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Comparative analysis of psychophysiological features of taekwondo athletes of different age groups

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Abstract

Background and Study Aim The importance of psychophysiological features in optimizing the functional state of athletes is beyond doubt. The aim of this study was a comparative analysis of the psychophysiological features of taekwondo athletes of different age groups.

Material and Methods The study involved 42 taekwondo athletes, skill level 2 Gup – 1 Dan. The participants were divided into groups of 14 people. Group 1 – (7.50±0.14) years, Group 2 – (10.07±0.22) years, Group 3 – (13.36±0.27) years. A special computer program for devices with the iOS operating system was used. The Apple iPad, 4th generation with a screen diagonal of 9.7 inches was used. The following tests were used: reaction choice (RC), reaction to a moving object (RMO) and size test (ST). The results of the groups were compared using the nonparametric Rosenbaum test (Q), and the Pearson correlation coefficient (r) was determined.

Results RMO test results in group 2 were significantly better than those in group 1 ($Q=12$, $p<0.01$). A similar correlation was determined for RC ($Q=14$, $p<0.01$) and ST ($Q=15$, $p<0.01$). When analyzing the frequency of incorrect reactions in RMO, it was found that athletes in the 1st group lagged behind more often ($Q=6$, $p<0.05$). A comparison of groups 2 and 3 confirmed that senior athletes had better results in RC ($Q=11$, $p<0.01$). For all tests used, the best results of group 3 compared with group 1 was determined: for RMO $Q=16$, ($p<0.01$), for RC $Q=22$, ($p<0.01$), for ST $Q=20$, ($p<0.01$). Senior athletes often had an anticipatory reaction in RMO, ($Q=7$, $p<0.05$). Significant correlations ($p<0.05$) were determined in group 1 between age and frequencies of anticipatory ($r=-0.57$) and lagging reactions ($r=0.57$), RMO and RC ($r=0.63$), RC and frequencies of anticipatory reactions ($r=0.57$) and lagging reactions ($r=-0.57$). In group 3, significant correlations were determined between age and RC ($r=-0.59$), RMO and RC ($r=0.76$), age and ST ($r=-0.53$), RMO and ST ($r=0.65$), RC and ST ($r=0.79$).

Conclusions A change in the speed of reaction to various stimuli of taekwondo athletes of different ages has been confirmed. An increase in age and training experience improves the reaction rate. This dependence is most pronounced when comparing junior and senior athletes. The determined correlations between all tests used also reflect the improvement in the psychophysiological state of the athletes with increasing age. The tests used are characterized by accessibility, specificity, informativeness and financial feasibility. The results obtained allow for recommending their use in monitoring the state of martial arts athletes.

Keywords: combat sports, taekwondo, sensorimotor reactions, age groups, correlation analysis.

Introduction

The importance of psychophysiological features in optimizing the functional state of athletes is beyond doubt. The study by Klymovych et al. [1] describes the developed experimental technology for acquiring professional-applied motor skills. The approbation of the program confirmed a significant improvement in such psychophysiological qualities as strength, mobility, and balance of the nervous system.

The impact of certain sports on cognitive sensorimotor abilities and basic brain functions was assessed in the study [2]. The authors analyzed the features of the psychophysiological state of athletes in martial arts, rock climbing, and racket. People who did not engage in sports were the control group. It is shown that martial arts athletes had the best indicators of reaction time. The test performance was the most stable with the lowest number of errors. These athletes show the best motor readiness. The highest activity associated with postperceptual processing of attention was also determined in martial arts athletes. It is concluded that martial arts can provide the best functional level for athletes.

The speed of reaction to various stimuli occupies a leading place among the success factors in martial arts [2, 3]. It largely determines effective defensive

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and attacking actions. We proposed to use this psychophysiological indicator for the classification of paraathletes [3].

It has been confirmed that the reaction time, strength and accuracy of the strike are among the most important factors in the state of martial arts athletes [2, 3, 4]. It is proposed to use them for monitoring the functional state of athletes. Controlling these factors is especially important in terms of preparing for competitions and losing weight [4].

Speed is one of the decisive factors for victory in martial arts. In the study by Yao [5], the influence of various training methods on the reaction rate of fencers was studied. The results confirmed the improvement of this indicator under the influence of the methods used. The selective response test was more informative than the simple response test. A conclusion is reached about the need for specific training to improve the reaction rate.

The effectiveness of attacking movements in fencing was studied in the study of Borysiuk et al. [6]. A set of special tests was used to analyze the condition of elite fencers. The presence of a strong correlation dependence of the reaction time and movement times with the activation time of the limb muscles was determined.

The systematic review synthesized the current evidence on the feasibility of volitional reaction time (RT) tests to evaluate the information processing abilities of athletes [7]. The most important downside of most implemented RT tests is their nonspecific nature (i.e., stimulus and response did not resemble the sports actions). Sports scientists should focus on developing RT tests specific for each sport and refine the testing procedures to obtain accurate, reproducible, and sensitive measurements of RT.

The reliability and sensitivity of the reaction rate test in quasi-realistic football situations were studied in the study of Tomic et al. [8]. The specificity of the sport led to the study of the reaction time of the legs. The states of the athletes and the control groups were compared. The results of the athletes were significantly better. The high reliability of the test used was confirmed.

Thus, the available results confirm the relevance of the study of the psychophysiological characteristics of athletes for monitoring their state, selection, and prediction of the growth of sportsmanship. It is of interest to evaluate the features of the speed of reaction to various stimuli of martial arts athletes of different age groups. Based on the foregoing, the aim of this study was a comparative analysis of the psychophysiological features of taekwondo athletes of different ages.

Materials and Methods

Participants

The study involved 42 taekwondo athletes, representatives of the Vulkan Sports and Youth Sports School in Cherkasy, Ukraine, skill level 2 Gup – 1 Dan. The participants were divided into groups of 14 people depending on age: group 1 – average age (7.50±0.14) years, group 2 – (10.07±0.22) years, group 3 – (13.36±0.27) years.

Ethics Statement and Participants. This study was approved by the Bioethics Committee for Clinical Research and conducted according with the Declaration of Helsinki. All participants and their parents gave their written consent to research and were informed about the purpose and test procedures and about the possibility of withdrawal of consent at any time for any reason.

Study design

The design of the study involved a complex of psychophysiological tests to assess the body's sensory systems. A special computer program for devices with the iOS operating system was used. The Apple iPad, 4th generation with a screen diagonal of 9.7 inches was used. The battery of tests included 3 functional tests.

Reaction choice (RC) or a complex visual-motor reaction was assessed by the reaction time to a stimulus with certain qualitative characteristics. In our case, stimuli of the same shape and size were used (5 circles). They appeared on the screen in a certain place simultaneously, but in an arbitrary sequence according to the manifestation of a signal feature (color) and did not move. The person being studied had to choose one circle of a given color as quickly as possible.

The reaction to a moving object (RMO) is to stop the object in a given place at a given speed of the object. The accuracy of performance was estimated by the time of deviation from the specified one. Stopping a moving object before a certain limit was counted as an error.

Size test (ST): it is necessary to fix the moment when the size of the gradually increasing circle matches the size of the template. The test can be performed in two versions – with the use of visual control and without it. The time when a circle changes at a constant speed corresponding to the dimensions of the template (standard) is equal.

Statistical analysis

Statistical analysis of the obtained data was carried out using licensed MS Excel. Descriptive statistics were determined the following: arithmetic mean (X), standard deviation (SD), and error of the mean (m). Considering the small size of the groups, the significance of differences was assessed using a non-parametric indicator – the Rosenbaum criterion

Table 1. Results of psychophysiological tests of taekwondo athletes of different age groups (X±SD)

Indicator	1 group (n=14)	2 group (n=14)	3 group (n=14)
The reaction to a moving object, ms	38.45±14.87	24.48±7.85	20.36±4.50
Anticipatory reaction, %	50.07±10.79	45.82±10.73	42.77±14.77
Lagged behind reaction, %	49.93±10.79	54.18±10.73	57.23±14.77
Reaction choice, ms	877.77±92.57	748.33±83.90	620.09±78.23
Size test, ms	1.26±0.13	1.06±0.10	0.95±0.10

(Q), the differences were considered significant at ($p<0.05$). The Pearson correlation coefficient (r) between the results of each group was determined. The correlation was considered significant at r not less than 0.5 ($p<0.05$).

Results

The obtained results are shown in Table 1.

The use of the nonparametric Rosenbaum test confirmed the presence of significant differences between the groups. RMO results in group 2 were significantly better than those in group 1 ($Q=12$, $p<0.01$). A similar correlation was determined for RC ($Q=14$, $p<0.01$) and ST ($Q=15$, $p<0.01$). When analyzing the frequency of incorrect reactions in RMO, it was found that athletes in the 1st group lagged behind more often ($Q=6$, $p<0.05$).

A comparison of groups 2 and 3 confirmed only one significant difference. Senior athletes had the best results in RC ($Q=11$, $p<0.01$).

For all tests used, the best results of group 3 were determined compared with group 1. The Rosenbaum criterion was for RMO $Q=16$, ($p<0.01$), for RC $Q=22$, ($p<0.01$), and for ST $Q=20$, ($p< 0.01$). Senior athletes often had an anticipatory reaction in RMO, ($Q=7$, $p<0.05$).

Interesting data were obtained from the analysis of correlations between test results. Significant correlations ($p<0.05$) were determined in group 1 between age and frequencies of anticipatory ($r=-0.57$) and lagging reactions ($r=0.57$), RMO and RC ($r=0.63$), RC and frequencies of anticipatory reactions ($r=0.57$) and lagging reactions ($r=-0.57$).

There was no significant dependence in group 2.

5 significant correlations were determined in group 3 and group 1. These are the correlations between age and RC ($r=-0.59$), RMO and RC ($r=0.76$), age and ST ($r=-0.53$), RMO and ST ($r=0.65$), RC and ST ($r=0.79$).

Discussion

The effectiveness of the analysis of the athletes' state is directly dependent on the chosen assessment method. The selection should be performed by considering the specifics of the sport, the validity, and representativeness of the methods, and the information content of individual criteria. This approach was tested in the study of Rovnaya et al. [9]. Its effectiveness has been confirmed in the analysis of the state of artistic swimming athletes of different skill levels.

Indexes are a simple, visual, and informative tool for assessing the condition of athletes. This method was used for the comparative analysis of athletes of various types of martial arts [10]. The battery of indices included indicators reflecting the specifics of the impact of sports on the body of athletes. The possibility of using these indicators to predict the success and growth of sportsmanship has been confirmed.

The selection and prediction systems in sports should include tests that evaluate attention, reaction speed, and concentration [11]. The reliability of the methods used and the relevance of the applied parameters were confirmed. Another way to improve the efficiency of analysis is to use the principle of complexity. Study by Logan et al. [12] and by Butenko et al. [13] is based on the application of such an approach. Various tests were used to assess the level of motor skills development. The use of complementary tests allows for a comprehensive assessment.

We used a battery of tests on the Apple iPad, 4th generation. This device allows testing directly in training. This significantly increases the information content of the results obtained and allows for effective monitoring of the athletes' state.

The use of multimedia technologies in sports and physical education is a promising direction at present. The use of mobile applications, interactive technologies, and computer tests can significantly increase the effectiveness of training and helps increase motivation.

The use of computer tests is a promising and convenient method for analyzing the state of athletes. The computer training program Rugby-5 is used for this purpose in the physical culture classes [14]. It is proved that this development contributed to an increase in the level of the functional state of the body of pupils.

The distribution of gadgets increases the efficiency and applicability of mobile applications. The effectiveness of the TReaction mobile application was evaluated in the study by Coswig et

al. [15]. This is a mobile app developed to determine strike response time at low cost and with easy application in combat sports. The findings suggest that the TReaction app is a valid tool for evaluating the response time in combat sports athletes.

The participation of athletes of different ages in the study makes it possible to assess the dynamics of their readiness, which depends on the training experience. This makes it possible to evaluate the influence of physiological features of development on the functional state of athletes. The study of such influence is important for predicting success.

The analysis of psychophysiological features is widely used when comparing the state of athletes at different levels of training. These qualities make it possible to objectively assess the condition of athletes, predict the growth of sportsmanship and success. Differences between taekwondo athletes with different levels of competition were analyzed in the study by De la Fuente et al. [16]. The winner athletes have the best reaction times. It is concluded that it is necessary to use such an analysis for selection.

Similar data were obtained in the study by Sarmet Moreira et al. [17]. The authors evaluated the performance parameters of the dollyo chagui in elite taekwondo athletes and subelite taekwondo athletes. The reaction time, co-contraction and speed of kicks are discriminant factors concerning the competitive level.

Our results confirm the data presented in the study by Chen et al. [18]. The authors compared the perceptual-motor abilities of karate and taekwondo athletes and those who did not practice martial arts. The speed of perception on the Covert Orienting of Visual Attention (COVAT) task was the best among taekwondo athletes. There were no differences between the groups in terms of the number of test performance errors. The results show that athletes involved in different types of martial arts demonstrate different profiles of perceptual-motor performance.

The results of the tests carried out confirm the improvement in results in direct proportion to the age of the participants. This can be explained by the increase in the experience with sports activities. It is known that the reaction speed is not trained as strength or endurance. However, certain improvements in this quality can be achieved in the process of specific sports. This is confirmed by the results of previous studies [3, 5, 7]. Additionally, the used tests are specific to martial arts. The possibility of using these tests to predict success in martial arts has been confirmed by Romanenko et al. [19].

The RMO test should be regarded as particularly important for the state assessment of martial arts athletes. The task is to stop a moving object in a given place, simulating a typical duel situation. The opponent makes an attack, it is necessary to perform a defensive action. The conditions for performing the test make it possible to evaluate not only the speed, but the ability of the athlete to evaluate his actions. Significantly better results of senior athletes demonstrate a high level of sportsmanship and a better level of tactical training.

An analysis of the frequency of incorrect reactions in the RMO test confirms the assumptions made. The junior participants most often give a lagged reaction, and the senior, in contrast, anticipatory one. In our opinion, this reflects an increased level of readiness in senior athletes. They have a better ability to concentrate and mobilize. This coincides with the available results of the analysis of the psychophysiological characteristics of martial arts athletes [18].

Similar results are given in the study by Gierczuk and Ljach [20]. The authors used computer tests to assess the development of motor skills in wrestlers. In Greco-Roman wrestling athletes, the information content of tests that study reaction speed, frequency of movements, spatial orientation, and adaptation to movements has been proven.

The reaction time of martial arts athletes to static and moving objects was studied in the study by Liu et al. [21]. Martial arts athletes had better reaction times to a moving object and made fewer mistakes compared with controls. The importance of attention and quick reaction in dynamic situations to achieve success in a duel has been confirmed. Our results are close to those obtained in this study.

An interesting fact is that significant differences were obtained in only RC test in all groups. It is a complex visual-motor reaction. The participant must perform several actions: assess the situation, select an object and take action. The performance of this test is quite close to the tasks of a combatant during a duel. More experienced athletes perform this task much better. The improvement in this test with increasing age reflects dependence on training experience.

The determination of the simple reaction time and the reaction of choice were used in the study by Balkó et al. [22]. The authors studied the effect of special 9-week training on the psychophysiological performance of fencers. The information value of the reaction of choice test was confirmed. It is concluded that it is necessary to use specific tests in the training of martial arts athletes, motorsport and ball games.

The RC test illustrates the response to a differentiating stimulus. The performance of this test puts the subject in a state of waiting for a decision. It is not only the speed of reaction that matters, but also the correct performance. This test should be assessed as important in the prediction and selection in martial arts, as it allows you to select athletes not only with a quick reaction, but also with a stable nervous system.

The ST test reflects the ability of athletes to spatial perception. This test allows you to control your own space, distance and movement prediction. All these are important factors for winning in martial arts.

It is necessary to consider the physiological characteristics of the bodies of the participants. Athletes in the third group are in puberty. This period refers to the critical stages in the development of the child. It is characterized by a rapid change in the state of organs and systems, the transition of regulation to a qualitatively new level. This is reflected in the state of psychophysiological characteristics.

Our results confirm this observation by Latyshev et al. [23]. The authors studied the influence of age on success in martial arts. It was confirmed that the greatest influence of the effect of relative age in athletes was revealed at the cadet level.

The analysis of correlation dependencies is widely used in sports science [4, 8]. A comparison of the number and strength of connections allows us to evaluate the dynamics of the functional system, which is formed in the process of sports training.

Correlations between the technical and tactical indicators of taekwondo athletes were studied in the article by Wąsik et al. [24]. There was a moderate correlation between the maximum speeds of both hands in the measured strokes. The highest correlation was noted between the difference in the values of the maximum speeds of both hands and the value of the maximum speed of the allotted (left) hand. Depending on the devices and methods of movement fixation, angular and linear speeds can serve as the main factors in the quality of strikes.

The determined dependencies in group 1 should be assessed as an illustration of the incompletely formed functional status of athletes. The correlations between age and the adverse reactions rate in the RMO test indicate that athletes have not yet reached the optimal level of training. This assumption is also supported by the dependence between the frequency of error tests and the results of the RC test. The correlation between RMO and RC test results should be assessed as evidence of the impact of the sport on the body of the athlete. Both of these tests are specific to martial arts. They allow us to predict the success and growth of sportsmanship of athletes.

An analysis of the dependence between performance indicators and the reaction rate of athletes in sports games was carried out in the study by Šimonek et al. [25]. Low correlation coefficients between these factors have been identified in football. Average values were observed in basketball and handball, whereas high values were observed in volleyball. A negative correlation was observed between triple jump performance and all other tests in all sports games.

The dependences between the level of physical fitness of judo athletes and the peculiarities of training preparation were studied in the study by Rovniy et al. [26]. A linear multiple regression coefficient was used. The level of each factor in the development of physical qualities and indicators of competitive activity of athletes was determined. The calculation of the inverse stepwise regression coefficient allows to determine the most important factors for increasing productivity.

The determined correlations in group 3 confirm the assumptions made earlier. A direct correlation between the tests used reflects the improvement in the psychophysiological state of the athletes. The growth of sportsmanship and an increase in the training experience improve the response to various stimuli. This assumption is also supported by the inverse correlation between age and test scores. The increase in the strength of the connection between RMO and RC compared to group 1 should be evaluated as an illustration of the increase in the level of fitness of athletes.

Conclusions

A change in the speed of reaction to various stimuli of taekwondo athletes of different ages has been confirmed. An increase in age and sports training led to an improvement in the reaction rate. This dependence is most express in comparing junior and senior athletes. The determined correlations between the tests used also reflect the improvement in the psychophysiological state of the athletes as the age increases. The tests used are characterized by accessibility, specificity, informativeness and financial feasibility. The results obtained allow us to recommend their use in monitoring the state of martial arts athletes.

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