, hand-to-hand fight), age (17.58 ±0.08) years; the 2nd group – 18 Greco-Roman and freestyle wrestlers, age (18.94 ±0.33) years; the 3rd group – 11 judo and sambo athletes, age (18.73 ±0.23) years. The participants' level of sport skills varied from the 1st category to the Master of Sports and did not differ in groups. The basic criteria for including athletes in the study sample were age (17–19-year-old) and sufficient level of sport mastery.

EXPERIMENTAL PROTOCOL

The study was conducted with a use of special computer software for devices with the iOS operating system. As a device, a tablet of Apple company - iPad, fourth-generation, with 9.7-inch screen was used. For the heart rate (HR) registration, BT4.0&ANT+ Heart Rate Monitor (Magene, China) was used.

Participants performed a trial: the response rate of the selection. The attempt was to react to one given signal from the five proposed ones. The duration of the attempt varied randomly between 3 and 10 seconds. The participant performed 3 series of 10 attempts. The average duration of the test was (168.02 ±1.27) seconds. The registration of the reaction time was synchronized with the recording of the heart rate.

Participants were not notified about the results in the process of the test implementation. The tests were not repeated. This allowed avoiding acquisition of experience of implementation of the test by the participants. All subjects gave their informed written consent to participate in the experiment. The study was approved by the Bioethics Commission of Kharkov State Academy of Physical Culture, minutes No. 10 of December 13, 2018. As research related to human use, this study has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the authors' institutional review board.

STATISTICAL ANALYSIS

Statistical analysis of results was performed with a use of licensed MS Excel software (2010). The minimum and maximum values of choice reaction time and the HR, the average values of these indicators for every test and for every period independently were fixed.

Statistical processing confirmed the absence of results that far differed from the average values. This made it possible to consider the results as valid, and the sample size was sufficient to substantiate the conclusions.

Correlation matrixes were created based on the calculated Pearson's correlation coefficients. The analysis of matrixes was performed by means of the indicators given in the work of Zosimov [18]. Their comparative analysis was conducted with the help of such indicators as the specific weight of significant and confident correlations, coefficient of synchronizing labilization (CSL) and the mean correlation coefficient (MCC). The two latter indicators were calculated by the formulas:

$$CSL = [n/N(N-1)] \times 100\% \quad (1),$$

where n was the sum of all significant correlations, created by every parameter of correlation structure; N – the total quantity of the structure's parameters.

$$MCC = \Sigma r_j/n \quad (2),$$

where Σr_j was the sum of all confident correlation coefficients in the structure; n was the number of significant correlations.
To determine the component of the correlation structure which makes the highest contribution in the creation of correlations, we found the indicator of system formation (IS) by the following formula:

$$IS= \Sigma r_j \times n \quad (3),$$

where Σr_j – was the sum of all significant correlation coefficients in the structure created by this indicator; n – the number of significant correlations of this indicator of the structure.

RESULTS

The comparative analysis of age confirmed that athletes of the 2nd group were significantly senior to participants from the 1st group ($t = 4.01$, $p < 0.05$). Athletes from the 3rd group were senior to athletes from the 1st group ($t = 4.72$, $p < 0.05$). The average age of wrestlers and judo athletes had no significant differences ($t = 0.52$, $p > 0.05$).

Table 1. Indicators of correlation matrixes of martial arts athletes

Groups	Specific weight of significant correlations (%)	Specific weight of confident correlations (%)	Coefficient of synchronizing labilization	Mean correlation coefficient
1	39.06 ±10.91[1]	35.94 ±10.73[1]	12.43	0.65
2	82.03 ±8.58	75.00 ±9.68	24.12	0.59
3	36.72 ±10.78[1]	21.88 ±9.24[1]	11.58	0.50

Notes. 1 – differences with the 2nd group are confident ($p < 0.05$)

In the 1st and the 3rd groups, the specific weight of confident and significant correlations was not significantly differed. The excess of the specific weight of significant communications was determined in the 2nd group compared with the 1st ($t = 3.1$, $p < 0.05$) and with the 3rd group ($t = 3.29$, $p < 0.05$). In comparison of the specific weight of confident communications, the tendency has remained ($t = 2.7$, $p < 0.05$) and ($t = 3.97$, $p < 0.05$), respectively.

The CSL indicators in the 1st and the 3rd groups are low and differ by 6.8%. In the 2nd group, this criterion is almost twice as high as in the other groups.

The MCC indicator in all groups belonged to an average interval and had no essential differences. IS were calculated for the analysis of a possible contribution of the studied indicators to the athletes' state. The received values are presented in Fig. 1. The IS values in the 2nd group were significantly higher than in the other groups, practically regarding all indicators.

The age contribution of the 2nd group athletes in the system formation was greater than in other martial arts athletes. The indicator value was 49.36 c.u. in this group. In the 1st group, this indicator was 15.12, in the 3rd one – 1.62 c.u. The low contribution to the system is determined for the percentage of the correct answers. It is 5.55, 9,24 and 5.72 c.u. in the groups, respectively. The highest parameter is the value IS of the maximum of choice reaction time. It is 155.16 c.u. in the 2nd group. In the 1st group, this indicator was 15.08, and in the 3rd group – 25.63.

Change of the contribution time of the test periods had a various focus in groups. The athletes of striking martial arts had an almost linear tendency. The value of the contribution increased in the dynamics of the test. Indicators were 18.74, 24.07 and 30.26, respectively. In the 2nd group in the second period of the test, the value of contribution decreased and increased again in the 3rd period: 124.81, 98.54 and 131.93, respectively. In sambo and judo athletes, the stability of contribution remained within two periods with the essential increase in the third period of the test performance: 22.19, 21.07 and 70.32, respectively.

The contribution of HR parameters to the system in athletes of different groups was different. In the 1st group, these parameters were stable in the 1st and the 2nd periods of the test and increased in the 3rd period. In the 2nd group the highest values of contribution were established. They practically did not change in the course of test performance. In athletes of the 3rd group the size of the contribution decreased in the 2nd period in comparison with the 1st period and increased in the 3rd period practically to the initial level.

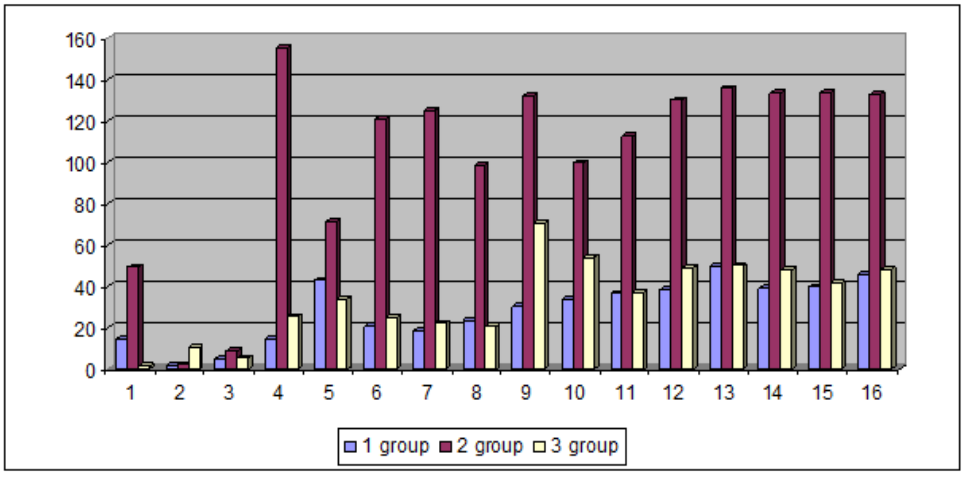

Fig. 1. The indicators of system formation in the studied groups of martial arts athletes (c.u.)

Notes. 1 – age, 2 – choice reaction time, 3 – percentage of the correct reactions, 4 – the maximum choice reaction time, 5 – the minimum choice reaction time, 6 – the average time of the test, 7 – time of the 1st period of the test, 8 – time of the 2nd period of the test, 9 – time of the 3rd period of the test, 10 – initial HR, 11 – the maximum HR, 12 – the minimum HR, 13 – average HR, 14 – HR of the 1st period of the test, 15 – HR of the 2nd periods of the test, 16 – HR of the 3rd periods of the test

DISCUSSION

The organization of the monitoring of athletes' state is the important direction of sports science. The key issues of this task solution include collecting the necessary information and analyzing the statistical data adequately. A lot of statistical methods are applied nowadays in the monitoring process. They are united by the purpose devoted to the implementation of the prediction of athletes' success.

The application of the consecutive analysis according to Wald allowed developing the complex techniques of successful prediction in arm-wrestling [19] and kickboxing [20]. The success model of Australian football players is created on the basis of regression analysis of physiological and anthropometrical parameters [21].

The correlation analysis is rather widely applied for forecasting. The success predictors are confident and significant correlations in structure. Logan et al. [22] estimated motor skills of school pupils and the dependence between them. The existence of a large amount of Pearson correlations between the ability to control motor actions, dexterity, and balance of motor actions is confirmed. It is considered as the mutual addition of physical qualities.

Jaworski et al. [23] estimated the level and rate of change in reaction time from 7 to 20 years. A rather large sample was used – 550 participants. The use of polynomial regression analysis allowed them to establish that the best results are observed at the age of 16-17 years. This is close to the age group of participants in our study.

Jarraya et al. [24] studied interrelations of physical, technical and tactical training of handball players. Nearly a half of interrelations were statistically significant. These correlations allow estimating athletes' training efficiency.

Korobeynikov et al. [25] confirmed the importance of psychophysiological qualities as success indicators in judo. The existence of interrelations of these qualities and motivation levels was determined. Practically similar results were received by Ivaskiene et al. [26], who defined the existence of interrelations between self-assessment and aggression in judo athletes. The value of interrelations increased with a growth in skills.

Sazonov [27] proved the existence of correlations between special efficiency and athletes' psychophysiological state. Zhang et al. [28] estimated general and special efficiency of Muay Thai athletes. They determined the existence of interrelations between the studied indicators. The validity and informational content of the applied tests was confirmed.

Thus, the available scientific literature confirms the validity of the study of the correlation between the indicators of the functional state of athletes. The change in the strength and directionality of correlations can be evaluated as a change in adaptation capabilities. Podrigalo et al. [29] applied a similar design for assessment of goniometric features of martial arts athletes. The specificity of the influence of preparation on the amplitude of motor actions of extremity joints was proved.

The selection of choice reaction time as a functional test is also reasonable for martial arts. This test illustrates the reaction of athletes to differentiation stimuli. The athlete is constantly in a state of decision waiting. He is put in a situation of a choice of various strategies and applied techniques. The situation demands the fastest reaction to the opponent's actions, and a mistake can lead to defeat.

This test allows finding athletes with a steady nervous system, capable of maximum concentration.

A comparison of psychophysiological features of martial arts athletes confirmed the high informational content of this test [8]. Its application is offered as a screening test in the selection of prospective athletes in "striking" martial arts – karate, taekwondo, hand-to-hand fighting [30]. Balkó et al. [31] received similar results. The choice reaction time was applied for fencers' fitness assessment. The positive dynamics of results are shown in the course of training. The conclusion is drawn concerning the prospects of the test to increase efficiency in martial arts training.

The age differences reflect the various level of athletes' sports experience. It is considered as a differentiating ability to form skill. In the absence of differences in the level of sports skill, an increase in age contribution into the system in wrestlers means adaptation of tension in performing a functional test. A comparative analysis of correlation matrixes allows estimating the athletes' functional state and determining the most important indicators for success. Rovnaya et al. [17] applied this method in synchronized swimming female athletes. The analysis of matrixes confirmed the expansion of adaptation potential functionality.

Characteristics of correlation structures (see Table 1) reflect the existence of essential differences in the specific weight of significant and confident correlations in wrestlers and other martial arts athletes. An increase in the number of interrelations reflects athletes' tension functionality in the implementation of psychophysiological tests. An increase in CSL in the 2nd group in comparison with the 1st and the 3rd groups also illustrates the tension of adaptable mechanisms in test performance. The proximity of MCC values in groups allows considering a low and acceptable tension level of adaptation opportunities for performing the functional tests.

The IS indicator allows assessing the state of correlation structures by the contribution of individual indicators to the system. Its value depends on the number of correlations and the strength of each bond formed by the indicator. This criterion is expressed in arbitrary units. This allows analyzing and comparing the contribution of indicators that belong to different groups (physiological, psycho-physiological, passport). This convenience is illustrated by the data in Fig. 1.

An increase in IS indicators in the 2nd group has to be estimated as the evidence of large tension of adaptation opportunities of Greco-Roman and freestyle wrestlers in performing the test in comparison with other martial arts athletes. This assumption is supported by the available literature data. The comparative analysis of test performance on choice reaction confirmed its specificity to striking martial arts (karate, taekwondo) [30]. The test models a decision-making waiting mode. The reaction speed and correct answer are important. In wrestling, these qualities are not as important as in striking martial arts. That is, wrestlers are in an unusual state in the process of test execution. It causes additional adaptation tension. The maximum values of choice reaction time in wrestlers are the worst of the other participants. Probably, the system tries to increase the stability by the formation of additional interrelations.

An increase in IS age confirms the previous assumptions concerning the reflection of athletes' various experience.

The low contribution of the percentage of correct answers to the system is caused by stability and a rather high level of this indicator in all participants. The carried-out functional test did not cause the development of exhaustion and was adequate. It allowed participants to show a high level of working capacity.

An increase in contribution to the system of various HR parameters reflects the arising adaptation tension. It is well-known that HR is an integrated indicator of a person's adaptation opportunities. The dynamics of this parameter are applied as a tolerance indicator of physical activities. The importance of assessment of adaptive shifts of athletes in the load period is emphasized by Roda et al. [32].

The obtained results allow recommending the applied set of tests and correlation analysis to evaluate the martial arts athletes' state. The dynamics of correlation structures' indicators allow predicting the development of the prenosological health state due to the irrational organization of training.

CONCLUSIONS

The performed analysis of correlation matrixes allows differentiating a functional state of martial arts athletes. The wrestlers are characterized by a higher degree of adaptation tension opportunities in comparison with other athletes. This assumption is supported by the increase in the specific weight of significant and reliable correlations in this group: the increase in the CSL indicator twice as high as the results of other groups. It is caused by the specific requirements of this sports and their impact on adaptation opportunities. Perhaps the higher degree of adaptation in wrestlers links not only with the specific requirements of the sport but also with peculiarities of motor skills and the structure of technical movements.

Martial arts athletes are characterized by substantially large values of most IS indicators. This should also be evaluated as evidence of the adaptive capacity stress. The small amount of load in performing the functional test allows considering the stress state as a result of training.

Defining the choice reaction time with a parallel control of HR brings informative research for monitoring athletes' functional state. The low value of loads in the process of test performance allows estimating the influence of martial arts on athletes' adaptation opportunities. Simplicity, availability and high informational content of the applied tests allows recommending them for wide application in the control of martial arts athletes' state.

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