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Study of the psychomotor abilities of athletes in cyclic sports, martial arts and esports

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Abstract

Purpose: to conduct a comparative analysis of psychomotor abilities in athletes of cyclic sports (short track), martial arts (karate, taekwondo) and esports (CS:GO).

Materials, participants and methods: The study involved athletes of percussion martial arts (n=10, age 18,9±0,12, candidates for master of sports), elite players of semi-professional CS:GO teams (n=10, age 19,2±0,50), short track speed skaters (n=10, age 19±0,09, masters of sports). The choice reaction time, the frequency of local movements (60-second tapping test), and the reaction time to a change in the size of the object (Size-test) were determined.

Research results. Esports athletes have the best reaction time of choice and tapping test compared to other athletes. The wrestlers showed the best reaction to distinguishing the size of an object in the Size-Test. Skaters have high rates of complex reaction time and frequency of movements. The duration of the tapping test has a likely inverse relationship with the frequency of tapping.

Conclusions. It was found that esports athletes have a significantly better choice reaction time ($p<0,05$) than martial arts athletes. The results of short track skaters do not have significant differences with martial arts and esports athletes ($p>0.05$). The results of the tapping test in terms of the total number of movements and the average number for 5 s in esports athletes tend to be higher compared to short track speed skaters and martial arts athletes. The fastest response time to a change in the size of an object in the Size-test was shown by martial arts athletes, the slowest by short-track skaters. This reflects the trend towards better results of this type of reaction in martial arts athletes compared to short track speed skaters and esports athletes.

Key words: choice reaction time, tapping test, Size-test, martial arts, sports, short track

Анотація

Світлана П'ятисоцька, Вячеслав Мулик, Анатолій Губа, Наталія Долгополова, Андрій Єфременко, Яна Жерновнікова. Дослідження психомоторних здібностей атлетів циклічних видів спорту, єдиноборств та кіберспорту. Мета: провести порівняльний аналіз психомоторних здібностей у атлетів циклічних видів спорту (шорт-трек), єдиноборств (карате, таеквондо) та кіберспорту (CS:GO). **Матеріали, учасники та методи:** У дослідженні взяли участь атлети ударних видів єдиноборств (n=10, вік 18,9±0,12, кандидати в майстри спорту), елітні гравці напівпрофесійних команд з CS:GO (n=10, вік 19,2±0,50), ковзанярі шорт-треку (n=10, вік 19±0,09, майстри спорту). Визначали час реакції вибору, частоту локальних рухів (60-секундний теппінг-тест) та час реакції на зміну розміру об'єкту (Size-test). **Результати дослідження.** Кібератлети мають кращі показники часу реакції вибору та теппінг-тесту у порівнянні з іншими атлетами. Єдиноборці показали кращу реакцію на розрізнення розміру об'єкту у Size-test. Ковзанярі мають високі показники часу складних реакцій та частоти рухів. Тривалість натискань у теппінг-тесті має вірогідний зворотний зв'язок із частотою натискань. **Висновки.** Встановлено, що кібератлети мають достовірно кращий час реакції вибору ($p<0,05$), ніж атлети єдиноборств. Результати ковзанярів шорт-треку не мають достовірних відмінностей із атлетами єдиноборств та кібератлетами ($p>0,05$). Результати теппінг-тесту за загальною кількістю рухів та середньою кількістю за 5 с у кібератлетів мають тенденцію до більших величин у порівнянні з ковзанярами шорт-треку та атлетами єдиноборств. Найшвидший час реакції на зміну розміру об'єкту у Size-test показали атлети єдиноборств, найповільніший – ковзанярі шорт-треку. Це відображає

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тенденцію до кращих результатів даного виду реакції у атлетів єдиноборств у порівнянні з ковзанярами шорт-треку та кібератлетами.

Ключові слова: час реакції вибору, теппінг-тест, Size-test, єдиноборства, esport, шорт-трек

Introduction

The psychophysiological functions of a person depend on the characteristics of the nervous system. They characterize the process of formation and improvement of special motor skills in the conditions of sports activity (Korobeinikov et al., 2012). Psychomotor abilities determine the coordination of motor actions with nervous processes and determine the ability of athletes to perform high-quality motor actions (Lyzohub et al., 2021). The time of sensorimotor reactions is one of the simplest, most accessible, and at the same time quite accurate neurophysiological indicators that reflect the dynamics of nervous processes and human motor coordination (Rovnyiy & Romanenko, 2016). At the same time, motor activity in different sports determines the features of the manifestation of sensorimotor abilities. It is customary to distinguish sports with a cyclic structure of movements (running, swimming, cycling, speed skating, etc.), acyclic (situational sports, in particular, sports and martial arts), as well as such specific types of sports activities that are not related to physical activity. (chess, go, sports poker, esports).

One of the characteristic representatives of cyclic sports is short track - it is a dynamic and high-speed sport. Short track racing is a direct competition held over several series. In each series, the rank by which the athlete is qualified for the next round is important, not the time. One of the most important performance indicators for athletes in short track is neuromuscular conduction and the associated dynamics and speed of muscle response (Felser et al., 2016). Then the whole race is full of dynamic accelerations to get a higher rank or defend your position in the current race. The race ends with a dynamic acceleration to the finish line (Menting et al., 2019). The performance of motor actions of elite athletes under other almost identical conditions - the speed of movement, strength, technique, conditions on the ice, equipment are similar, and the performance may differ by milliseconds. Therefore, at the beginning of the race, it is especially important to take an advantageous position and be the first to start moving at the start. As in other cyclic sports, simple reaction time plays an important role in short track speed skating (Noorbergen et al., 2016). The researchers note that “reaction time to peripheral stimuli increases as race tension increases and situational demands increase”, which affects on-ice safety even in the face of ever-changing ice conditions, as well as distractions such as visual tracking of others skaters while drafting or watching the coach’s signals from the side (Konings & Hettinga, 2018). Therefore, when solving strategic problems during the race, the complex reactions of athletes also play an important role (Podrigalo, O. et al., 2019).

The success of competitive activity in martial arts is closely related to the speed of response in conditions of increased mobility of an athlete and dynamic variability of the situation (Podrigalo, L. et al., 2022). At the same time, the athlete’s performance is determined by the level of mastery of technical techniques and tactical readiness (Veretelnykova et al., 2022). The adequacy of reactions of psychophysiological functions to training or competitive loads can be an indicator of both the level of preparedness of an athlete and the development of fatigue and overstrain processes in him (Podrigalo, L. et al., 2019). Training and competitive activities in martial arts contribute to the formation of a whole complex of specific reactions and perception abilities in athletes (Lyzohub et al., 2021; Iermakov et al., 2016). They are based on the threshold of perception of stimuli entering different sensory systems. The main role is played by the levels of musculoskeletal, visual, vestibular and auditory sensations. The higher the level of sportsmanship of an athlete, the more important is the development of psychophysiological functions to achieve a competitive result (Podrigalo, L. et. al., 2022). The level of complex sensorimotor reactions is of great practical importance for martial arts athletes. A high level of manifestation of sensorimotor reactions allows you to quickly master the technical and tactical actions, effectively solve the tasks in a competitive duel.

Separately, it is necessary to consider sports in which competitive activity is not associated with physical activity. One of the new sports in this category is esports, in which the competition takes place in a virtual environment (Pluss et al., 2020). To achieve victory, the player must quickly and accurately control the game character in the virtual space using the keyboard, computer mouse or joystick (Campbell et al., 2018). It should be noted that, unlike intellectual games, success in e sports is associated with the development of psychomotor abilities, cognitive functions and the speed of sensorimotor reactions of players. Researchers argue that there is a connection between individual manifestations of these abilities and the ability to solve game problems with maximum speed and efficiency (Pluss et al., 2020). In esports, both specific and general components of motor activity play an important role. Experienced video game players outperform amateurs on a variety of cognitive and perceptual tasks, including visual selective attention (Leigh & Clark, 2022), visual stimulus detection, visual search efficiency, contrast sensitivity, cognitive flexibility, visual conciseness (Bediou et al., 2018), and attention switching and multisensory integration (Di Luzio et al., 2021).

Thus, the researchers note the extremely important role of psychomotor abilities for the implementation of effective competitive activity. Therefore, the study of the features of the manifestation of psychomotor abilities in athletes with different types of competitive activity is an important area of scientific research.

Purpose of the study: to conduct a comparative analysis of the psychomotor abilities of elite athletes in cyclic sports (on the example of short track), martial arts (on the example of karate and taekwondo) and eSports (on the example of the CS:GO discipline related to the first-person shooter genre).

Material and Methods of the research

This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki (protocol of the Commission on Bioethics of the Kharkov State Academy of Physical Culture No. 38).

Participants: the study involved 30 middle-aged athletes (19±0.24) years old, divided into groups according to the sport. Group 1: athletes of percussion martial arts, n=10, age (18.9±0.12) years, candidates for master of sports. Group 2: elite players of semi-professional CS:GO teams, n=10, age (19.2±0.50) years. Group 3: short track speed skaters n=10, age (19±0.09), masters of sports.

Methods. Using special programs for tablet computers running iOS, developed at the departments of martial arts, computer science and biomechanics of the KSAPC, the following manifestations of the psychomotor abilities of athletes were

studied: 1) choice reaction time; 2) frequency of local movements (60-second tapping test); 3) Size-test.

The evaluation of the *choice reaction* among static objects was carried out using the following test: the subject must respond to one given signal out of 5 proposed (12 attempts). In case of an incorrect reaction, an error is counted. If the subject scores more than 3 errors, the program offers to take the test again. The test result includes the average value of the 10 best attempts, the value of the Shapiro-Wilk criterion, the number of errors.

Assessment of the frequency of local movements (60-second tapping test). To assess the strength of nervous processes, namely the frequency of movements, the TappingPro program was used. The study used a test duration of 60 seconds. The program allows, along with determining the number of clicks (in each 5 second interval), to record the duration of the clicks, which is very important for additional characterization of the dynamics of nervous processes.

Size test. Evaluation of the speed of interaction between the visual analyzer and the neuromuscular apparatus, the ability to respond to the moment of removal or approach of an object. The subject needs to respond to a change in the size of the object (square). The test can be run in three modes:

"Increase" – object increase;

"Decrease" – object decrease;

"In/De", where the object can both increase and decrease. An early reaction is considered a mistake. If the subject scores more than 3 errors, the program offers to take the test again. The velocity of the object size configuration is 0,002 m/s. The test result includes: average of the best 10 attempts, Shapiro-Wilk test, number of errors.

Statistical processing of the research results was carried out using the Statistica 13 program, the following methods were used: descriptive statistics, checking the compliance of the distribution of the sample population with the normal law according to the Shapiro-Wilk criterion, testing statistical hypotheses using the Mann-Whitney criterion, analysis of variance using the Kruskal-Wallis criterion, correlation by Spearman criterion.

Results of the research

A study of the choice reaction time allowed us to establish that this indicator for esports athletes is 1,4% less (better) than short-track skaters ($p>0,05$), and 7,98% for martial arts athletes ($p<0,05$). The verification of compliance with the normal distribution of populations was carried out using the Shapiro-Wilk test. This criterion is highly sensitive and helps to identify deviations from the normal distribution already at $n\geq10$. It was found that the distribution in each of the three groups corresponds to the normal $\alpha=0,05$ (Table 1).

The significance of differences between the reaction times of the three groups of athletes was tested using the Kruskal-Wallis test. It was found that at least 2 study groups have significant differences ($H=6,17$, $p<0,05$). This necessitated a subsequent verification by the Mann-Whitney criterion. There was a significant difference between the reaction time indicators of esports athletes and martial arts athletes ($Z=2,38$, $p<0,05$). There were no significant differences between the results of short track speed skaters with esports athletes ($Z=0,72$, $p>0,05$) and martial arts athletes ($Z=1,62$, $p>0,05$).

Comparison of the total number of local movements and the average number of clicks in 5 s showed that esports athletes have the highest result of all three groups, however, these differences are not significant ($p>0,05$). The greatest range of variation is observed in the group of short track skaters, although the group is homogeneous in terms of skill level (Table 2).

The smallest range of variation was found in the group of martial arts athletes, which indicates a lower variability of the results within the group (Figure 1).

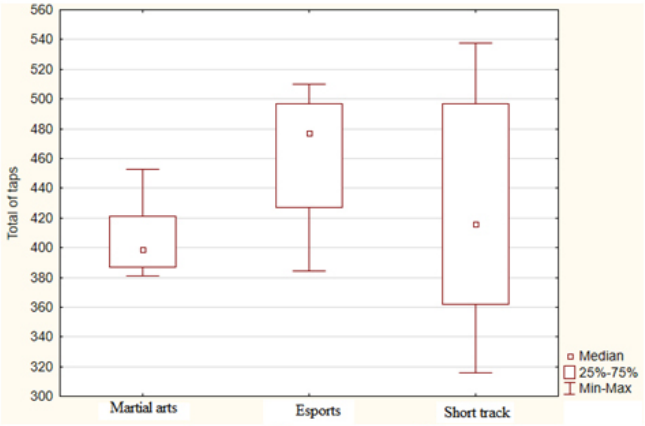
Analyzing the dynamics of the frequency of movements of athletes of cyclic types and martial arts, we can conclude that the number of local movements in each group tends to decrease from the 1st to 5-6 stages, then the graphs enter the stabilization stage. In esports athletes, the highest frequency is observed at the beginning of the test, by the 3rd stage it slightly decreases, then from 3 to 5 the stage increases, and the frequency stabilizes from stage 7 until the end of the test. In

Table 1. Choice reaction time test results

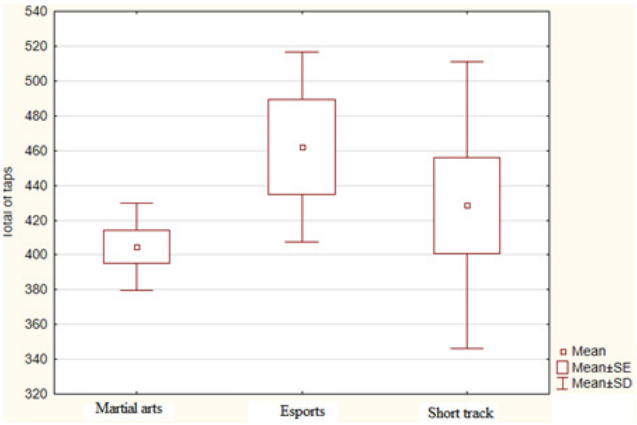
Indicator	Sports specialization	$\bar{X}\pm m$	Me	σ	v	Shapiro-Wilk
Choice reaction time, ms	martial arts	655,5±21,3	665,4	73,68	11,24	0,86
	esports	607,1±8,8	579,1	55,94	9,22	0,91
	short track	617,6±17,3	607,9	54,58	8,84	0,96

Table 2. Results of testing the frequency of local movements according to the 60-second tapping test

Indicators	Sports specialization	$\bar{X}\pm m$	σ	v
Average number of clicks per 5 s	martial arts	33,7±0,9	2,11	6,27
	esports	38,5±2,6	4,55	11,81
	short track	35,7±2,4	6,86	19,21
Total number of clicks in 60 s	martial arts	404,7±10,3	25,12	6,21
	esports	462,0±31,5	54,58	11,81
	short track	428,4±29,1	82,42	19,24



a) median, quartiles



b) average, standard deviation, standard error

Figure 1. Comparison of three groups of athletes by the range of variation

martial arts athletes, the highest frequency of movements is observed at 1-4 stages of the test, then there is a decrease in frequency and stabilization by the end of the test. Short track skaters showed the highest frequency of movements from stages 1 to 5, then the frequency decreased slightly and remained at the level of stages 3-4 (Figure 2).

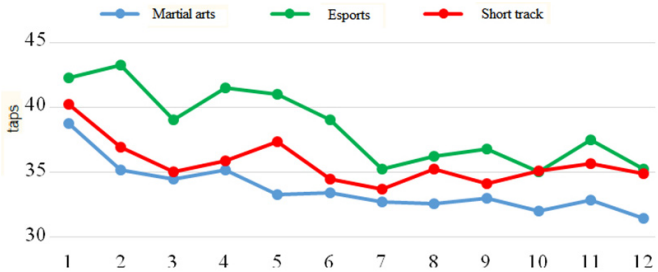


Figure 2. Dynamics of movement frequency during the test

For a qualitative analysis of the test results, the average duration of clicks is also observed at each stage of the test. The duration of clicks has a has a reverse relationship with the frequency of clicks (the correlation ratio from -0,46 to -0,83). As can be seen from the schedule (Figure 3), with an increase in the stage, the duration of clicks tends to increase due to fatigue. The smallest time of clicks is observed in a group of esports athletes, the largest short tracks.

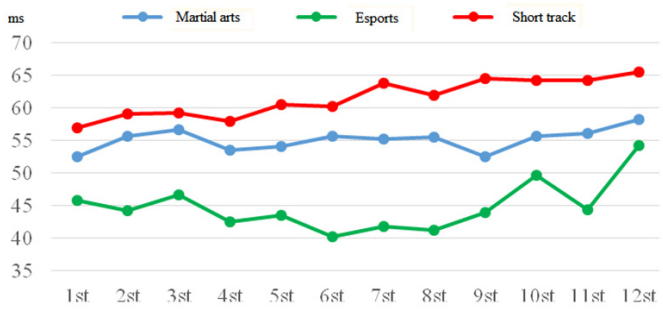


Figure 3. The average duration of clicks at the stages of the test

During the implementation of SIZE-Test, the reaction time to a change in the size of the object was recorded. The fastest reaction was shown by the athletes of martial arts, the slowest athletes of the short track. Checking the conformity of the normal distribution of electoral aggregates was made using the criterion of the Shapiro-Uylka. It was established that the distribution in each of the three groups corresponds to normal at α = 0,05 (table 3). However, in the group of martial arts and esports athletes there was a shift in the median towards an increase relative to the distribution center (Figure 4).

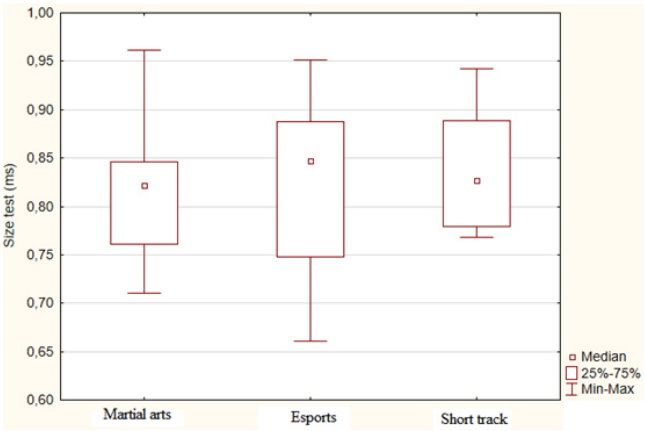


Figure 4. Comparison of the results of the Size-test performance of different specializations athletes

Testing of the statistical hypothesis about the reliability of differences between the results of athletes of different special-

Table 3. Size-test test results

Indicator	Sports specialization	$\bar{X}$±m	Me	σ	v	Shapiro-Wilk
Reaction time, s	martial arts	0,816±0,028	0,822	0,080	9,86	0,96
	esports	0,828±0,028	0,847	0,090	10,87	0,96
	short track	0,836±0,021	0,827	0,064	7,64	0,88

izations was carried out according to the Kruskal-Wallis criterion, no significant differences were found (H=0,37, p>0,05). According to the scattering characteristics, the groups also did not have significant differences, in all groups a high degree of uniformity (within 10%) was observed.

Discussion

The study of the functional capabilities of the central nervous system in terms of the speed and accuracy of performing a visual-motor test is a method with a high level of sensitivity. It allows you to identify the magnitude of functional shifts in dynamically changing sports situations. In this case, the response time to simple sensory stimuli will reflect the functional state of the central nervous system (Veretelnykova et.al., 2022). By the magnitude of the latent period, one can judge the functional state of the body and the lability of the central nervous system (Podrigalo, LV, et. al., 2019; Romanenko et. al., 2020; Korobeynikov et. al., 2021)

The design variant used - comparing the characteristics of athletes from different sports is widely used in sports science (Podrigalo, OO, et al., 2019; Grushko et al., 2021). Psychophysiological research allows to identify the factors that are important for effective selection in certain sports. The results reflect the specific impact of the sport on the body of athletes (Podrigalo, OO, et al., 2019). Grushko et al. (Grushko et al., 2021) conducted a comparative analysis of the perceptual-cognitive abilities of semi-professional esports athletes and professional football and basketball players. Esports athletes and athletes performed equally well on complex tests measuring attentional control, short-term and working spatial memory, attention distribution, reaction time, and hand-eye coordination. Esports athletes outperformed athletes in visual search speed. These data support the idea that esports and traditional team sports require the same level of perceptual-cognitive ability from professionals and can provide similar cognitive benefits and hand-eye coordination. The researchers also argue that perceptual-motor abilities may underlie professional esports prowess (Deleuze et al., 2017; Pluss et al., 2020).

The choice reaction is defined as the ability of a person to choose the most appropriate motor response to various visual signals in the shortest time (Rovnyiy & Romanenko, 2016). As a result of the study, it was found that the reaction of choice is a very important type of reaction for athletes of the chosen specializations. An analysis of the manifestation of the reaction of choice showed that martial artists are of greater importance compared to other specializations. Also, the indicators of martial arts athletes have the greatest variability. This can be explained by the fact that martial arts athletes of different manners and styles of fighting took part in the study. Another study (Tropin et.al., 2021; Romanenko et.al., 2022) proved that representatives of different manners, fighting styles and weight categories have different levels of its manifestation. Comparison of the results of martial arts athletes with the previously established model characteristics (Rovnyiy & Romanenko, 2016) showed that the results of qualification athletes, candidates for the master of sports, have an average level within the established standards.

Esports athletes showed the best indicators of choice reaction time in three sports specializations. In our opinion, this is due to the peculiarities of the esports disciplines in which the studied players specialize, namely CS:GO and DOTA 2. Competitive activity is to localize the position of the opponent as quickly as possible and eliminate him. In this case, the players use the keyboard and mouse to control the activities of the game character and all operations to achieve victory. The selectivity of their reaction consists in identifying a player of the opposing team and applying a technique that is adequate to the situation (Bediou et al., 2018). Esports players must anticipate the stimulus from the opponent and respond to it as quickly and accurately as possible by manipulating the keys or joystick. Pluss et al. note that for success in esports, developed perceptual-motor abilities are necessary, since successful control of the keyboard and mouse is one of the most important factors for victory (Pluss et al., 2020). Playing computer games requires higher perceptual, attentional, cognitive and fine motor skills (Sousa et al., 2020). For example, in games, visual information displayed on the monitor and auditory information through headphones can be stimuli. So, perceptual-motor abilities can underlie professional skills in esports (Pluss et al., 2020).

Experts note the exceptional importance of control and development of reaction time in different sports (Campbell et al., 2018; Konings et al., 2008; Podrigalo, OO, et al., 2019; Sousa et al., 2020). Biofeedback methods have been proven to be effective in improving the performance of professional athletes in many sports (Podrigalo OO, et al., 2019; Grushko et al., 2021). In short track skating in particular, the fastest starting reaction combined with the starting technique, starting power and acceleration gives a significant advantage to the athlete. Short track speed skating is influenced by several factors, including reaction time and speed during sprints, muscle strength and endurance during long distance skating, style of skating over different distances, mental focus for constant attention during competitions (Noorbergen et al., 2016). All of the above factors are related to each other and have a mutual influence. For example, factors related to reaction time and speed are combined with muscle strength and indicate plyometric strength index (Menting et al., 2019). Also, factors that take into account the length of the sliding time are combined with factors regarding the speed and direction of repulsion, and are an indicator of technical readiness (Konings et al., 2016). Konings and Hettinga (Konings & Hettinga, 2018) suggest that developing reaction time abilities in skaters will improve both speed and safety during the race.

In most sports, neuromuscular evaluation plays a very important role in achieving better performance (Chaabouni et al., 2022). Indeed, physical exercise is associated with various physiological changes and neuromuscular adaptation aimed at identifying factors that limit performance. Many tests have been used to examine neuromuscular responses in the upper and lower extremities, allowing a simple and rapid assessment. The finger tapping test is a neuropsychological test that assesses movement speed and motor control. Based on the results of this test, you can evaluate the properties of the nervous system [Hubel et al. 2013].

An analysis of the results of the frequency of local movements of the hand showed that among the athletes of the three groups of sports, esports athletes have the best result, and also show a shorter duration of touch during the test. It has been established that the characteristic features of highly qualified athletes of various sports specializations are a high level of development of sensory-motor reactions with little variability within groups (V<12%). This once again confirms the assumptions made on the adequacy of the study of psychomotor properties for the analysis of the state of athletes in these sports. High rates of frequency of local movements were also determined, with somewhat greater variability within groups (V<20%).

High results in the tapping test among esports athletes are

due to the fact that during the game they analyze a different number of stimuli and perform complex actions with their fingers. This allows for the creation of a smooth, coordinated action and minimizes the number of erroneous decisions that could harm his desired goals. Some studies have shown that people who play video games may have faster response times but lower accuracy in some measures of executive function (Campbell et al., 2018). Similarly, a study of FPS and MOBA game types found that FPS gamers had faster reaction times but lower braking control than MOBA players (Deleze et al., 2017). In a study by Sousa, A., et al. (Sousa et al., 2020) determined index finger speed on both the dominant and non-dominant hand as a proxy for motor cortical area, efferent motor pathway integrity, and motor functioning. It has been established that after the game, the speed of movement of the dominant hand significantly increases compared to the non-dominant one. Şahin et al. found that highly skilled athletes have significantly better test performance compared to lower-skilled athletes and non-athletes (Şahin et al., 2020).

The study of the reaction time to a change in the shape of an object in the Size-Test made it possible to determine that visual discrimination of a change in the size of an object is important for all athletes who took part in pedagogical testing. In practice, the manifestation of this reaction can be seen in martial arts athletes in a sports duel, short-track skaters during a competitive race, when athletes react to minor changes in the distance to their opponent. For esports athletes, this type of reaction allows you to distinguish the slightest changes in the game situation, which is closely related to the performance of the player, the duration of his stay in each game round. Comparison of the results of martial arts athletes with previously established model characteristics (Rovnyiy & Romanenko, 2016) showed that the results of qualified athletes, candidates for master of sports, correspond to the average level of established standards for highly qualified athletes (MSIG and MS).

Conclusions

In a comparative analysis of elite athletes in martial arts, short track and esports, it was found that psychophysiological features are important for achieving the highest level of skill. The current level of development of these abilities is also important, as well as the possibility of their improvement in the course of performing activities specific to different sports. Objective criteria that allow assessing the functional state of the nervous system are indicators of sensorimotor reactions.

It has been established that esports athletes have a significantly better choice reaction time ($p<0.05$) than martial arts athletes. The results of short-track skaters do not have significant differences with martial arts athletes and esports athletes ($p>0,05$).

The results of the tapping test in terms of the total number of movements and the average number for 5 seconds of esports athletes tend to be higher in comparison with short track speed skaters and martial arts athletes.

The fastest response time to a change in the size of an object in the Size-test was shown by martial arts athletes, the slowest by short-track skaters. This reflects a trend towards better results of this type of reaction in martial arts athletes compared to short track speed skaters and esports athletes.

More research is needed to confirm established trends and provide the necessary information. The approved set of tests is an adequate and informative tool and can be used in monitoring the functional state of athletes in these sports.

Author Contributions

A – research design/planning; B – data collection/entry; C – data analysis/statistics; D – data interpretation; E – manuscript preparation; F – literature analysis/search; G - fundraising.

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Conflicts of Interest

The authors declare no conflict of interest.

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