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Methodology for assessing the reaction of combat athletes to a moving object

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Author's contribution: A – research methodology development; B – data collection; C – statistical analysis; D – manuscript preparation; E – Funds Collection

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Abstract

The purpose of the study is to develop and test the method of evaluating the reaction to a moving object of combat athletes using computer technologies.

Material and methods. Representatives of Taekwon-Do ITF with qualifications 4 Gup – 1 Dan (first stage of the study: n=32, 15.9±0.56 years) and representatives of Cossack Fight of medium qualification (second stage of the study: n=20, 18.0±0.17 years). At the first stage of the study was developed the computer program "Reaction RMO Pro" to assess the reaction to a moving object. The athlete performer is asked to complete a test exercise over three stages, where the complexity of the tasks gradually increases. At the second stage of the study the reliability, validity and reliability of the proposed methodology were determined. To activate the sensory and motor mechanisms of movement control, before testing, athletes were asked to perform simple exercises with tennis balls. The second measurement was taken three weeks later.

Results. For preliminary testing, software modeling of various situations of test tasks was carried out. For a detailed characterization of the obtained data, a cluster analysis was carried out and three groups of athletes can be distinguished/ The first group (G1) included athletes (14.6±0.28 years), who had the highest reaction time and predominantly premature reactions. The second group (G2) included athletes (15.6±0.90 years) with an average reaction time and predominantly delayed reactions (Delayed: 49.03%). The third group (G3) included athletes (17.8±1.34 years) who had the lowest reaction time and predominantly premature reactions (Premature: 52.45%). Analysis of changes in reaction time at individual stages of the test showed that the best reaction time was noted at the second stage of the test, where the speed of the visual stimulus increases. The worst time was recorded in the first stage of the test. At the third stage, where interfering signals act, the reaction time is less than at the first stage, but longer than at the second. Analysis of the results of determining the direction of reactions to a moving object indicates that premature reactions predominate, both in the first measurement (52.75%) and in the second (51.92%).

Conclusions. The highly qualified athletes have a more advanced mechanism for perceiving information and corresponding motor reactions. the method for determining reaction time to a moving object using the computer program "Reaction RMO Pro" is reliable, valid and reliable, as evidenced by the results of correlation analysis (r = 0.78), the absence of differences between the first and second measurements, both at individual stages of the test (p>0.05), and relative to the integral assessment of reaction time to a moving object (t=0.35, p>0.05), preservation of the dynamics of changes in reaction time at individual stages of the test and the predominant direction of premature reactions (first measurement 52.75% , second 51.92%).

Key words: sensorimotor reactions, martial arts, highly qualified athletes, computer technologies.

Методика оцінки реакції спортсменів-єдиноборців на рухомий об›єкт. Вячеслав Романенко, Світлана Пятисоцька, Андрій Литвиненко, Максим Байбіков, Наталя Бойченко, Віктор Пономарьов.

Мета дослідження – розробити та апробувати методику оцінки реакції на рухомий об'єкт спортсменів-єдиноборців за допомогою комп'ютерних технологій.

Матеріал і методи. Представники таеквон-до ІТФ з кваліфікацією 4 Gup – 1 Dan (перший етап дослідження: n=32, 15,9±0,56 року) та представники Козацького бою середньої кваліфікації (другий етап дослідження: n=20, 18,0± 0,17 року). На першому етапі дослідження була розроблена комп'ютерна програма «Reaction RMO Pro» для оцінки реакції на рухомий об'єкт. Спортсмену-виконавцю пропонується виконати тестову вправу в три етапи, де складність завдань поступово зростає. На другому етапі дослідження визначено достовірність, валідність та надійність запропонованої методики. Для активації сенсорних і моторних механізмів управління рухами перед тестуванням спортсменам пропонувалося виконати нескладні вправи з тенісними м›ячами. Друге вимірювання було зроблено через три тижні.

Результати. Для попереднього тестування було здійснено програмне моделювання різних ситуацій тестових завдань. Для детальної характеристики отриманих даних було проведено кластерний аналіз і виділено три групи спортсменів. До першої групи (G1) увійшли спортсмени (14,6±0,28 років), які мали найвищий час реакції та переважно передчасні реакції. До другої групи (G2) увійшли спортсмени (15,6±0,90 років) із середнім часом реакції та переважно уповільненими реакціями (Delayed: 49,03%). До третьої групи (G3) увійшли спортсмени (17,8±1,34 року), які мали найнижчий час реакції та переважно передчасні реакції (Premature: 52,45%). Аналіз зміни часу реакції на окремих етапах тесту показав, що найкращий час реакції відзначено на другому етапі тесту, де швидкість візуального стимулу зростає. Найгірший час було зафіксовано на першому етапі випробувань. На третій стадії, де діють заважаючі сигнали, час реакції менше, ніж на першій, але більше, ніж на другій. Аналіз результатів визначення спрямованості реакцій на рухомий об'єкт

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свідчить про те, що передчасні реакції переважають як у першому вимірюванні (52,75%), так і в другому (51,92%).

Висновки. Спортсмени високої кваліфікації мають більш досконалий механізм сприйняття інформації та відповідних рухових реакцій. Методика визначення часу реакції на рухомий об'єкт за допомогою комп'ютерної програми "Reaction RMO Pro" є надійною, валідною та достовірною, про що свідчать результати кореляційного аналізу (r=0.78), відсутність відмінностей між першим та другим вимірюваннями, як на окремих етапах тесту (p>0.05), так і щодо інтегральної оцінки часу реакції на об'єкт, що рухається (t=0.35, p>0.05), збереження динаміки змін часу реакції на окремих етапах тесту та переважною спрямованістю передчасних реакцій (перше вимірювання 52.75%, друге 51.92%).

Ключові слова: сенсомоторні реакції, бойові мистецтва, спортсмени високої кваліфікації, комп'ютерні технології.

Introduction

One of the methods for increasing the reliability and efficiency of professional and sports activities is monitoring and predicting the functional state of the human central nervous system [12, 30, 16].

A feature of sports activities in martial arts is the performance of various technical and tactical actions against the background of high mental tension, where the success of competitive struggle depends not only on the athlete himself, but also on the actions of the opponent [10, 1, 19].

Modern practical experience confirms that the psychophysiological characteristics of athletes in martial arts influence their success in competitive activities [6, 14, 31]. The definition and analysis of sensorimotor reactions in martial arts are of great theoretical and practical importance both from the point of view of characterizing the functional state of athletes and from the point of view of improving existing and developing new training methods [13, 15, 25].

Reaction time represents the level of neuromuscular coordination at which visual, auditory or tactile stimuli are interpreted by the body through various processes (physical, chemical, mechanical) and are received by the brain as sensory stimulation [2, 24]. The speed of processing visual information can be considered an indicator of the level of interaction between the sensory and motor components of movement [16, 11].

One of the methods for monitoring the functional state of the human central nervous system is to determine the ratio of excitation and inhibition processes when reacting to a moving object. A person's reaction to a moving object (RMO) is understood as the ability to determine the spatial and temporal parameters of the movement of a visual stimulus, and quickly and accurately perform the necessary response actions [22]. When observing the movement of an object, physiological mechanisms are activated that provide a high level of coordination of the visual and motor analyzers, and the afferent impulses of the latter play the role of feedback in the implementation of movements and the assessment of spatio-temporal relationships [20, 27].

Sensorimotor reaction times can be measured by various means. For this, computer technology is used on various platforms [9, 30, 25]. Sports scientists and coaches who study the sensorimotor reactions of athletes are very interested in the availability of specialized, mobile, simple tests from the point of view of use in "field" conditions that correspond to the nature of the competitive activity of combat athletes.

The purpose of the study: to develop and test the method of evaluating the reaction to a moving object of combat athletes using computer technologies.

Methods

The study was conducted in compliance with the main bioethical provisions: the Council of Europe Convention on Human Rights and Biomedicine of 04/04/1997, the World Medical Association Declaration of Helsinki on the ethical principles of scientific medical research involving human subjects (1964–2008), as well as order of the Ministry of Health of Ukraine No. 690 dated September 23, 2009.

Participants. Representatives of Taekwon-Do ITF with qualifications 4 Gup – 1 Dan (first stage of the study: n=32, 15.9±0.56 years) and representatives of Cossack Fight of medium qualification (second stage of the study: n=20, 18.0±0.17 years). All participants consented to the study and were informed of the purpose of the study, testing procedures, and the ability to withdraw consent at any time for any reason. For minor athletes, consent to participate in the study was provided by their parents.

Methods. The following methods were used for the study: analysis of scientific and methodological information and sources on the Internet, generalization of best practical experience, computer programming method, psychophysiological measurements and methods of mathematical statistics.

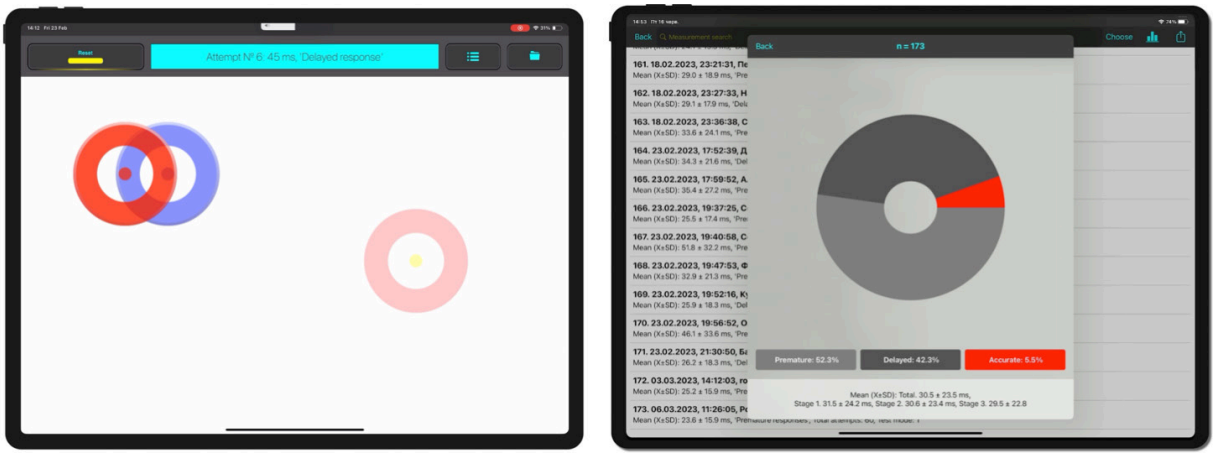

Figure 1. Reaction RMO Pro program

Procedure. The study was carried out in several stages. At the first stage, taking into account the characteristics of the sports activities of martial artists, the computer program "Reaction RMO Pro" was developed to assess the reaction to a moving object (Certificate of copyright registration for the work No. 125201 dated 03/29/2024.). The mobile application is intended for use on Apple devices with the iPad OS operating system (Figure 1).

The athlete performer is asked to complete a test exercise over three stages, where the complexity of the tasks gradually increases. At the first stage of the program, you need to react to a moving object at a slow speed. At the second stage of the program, in order to complicate the task, the speed of the visual stimulus was increased by 1.5 times. At the third stage of the program, additional chaotically moving objects were added that changed the speed, color and intensity of the display. After finishing the test exercise, the program provides the following information on measurements: the average reaction time for the entire test (Mean, ms); standard deviation (SD, ms); the predominant direction of excitation or inhibition processes for the entire test (Premature - premature reactions, Delayed - delayed reactions, Accurate - accurate reactions); number of samples in a stage; test mode; average reaction values (ms), standard deviations (ms), Shapiro-Wilk test (W) for each stage separately; percentage of reactions for the entire test (Premature, % - premature reactions, Delayed, % - delayed reactions, Accurate, % - accurate reactions). To conduct studies of various directions, you can choose one of three modes: "Main mode" – the main test mode (increasing the complexity of test tasks at each stage) "Slow mode" – a test exercise where there are no interfering additional visual objects, the speed of movement of the stimulus is "slow"; "Fast mode" is a test exercise where there are no additional interfering visual objects, the speed of movement of the stimulus is "fast". The researcher has the ability to view, edit (change information about the performer, delete measurements) and send measurements to any location (save as a separate file in CSV, Numbers, PDF, Excel, email, cloud storage). It is also possible to see the test result in a graphical display of both one athlete performer and a group of athletes.

Also, at the first stage of the study, preliminary testing of the mobile application was carried out. To determine errors and adjustment procedures, software modeling and testing of combat athletes (n=32, 15.9±0.56 years) during the training process were used.

At the second stage of the study, the reliability, validity and reliability of the proposed methodology were determined. According to the research procedure, two measurements were carried out [4, 17]. The measurements took place at the same time in the second half of the day. 20 combat athletes aged 18.0±0.17 years took part in the testing. To activate the sensory and motor mechanisms of movement control, before testing, athletes were asked to perform simple exercises with tennis balls. The second measurement was taken three weeks later.

Statistical analysis of the obtained data was performed using RStudio and Numbers programs.

Research results. Based on the analysis of scientific and methodological literature, pedagogical observations, practical experience, analysis of the competitive activity of combat athletes of various sports specializations, conversations with coaches and qualified athletes, the computer program "Reaction RMO Pro" was developed to assess the reaction to a moving object.

The visual stimulus to which one should respond moves at a constant speed (the first stage is one step per 0.003 s, the second is one step per 0.002 s). The speed was chosen experimentally, which in feel can be considered slow (v=63 mm/s). Since some iPad generations have different screen sizes, a feature has been added to ensure the same speed on different screen sizes. The shape, color and size of the visual stimulus were chosen based on preliminary studies [25] with some modifications.

For preliminary testing, software modeling of various situations of test tasks was carried out. The main focus of this stage is to search for situations where program malfunctions are possible. Software modeling made it possible to determine the characteristics of passing the test and some violations of the program. Test modeling showed that situations are possible when the values of any stage do not correspond to the law of normal distribution. To solve this situation, the following solution is provided - the program removes the worst value and gives an additional attempt (Table 1).

Determination of the reaction time of combat athletes to a moving object during the training process was carried out with the participation of taekwondo athletes of all ages and qualifications (n=32).

For a detailed characterization of the obtained data, a cluster analysis was carried out (Figure 2).

Based on cluster analysis, three groups of athletes can be distinguished. The first group (G1) included athletes (14.6±0.28 years), who had the highest reaction time and predominantly premature reactions. The second group (G2) included athletes (15.6±0.90 years) with an average reaction time and predominantly delayed reactions (Delayed: 49.03%). The third group (G3) included athletes (17.8±1.34 years) who had the lowest reaction time and predominantly premature reactions (Premature: 52.45%) (Table 2).

Table 1. Results of test modeling (range: -50…50 ms, n=20)

Number of attempts	«10», total – 30	«20», total – 60	«30», total – 90
Additional attempts, n (X±SD)	0.3±0.8	1.6±2.2	17.2±24.6
Reaction time, ms (X±SD)	24.1±5.8	24.9±2.8	23.1±5.2

Table 2. Results of measurements of the studied combat athletes

Groups	Mean (ms)	Stage 1 (ms)	Stage 2 (ms)	Stage 3 (ms)	Premature (%)	Delayed (%)	Accurate (%)
G1	37.17	43.52	32.61	35.15	60.69	34.76	4.55
G2	32.05	29.22	32.85	34.19	45.28	49.03	5.69
G3	26.69	25.69	32.84	21.68	52.45	39.74	7.81

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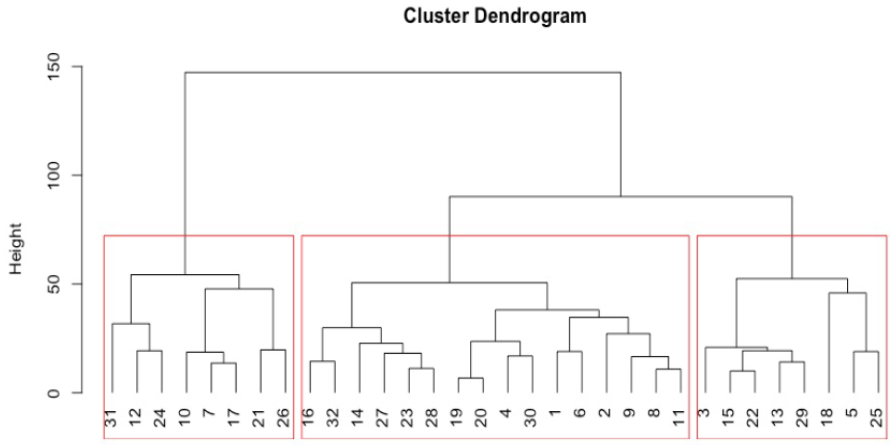

Figure 2. Results of cluster analysis of the studied combat athletes

As noted earlier, the second stage of the study was devoted to determining the reliability, validity and reliability of the proposed methodology.

To analyze the differences between the first and second measurements, the average value for the entire test was used as an integral indicator of reaction time to a moving object (Table 3).

Table 3. Reaction Time Measurement Results

	Mean	SD	Median	1st Qu.	3rd Qu.
First measurement (ms)	26.21	5.70	25.35	22.61	27.99
Second measurement (ms)	25.65	4.30	25.66	21.94	29.88

The measurement results correspond to the law of normal distribution (Table 4), which made it possible to use the Pearson correlation coefficient to determine the relationship and the Student criterion to determine the differences.

Table 4. Compliance with the law of normal distribution

	Shapiro-Wilk	p-value
First measurement (ms)	0.93	0.13
Second measurement (ms)	0.93	0.18

Correlation analysis indicates a strong statistically significant relationship (r=0.78) between the indicators of the first and second measurements (Figure 3).

As for determining the differences, based on a comparison of the indicators of the first and second measurements, it can be argued that there are no statistically significant differences between these measurements (Table 5).

Table 5. Determining differences between measurements

Student's t-Test	p-value
0.35	0.73

Analysis of changes in reaction time at individual stages of the test showed dynamics that were present in the first and second measurements.

Thus, the best reaction time was noted at the second stage of the test, where the speed of the visual stimulus increases. The worst time was recorded in the first stage of the test. At the third stage, where interfering signals act, the reaction time is less than at the first stage, but longer than at the second (Figure 4).

Due to the lack of normal distribution in some results at certain stages of the test, the Mann-Whitney test was used for comparison. The comparison results indicate that there are no statistically significant differences between the indicators of the first and second measurements at the test stages (Table 6).

Table 6. Differences between measurements according to test stages

	Mann-Whitney	p-value
Stage 1	102	0.94
Stage 2	120	0.59
Stage 3	117	0.67

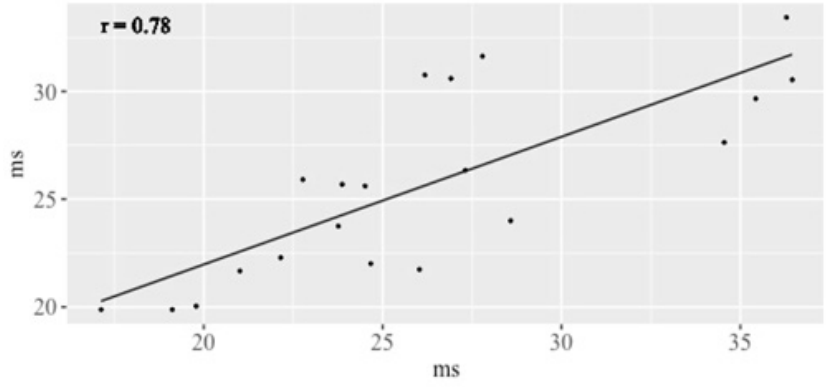

Figure 3. Scatter plot with regression line of measurement results (Pearson's correlation coefficient)

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The presence of relationships between the first and second measurements was also revealed, but they are not statistically significant (Figure 5).

Analysis of the results of determining the direction of reactions to a moving object indicates that premature reactions predominate, both in the first measurement (52.75%) and in the second (51.92%) (Figure 6).

Due to the lack of normal distribution in some indicators that determine the direction of reactions, the Mann-Whitney test was used to compare the measurement results. Thus, a comparison of the results of the first and second measurements showed that the differences between the indicators are not statistically significant (Table 7).

Table 7. Differences between measurements (directionality of reactions)

	Mann-Whitney	p-value
Premature	112	0.81
Delayed	88	0.79
Accurate	90	0.86

Regarding the relationships between the values of the first and second measurements, which characterize the direction of the reaction to a movable object, no statistically significant connections were noted.

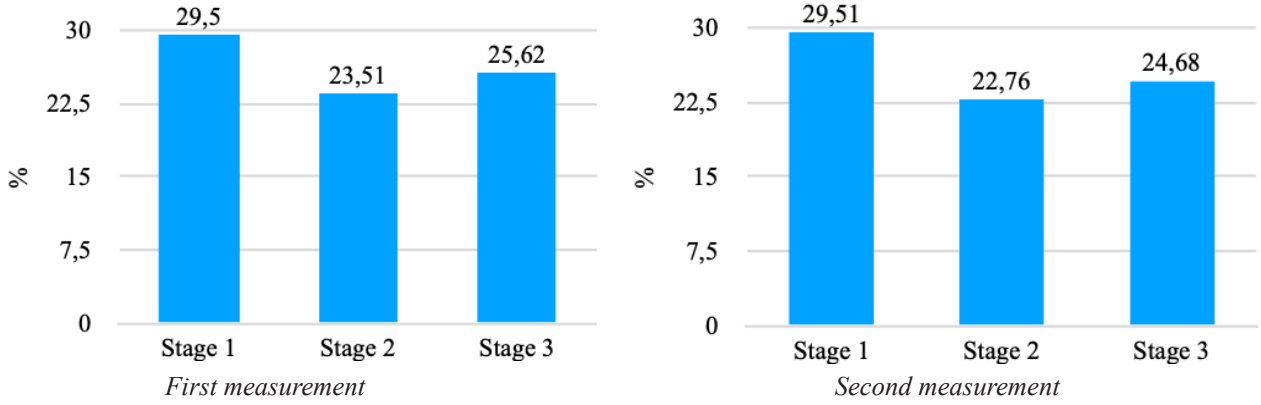


Figure 4. Reaction times at test stages

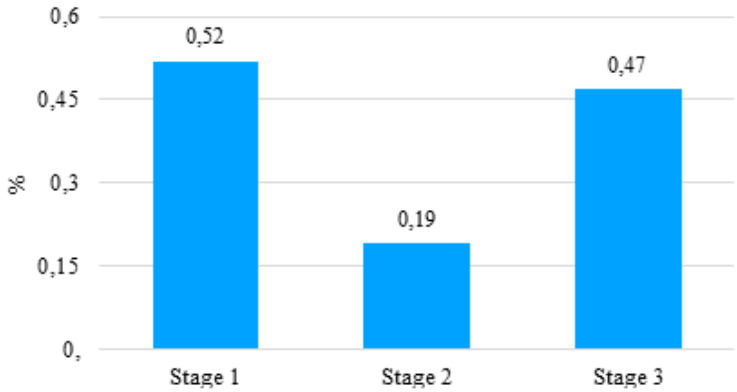


Figure 5. Relationships between the first and second measurements (Spearman's correlation coefficient)

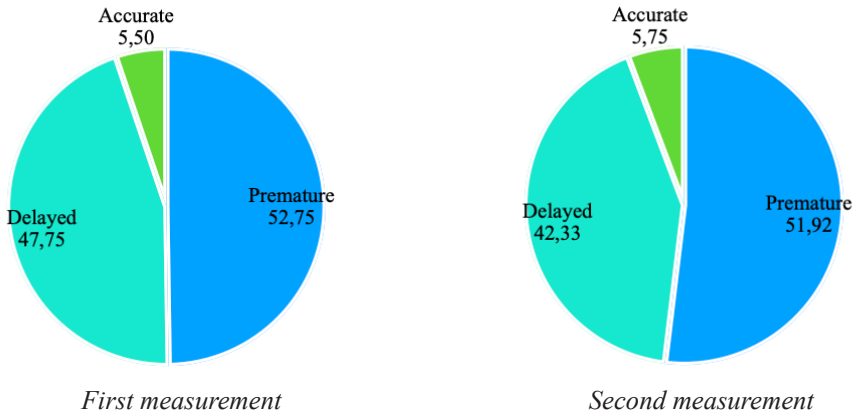


Figure 6. Direction of reactions to a moving object

Discussion

Determining the reaction time to a moving object is one of the methods for monitoring the functional state of the human central nervous system [20, 12]. In a study [27], to determine this type of reaction, experts suggest reacting to a line moving in a circle. It is necessary to stop the line at the right place.

Scientists [20] in RMO studies used an electric stopwatch, the dial of which is marked with divisions of tenths and hundredths of a second. The performer had to stop the electric stopwatch hand at the desired mark.

There are differences in methodological approaches in determining the predominant direction of nervous processes. According to research [27], a positive RMO value indicates the advantage of inhibition processes over excitation processes, while a negative value, on the contrary, indicates an advantage of excitation processes. In the study [20]. The results of the RMO test (reaction to a moving object), where the performer was asked to perform 30 attempts, were classified as accurate, premature and delayed reactions (33.33% with a "0" sign, 33.33% with a "-" sign and 33. 33% with a "+" sign). We can roughly assume that persons with balanced nervous processes made 33.33% or more clear answers. Persons who make more than 66.66% premature and delayed reactions during the test should be considered persons with unbalanced nervous processes.

As noted earlier in the computer program "Reaction RMO Pro", the visual stimulus moves at a speed of one step per 0.003 s. In this regard, the determination of the suppressive direction of nervous processes is implemented as follows: premature reactions will include values that are less than -0.003 s; to reactions with a delay of more than 0.003 s; accurate reactions will include values in the range from –0.003 s to 0.003 s.

The computer program "Reaction RMO Pro", developed to assess the reaction to a moving object, is a continuation of a series of tests to assess the sensorimotor reactions of combat athletes [3, 25]. Taking into account the peculiarities of sports activities in martial arts, where an opponent can perform technical and tactical actions from different sides at different speeds, the Reaction RMO Pro program implements the possibility of the appearance and movement of a visual stimulus from any point on the screen. The program algorithm is implemented according to the principle from simple to complex After each stage of the test exercise, the measurements are checked for normality of distribution. To determine compliance with the law of normal distribution, the Shapiro-Wilk test was used. If the values do not correspond to the normal distribution of the performer, an additional attempt will be offered and the worst result will be discarded. It should be noted that checking each stage of the test for normality of distribution and the occurrence of additional attempts allows the performer to show a result that best matches his abilities. This is in keeping with the spirit of competition in martial arts, where an athlete is able to correct mistakes by mobilizing his individual capabilities and achieve victory.

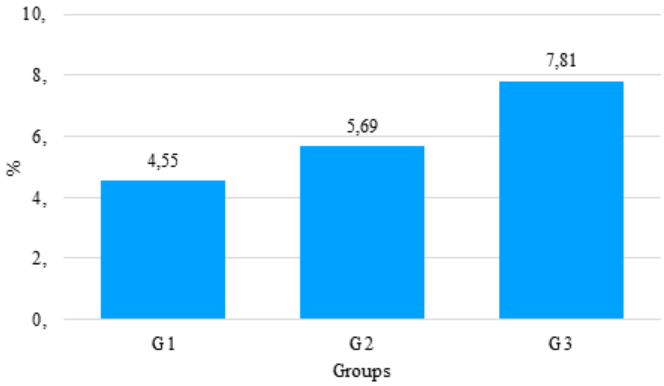
Based on test modeling, it was determined that when the number of attempts is reduced to 10 in a stage, the probability of additional attempts also decreases. In this regard, we can recommend "10" (30 attempts) or "20" (60 attempts) as the main modes. The "30" mode (90 attempts) can be used to study the reaction to a moving object in highly qualified combat athletes who have a more stable state of the nervous system and greater endurance of the visual analyzer.

Software modeling carried out to identify errors in the operation of a computer program does not reflect the nature and dynamics of real measurements. The random values offered by the program are in no way related to the previous reaction values. When performing a test exercise, an athlete has the opportunity to mobilize his capabilities and show the best result. The higher the athlete's qualifications, the better his ability to control nervous processes [23, 13].

Approbation of the methodology for assessing the reaction to a movable object with the participation of combat athletes of all ages and qualifications made it possible to obtain significance and test the operation of the program during the training process. Based on the analysis of the obtained data using cluster analysis, several groups of combat athletes were identified. A review of the formed groups allowed us to conclude that the athletes were mainly distributed into groups in accordance with their sports qualifications and age. Thus, the third group (G3) included highly qualified combat athletes (17.8±1.34 years). It was the athletes of this group who showed shorter reaction times.

The first group (G1) included low-skilled combat athletes (14.6±0.28 years). It was also noted that at the first stage of the computer program, athletes from this particular group showed the longest reaction time. This may indicate an increase in the duration of adaptation to interaction with visual stimuli by junior combat athletes with low sports qualifications.

An analysis of the direction of the motor reaction in the study showed that qualified combat athletes have predominantly premature reactions (52.45%) and the highest percentage of accurate reactions (7.81%) (Figure 7).



G1 - 14.6±0.28 years, G2 - 15.6±0.90 years, G3 - 17.8±1.34 years

Figure 7. Percentage of accurate reactions of combat athletes

The results obtained confirm the conclusion that more qualified combat athletes have a more advanced mechanism of interaction between the sensory and motor components of movement control [13, 2, 16].

Based on the analysis of scientific and methodological literature, pedagogical observations, practical experience, conversations with specialists, it was determined that tests to determine any quality must meet the following requirements: test reliability (consistency of results when applied multiple times to the same person); test validity (the test must measure what it purports to measure); standardization (the test must be administered in the same way and standardized for all participants); sensitivity (the test must be sensitive enough to detect small differences between individuals); accessibility (the test must be accessible and convenient for participants of all ages and abilities) [4, 17].

As for the reliability and ease of use of the Reaction RMO Pro computer program, testing has shown that the algorithm of its operation is easily understood by athletes of all ages. Demo mode allows you to perform several training attempts and fa-

miliarize yourself with the test task. The main requirement for the person conducting the research is to create high motivation among the athletes performing the test exercise. This is very important from the point of view of the objectivity of the results obtained. Such testing can help improve the competence of athletes, as they gain new knowledge and new sensations [29]. Athletes have the opportunity to test their capabilities and challenge themselves to perform a test exercise. The positive experience gained can help increase awareness and build their competence, since competence is the cornerstone of intrinsic motivation [8, 21].

Compared to the choice reaction time, where values can average about 700-900 ms [25], the reaction time to a moving object in the study is only 26.2±5.7 ms (first measurement) and 25.6±4.3 ms (second measurement). In this regard, to increase the objectivity of the data obtained, before performing the test exercise, the "Reaction RMO Pro" computer program, the combat sports athletes were offered simple exercises with tennis balls. The study [26] determined that exercises with tennis balls have a positive effect on the manifestation of reactions and activate the mechanisms of movement control of combat sports athletes.

Validity is a measure of whether a concept, conclusion, or measurement is valid and is likely to accurately correspond to the real world [5]. The validity of an assessment is the measure by which it measures what it is supposed to measure [18]. To determine validity, test developers must properly articulate the intended purpose of the test item (Stephen, G. Sireci, 2013). In the proposed computer program, the goal of passing the test exercise is clearly formulated, namely: "Stop a moving object in a specified location." The time demonstrated by the performer in this application reflects the accuracy of the execution of motor acts. The algorithm of the "Reaction RMO Pro" application makes it impossible for cases of incorrect use of the test - this gives objectivity to the measurement results.

According to the results of the correlation analysis, it can be argued that there is a statistically significant relationship ($r=0.78$, $p<0.05$) between the reaction time to a moving object in the first and second measurements. It was also determined that there were no differences in reaction time between the first and second measurements ($t=0.35$, $p>0.05$).

Analysis of the dynamics of reaction time to test tasks proposed by a computer program made it possible to obtain additional information about the characteristics of athletes' response to various obstacles. Thus, at the second stage of the application, where the speed of the visual stimulus increases by 1.5 times ($v=94.5$ mm/s), the majority of combat athletes react faster than at the first stage. This may indicate that the speed at the second stage is more favorable for representatives of Cossack Fight and is more consistent with their movement patterns. At the third stage, where interfering visual stimuli were added, a slight increase in reaction time was recorded. Indeed, interfering visual stimuli have an impact on reaction time [25]. The difference between the reaction time at the third and second stages may indicate the stability of movement control mechanisms in athletes. This dynamics takes place in both the first and second measurements, and the absence of differences between the reaction times at individual stages of the test ($p>0.05$) indicates the reliability of the test exercise.

Analysis of the research results, namely the direction of reactions of combat athletes, indicates that premature reactions are preferred, both in the first measurement (52.75%) and in the second (51.92%), which also confirms the reliability of the test exercise. A larger percentage of premature reactions characterizes the functional state of the athlete's central nervous system, namely the prevalence of excitation processes. This may be due to the development of the sports form of combat sports athletes. A significant percentage of exercises performed by athletes during this particular period of preparation for competitions is associated with the development of technical and tactical actions in pairs, both in attacks and counterattacks, where the requirements for complex types of reactions and speed of decision-making increase [2, 13, 16].

The absence of statistically significant relationships between the values characterizing the direction of the reaction to a moving object at individual stages of the test is associated with the individual characteristics of the perception of visual information and the nervous processes occurring in the cortex and subcortical centers of the brain of combat sports athletes. This parameter of this test task is important from the point of view of characterizing the manner of conducting a fight and assessing the functional state of the athlete and is a confirmation of the sensitivity of the proposed method.

Conclusions

1. Analysis of scientific and methodological information and generalization of advanced practical experience made it possible to establish that in martial arts, a timely, adequate reaction to a competitive situation is crucial for victory. Therefore, information obtained thanks to reliable methods allows you to objectively assess the issues being studied and provide practical recommendations for adjusting the learning process or improvement.

2. It has been confirmed that highly qualified athletes have a more advanced mechanism for perceiving information and corresponding motor reactions. An increase in the process of adaptation of the visual-motor mechanism for controlling movements of younger athletes with lower qualifications was also noted.

3. The results of the study indicate that the method for determining reaction time to a moving object using the computer program "Reaction RMO Pro" is reliable, valid and reliable, as evidenced by the results of correlation analysis ($r = 0.78$), the absence of differences between the first and second measurements, both at individual stages of the test ($p>0.05$), and relative to the integral assessment of reaction time to a moving object ($t=0.35$, $p>0.05$), preservation of the dynamics of changes in reaction time at individual stages of the test and the predominant direction of premature reactions (first measurement 52.75% , second 51.92%).

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