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Study of short-term visual memory of athletes in cyclic sports, martial arts and esports

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Abstract

Background and Study Aim To carry out a comparative analysis of indicators of short-term visual memory in athletes of cyclic sports (short track), martial arts (karate, taekwondo) and esports (CS:GO).

Material and Methods The study involved athletes of percussion martial arts (n=13, age 18.8±0.52, experienced athletes), elite players of semi-professional CS:GO teams (n=10, age 19.2±0.50), short track speed skaters (n=12, age 19.1±0.25, experienced athletes). Short-term visual memory was determined using a special program for tablet computers running iOS.

Results Certain trends have been established regarding the characteristics of the state of the body of elite athletes in martial arts, short track and esports in terms of averaged indicators. In terms of the short-term visual memory coefficient and the average percentage of errors, martial arts athletes showed the best result, and short trackers showed the worst result. The shortest average test duration was recorded for short trackers. At certain stages of the test, they dominated athletes of other specializations in terms of reaction time. However, the trend towards faster response was associated with a decrease in the accuracy of the selection, that is, a greater percentage of errors. Cyberathletes and martial arts athletes were characterized by better adaptive abilities than short track athletes.

Conclusions The specificity of sports activities of cyberathletes determined the best results of the most difficult stage of the test both in terms of speed and accuracy. This criterion can be recommended for esports selection and prediction. The control of the cognitive functions of athletes is expedient in the course of monitoring their physical condition and is a promising direction for predicting the reliability and success of competitive activity.

Keywords: short-term visual memory, martial arts, esports, short track, psychophysiological study.

Introduction

The success of an athlete at a professional level is determined in four main areas: physical, technical, cognitive (related to strategy, tactics, perception and decision-making) and emotional (overcoming, emotional control). Psychophysiological properties of a person affect physical performance in different ways. This is especially evident in extreme conditions that arise in the course of competitive activity. The study of the psychophysiological properties of athletes is expedient in monitoring their physical condition and a promising direction for predicting the reliability and success of competitive activity [1, 2].

Psychophysiological properties are closely related to cognitive abilities. This connection is manifested through sensory systems. In particular, the visual sensory system provides a significant percentage of the information received by an athlete in the course of competitive activity [3]. The number and complexity of stimuli that appear in the field of view of athletes during competition is constantly changing. At the same time, depending on the sport, the field of view is limited to a playground (in sports games), a track (athletics, short track, cycle track), a ring or tatami (martial arts) or a computer screen (esports). The number of stimuli simultaneously memorized by an athlete varies significantly. In sports games, this is the position of the ball (puck, shuttlecock, etc.), the location of teammates and opponents. In martial arts – the position of the opponent and his individual biolinks. In cyclic sports - the location of the nearest competitors, a limited number of objects. In esports, there are a significant number of objects of various shapes and colors that move at high speed on the monitor screen. Therefore, the function of short-term visual memory is of particular importance in the structure of the preparedness of athletes. Powless et al. note that the amount of working memory is also associated with the adoption of tactical decisions in sports [4].

The available work indicates that each of three or

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four independent memory cells stores information about one visual object [5]. This notion has been challenged by studies regarding the accuracy with which the elements are mentioned [6, 7]. This new approach has shown that the resolution at which a visual element is stored is critically dependent on how many other elements are held in memory at the same time. An alternative model suggests that one memory resource can be shared between visual elements. According to this hypothesis, the storage accuracy of an element is determined by the share of total resources allocated to it [7]. The more items that are saved, the less resources are available for each item, so the resolution at which each item is saved decreases.

To date, the question of the number and complexity of objects that can be stored in short-term visual memory (VSTM) has not been fully defined. VSTM research has focused primarily on stimulus-based properties such as the number or complexity of items retained. This also implies that the capacity is greatly reduced for items in the same category. For example, faces are treated more holistically than other objects [8].

Alvarez & Cavanagh [9] found that the greater the information load of each element in a stimulus class (indicated by a lower search rate), the fewer elements of that class can be held in memory. Extrapolating from this linear relationship shows that there is an upper capacity limit of about four or five objects. Awh et al. [6] measured the accuracy of change detection between samples and test displays and found that visual working memory is represented by a fixed number of items, regardless of their complexity. The results of Bays et al. [10] show that the accuracy with which subjects report the color of an object decreases as the number of objects in the memory array increases. This conclusion is consistent with the visual working memory model, where a shared resource must be shared among all items on the display [7]. In this model, the accuracy with which an item is stored depends on the proportion of the shared resource allocated to store it.

This property of memory is of no small importance in sports. The nature and conditions of competitive activity determine the features of the manifestation of short-term visual memory in athletes and can have a significant impact on its effectiveness. The function of visual memory is an active process in the activity of athletes, and therefore it can undergo significant changes. Horoshuha et al. [11] testify to the specific impact of training of various directions on the psychophysiological functions of the body of athletes. They found that under the influence of physical exercises of a speed-strength nature, slight changes in the average values of the function of short-term visual memory are observed, while when working on endurance, there is a statistically significant improvement in the dynamics of this function. Kunzler and Carpes claim that intense exercise promotes long-term cognitive development. They can also lead to acute effects not clearly defined for cognition [12]. So, practicing percussion martial arts, in particular boxing, may be associated with a deterioration in memory function [13].

Comparison of the psychophysiological characteristics of athletes from different sports makes it possible to evaluate the qualitative characteristics of the influence of the specifics of a sport on the body of athletes and the ability to achieve a high result. The work [14] assessed the degree of similarity at the professional level of the perceptual-cognitive abilities of semi-professional cyber-athletes and professional football and basketball players. It has been established that esports and traditional team sports require similar levels of perceptual-cognitive abilities from professional athletes and can provide similar cognitive benefits.

Thus, the study of indicators of short-term visual memory should be recognized as a promising way to monitor the state of athletes of a high level of skill, specializing in sports of various directions. This determined the direction of our research.

Purpose of the Study. The purpose of the study was to carry out a comparative analysis of indicators of short-term visual memory in elite athletes of cyclic sports (on the example of short track), martial arts (on the example of karate and taekwondo) and esports (on the example of the discipline CS:GO, related to the first-person shooter genre).

Materials and Methods

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 35 athletes with an average age of 19±0.24 years, divided into groups according to the sport. Group 1: athletes of percussion martial arts, n=13, age (18.8±0.52), experienced athletes). Group 2: elite players of semi-professional CS:GO teams, n=10, age (19.2±0.50) years. Group 3: short track skaters n=12, age (19.1±0.25) years, experienced athletes.

Research Design

With the help of a special program for tablet computers running iOS TestSTMemory the indicators of short-term visual memory were evaluated.

The testing procedure involved the execution of 5 stages of the task, 10 attempts each. At the first stage, on the first five attempts, it was necessary to react to one monochrome signal, remember its location and click on the corresponding circle. On the second five attempts, it was necessary to respond to a color signal. At each subsequent stage, the number of simultaneously appearing signals increased by one. At the fifth stage, it was necessary to memorize the location of the five signals and press the corresponding circles. The result of the test was evaluated according to the following parameters: the number of exact clicks (abs), the percentage of exact clicks (coefficient of short-term visual memory - the ratio of the number of exact clicks to their total number) (%), the number of errors (abs), test duration (s), duration at stages 1–5 (s), reaction time at stages 1–5 (ms), percentage of errors at stages 1–5 (%). The reaction time of the athletes during the test was defined as the ratio of the time from the moment the visual signal appeared to the last lap to the number of signals in the series. In total, for the entire test, the athletes performed 150 presses, 10 at the first stage, at the second stage 10 series of 2 presses, at the third stage 10 series of 3 presses, at the fourth stage 10 series of 4 presses and at the fifth stage 10 series of 5 presses. In each series, the time of the visual-motor reaction was determined. The reaction time at the present stage was determined as the average value of the series. For an objective assessment of the level of short-term visual memory (SVM), the percentage of errors at each stage of the test was determined. Clicking on a circle that was different from the one proposed was considered a mistake.

Statistical Analysis

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

Results

Comparison of the results of athletes of different specializations made it possible to establish that representatives of martial arts have the highest (best) coefficient of short-term visual memory, cyberathletes showed a result of 0.3% less, and short track – 1.1% less. In terms of the duration of the entire test, the representatives of the short track performed it the fastest, the cyber-athletes took 5.1 seconds longer, the martial arts athletes – 10.2 seconds longer. This observation allows us to trace the trend that with an increase in the test execution time, the coefficient of short-term visual memory improves ($r = -0.48$). The Kruskal-Wallis test showed that according to these indicators, there were no significant differences among representatives of different specializations ($p>0.05$) (Table 1).

An increase in the test execution time in cyber-athletes and martial arts athletes at the later stages may be associated with an increase in reaction time, and, consequently, with an increase in the percentage of accurate reactions (Figure 1).

The study of the sensorimotor component in this test, namely the reaction time to different visual signals, showed certain features of the manifestation of the visual-motor reaction in athletes of different specializations. The results of assessing the visual-motor reaction of athletes are shown in Figure 2.

For representatives of all three sports specializations, the reaction time improves with each stage of the test up to and including the fourth stage, and at the fifth stage it has a slight increase. The best result at all stages of the test was shown by short track athletes, the second place was taken by cyberathletes, martial arts athletes showed the greatest reaction time at all stages of the test.

A check using the Kruskal-Wallis criterion showed that athletes of different specializations have significant differences in reaction time at different stages of the test (Table 2):

- at the 1st stage of the test, short track athletes

Table 1. The results of testing short-term visual memory.

Indicators	Sports specialization	$\bar{X}\pm m$	σ	ν
Coefficient of short-term memory, %	martial arts	85.07±1.39	4.80	5.64
	cybersport	84.76±1.92	5.44	6.42
	short track	83.96±1.41	4.67	5.57
Duration of test (s)	martial arts	147.54±6.31	21.87	14.83
	cybersport	142.44±8.27	23.40	16.43
	short track	137.33±9.36	31.03	22.59
Percent of errors: Average (%)	martial arts	10.75±1.59	5.49	51.10
	cybersport	11.08±1.99	5.62	50.77
	short track	11.45±1.60	5.32	46.42

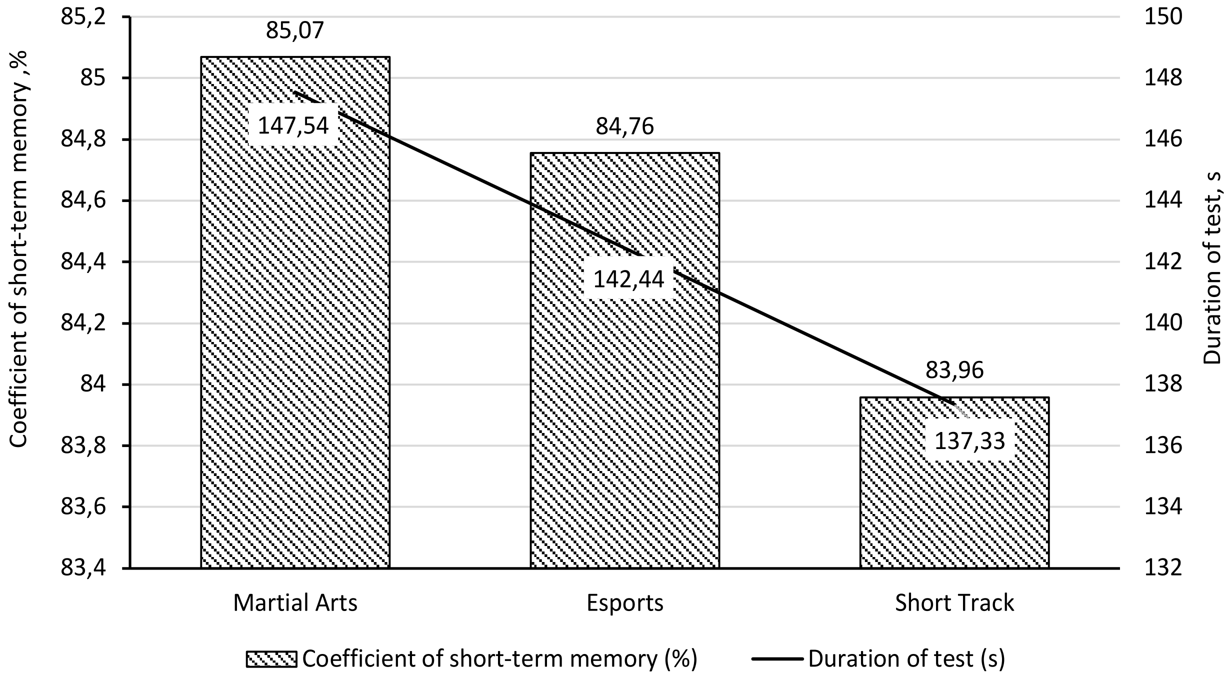

Figure 1. Visual short-term memory ratio and the duration of the whole test

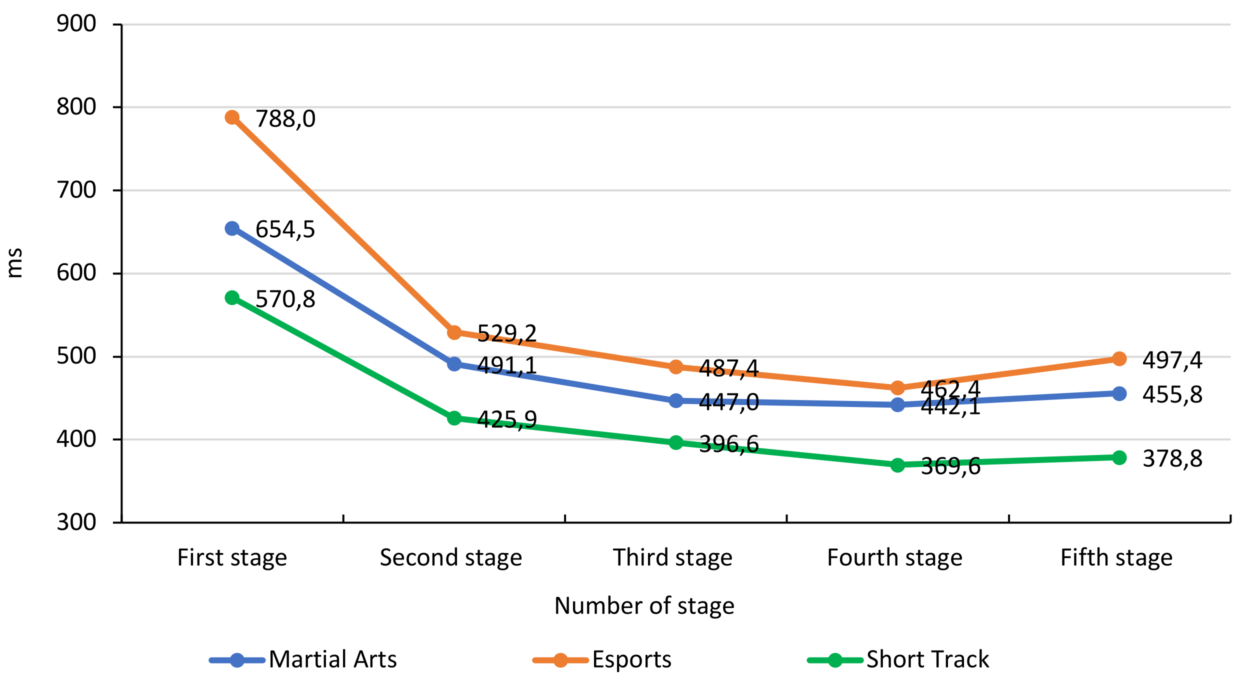

Figure 2. Comparison of reaction time at the test stages for athletes of different specializations

showed a shorter reaction time than martial arts athletes (H=5.99, p<0.05) and cyberathletes (H=13.14, p<0.01); wrestlers showed significantly less time than cyberathletes (H=4.71, p<0.05);

- at the 2nd stage of the test, short track athletes showed a shorter reaction time than martial arts athletes (H=5.60, p<0.05) and cyberathletes (H=6.19, p<0.05).
- at the 3rd stage of the test, short track athletes showed less reaction time than martial arts athletes (H=4.27, p<0.05) and cyberathletes (H=6.37, p<0.01);

Table 2. Comparison of reaction time at each stage of the test of athletes of different specializations.

Time of reaction:	Sports specialization			Kruskal-Wallis test	p
	martial arts	cybersport	short track		
	Mean Rank				
First stage (ms)	18.46	26.78	9.50	15.68	<0.01
Second stage (ms)	20.19	22.33	10.96	8.25	<0.05
Third stage (ms)	19.12	23.44	11.29	8.22	<0.05
Fourth stage (ms)	20.31	23.00	10.33	9.99	<0.01
Fifth stage (ms)	19.58	22.61	11.42	7.42	<0.05

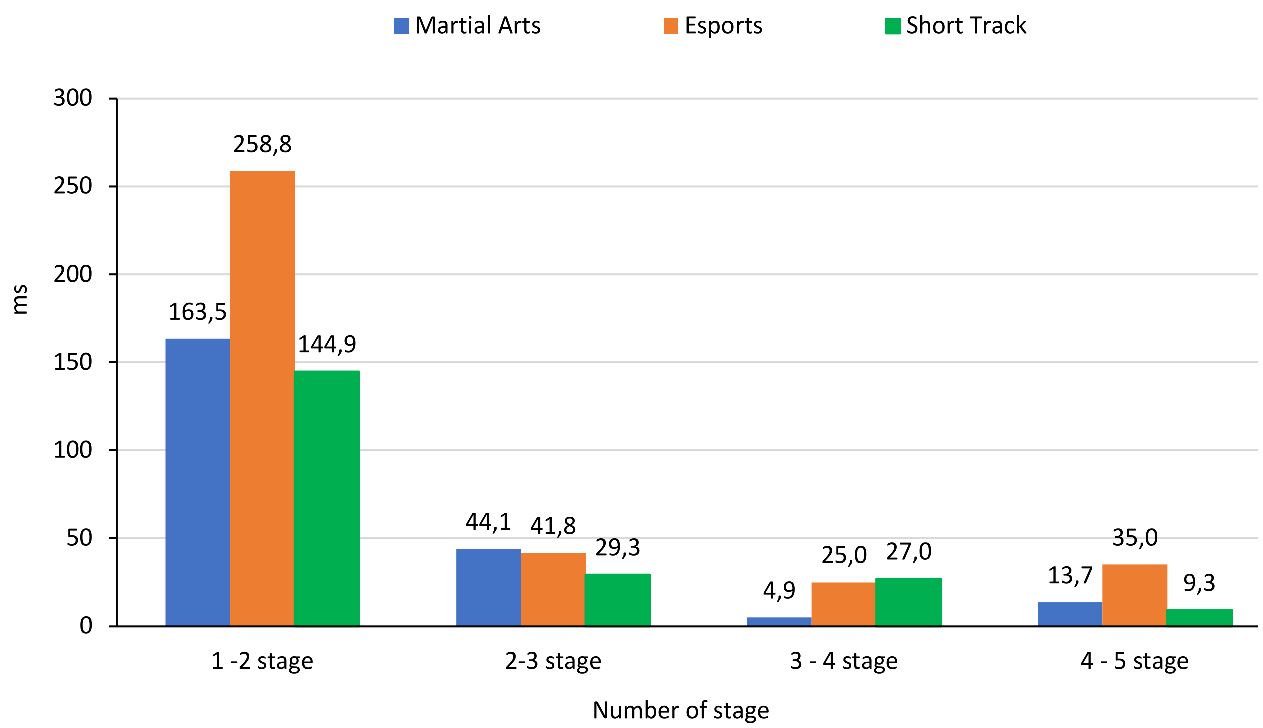

Figure 3. Difference in reaction time between successive stages of the visual short-term memory test

- at the 4th stage of the test, short track athletes showed a shorter reaction time than martial arts athletes (H=6.82, p<0.01) and cyberathletes (H=7.29, p<0.01);
- at the 5th stage of the test, short track athletes showed less reaction time than martial arts athletes (H=4.27, p<0.05) and cyberathletes (H =6.19, p<0.05).

The results of cyberathletes and martial arts athletes from the 2nd to 5th stages of the tests do not have significant differences (p>0.05).

Analyzing the difference between the reaction time at the stages of the test, we can conclude that the greatest difference is observed between the time of stages 1 and 2, this difference turned out to be the largest for cyberathletes (Figure 3).

In the course of the analysis of the duration of passing the test stages for athletes of different specializations, it was found that short track athletes passed the 1st and 4th stages of the test the fastest, cyberathletes – the 3rd and 5th stages, martial arts athletes – the 2nd stage. It was found that almost the same difference between the duration of the 1st and 2nd stages of the test in representatives of all specializations. The difference between the 2nd and 3rd stages of the test in cyberathletes was 1.18 s less than in short track athletes and 3.09 s less than in martial arts athletes (Figure 4).

The difference between the duration of successive stages of the test was analyzed (Figure 5). For representatives of martial arts athletes, the time difference between all stages of the test was stable, did not have significant fluctuations. For cyberathletes, the difference between the 2nd and 3rd stages of the test was significantly different. For short track athletes, the time between the 3rd and 4th stages (small) and between the 4th and 5th stages is especially different – the largest indicator among all is 10 s.

Throughout the test, the athlete was offered an ever-increasing number of visual cues, and the number of errors increased accordingly. An analysis of the number of errors made during the test showed that martial arts athletes made the least number of them at the 2nd and 4th stages of the test, short track athletes – at the 3rd, and cyberathletes – at the 5th, which is the most difficult. (Figure 6).

The difference between the number of errors at the test stages was analyzed (Figure 7). All specializations tend to increase the number of errors with each successive stage of the test.

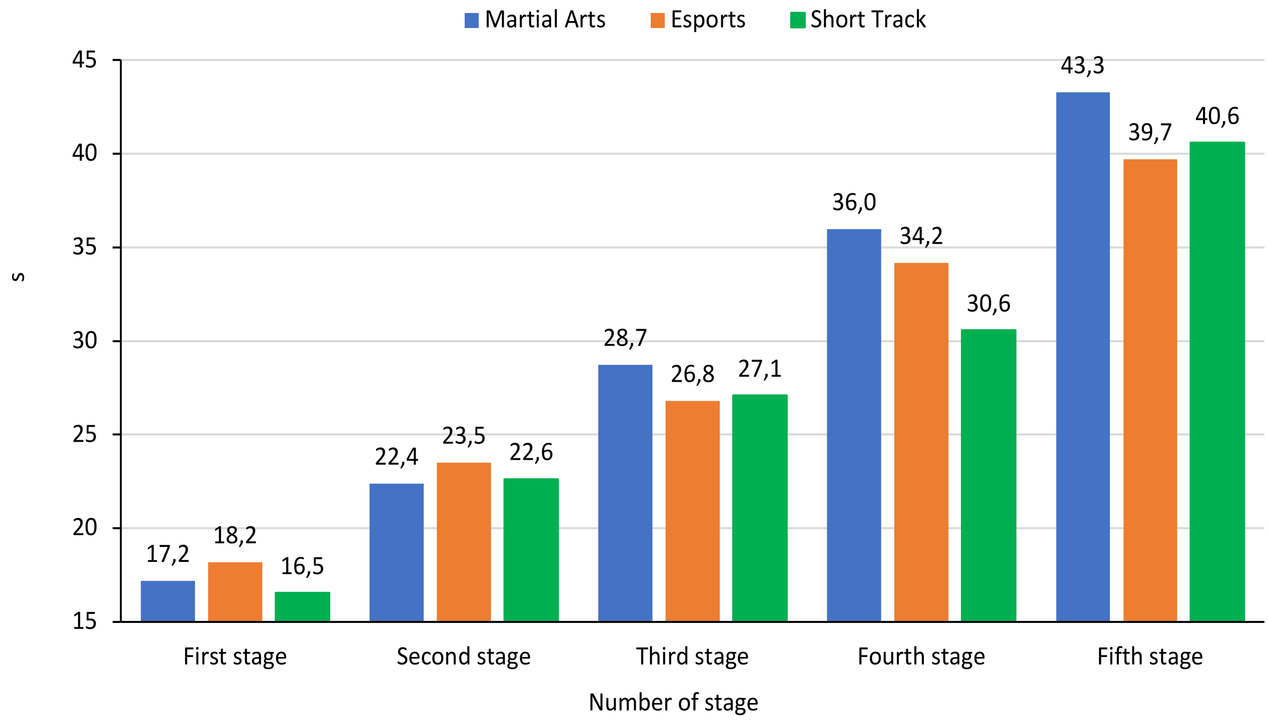

Figure 4. Comparison of the duration of the test stages for athletes of different specializations

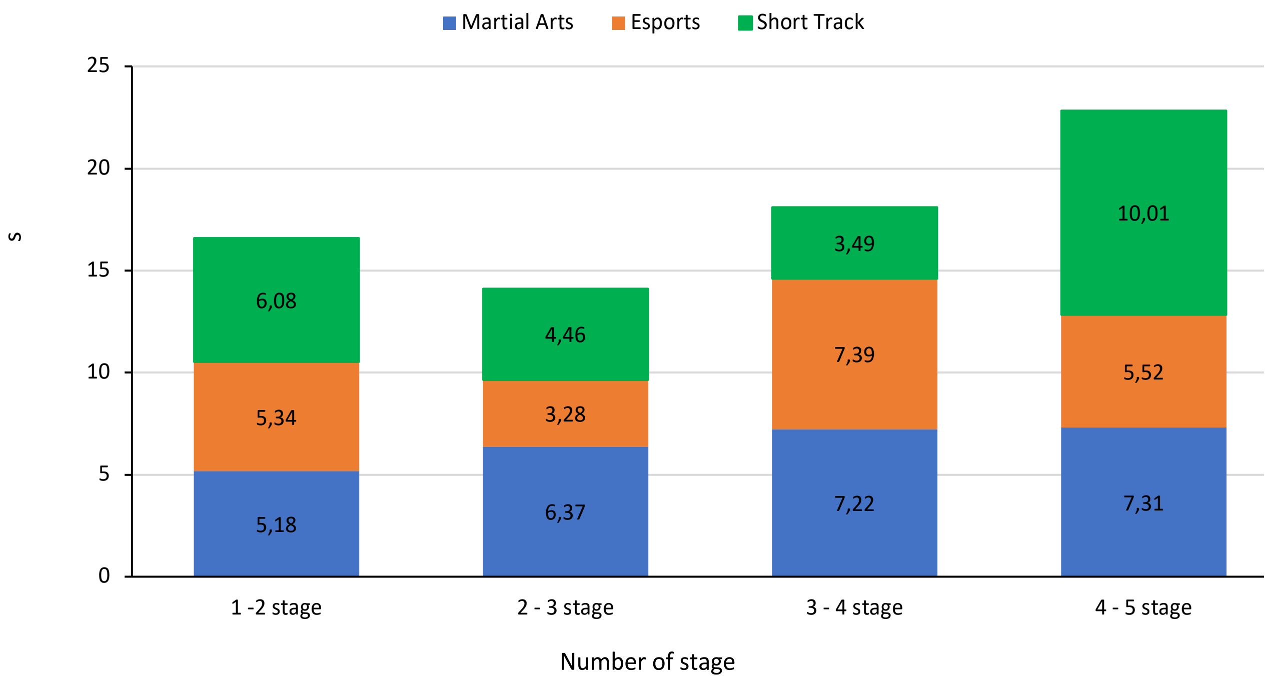

Figure 5. Difference between the duration of successive stages of the short-term visual memory test

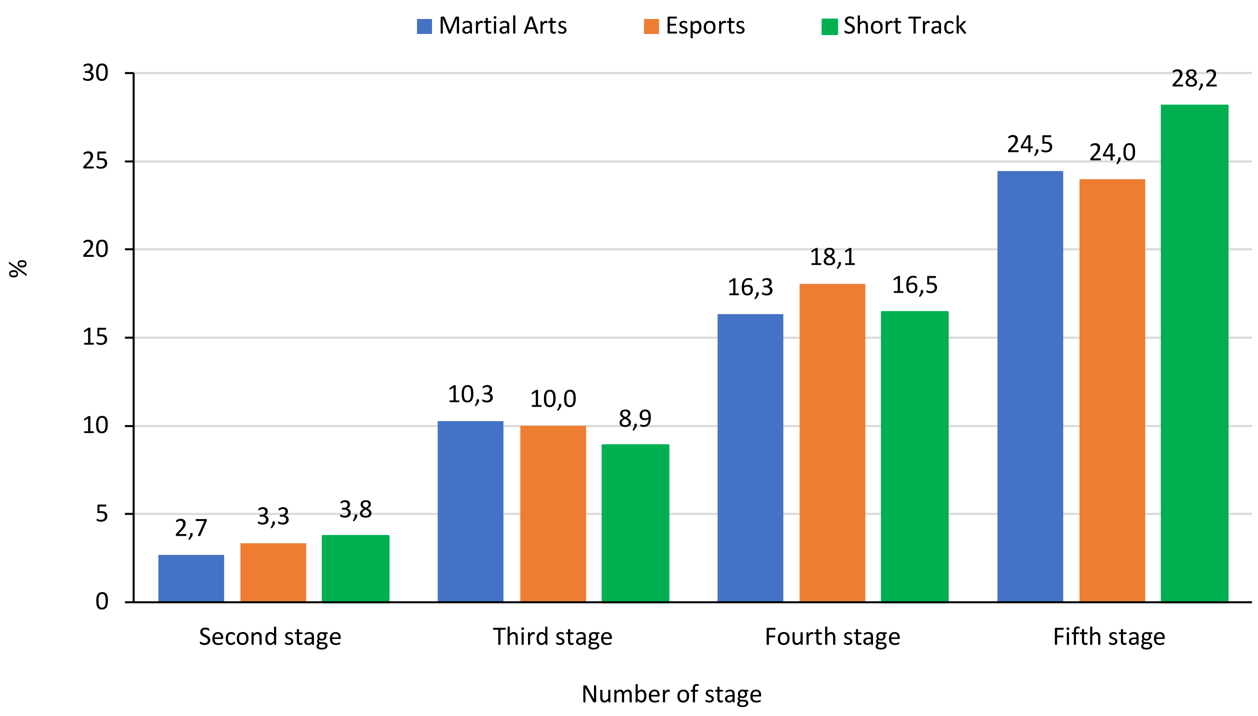

Figure 6. Comparison of the percentage of errors at the stages of the test for athletes of different specializations

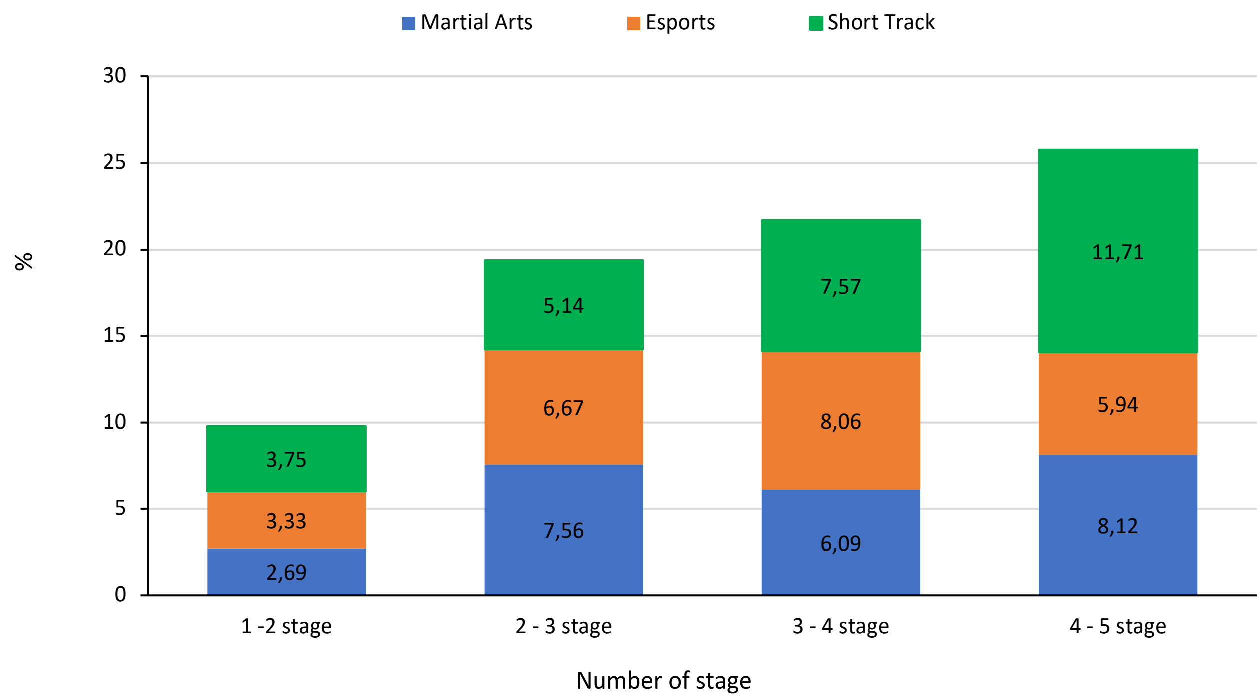

Figure 7. The difference between the percentage of errors in successive stages of the short-term visual memory test

Discussion

This work is a continuation of a series of studies to determine the features of the manifestation of the psychomotor qualities of athletes in cyclic sports, martial arts and esports [15, 16]. To determine the features of the manifestation of these qualities, caused by the specifics of sports specialization, we studied the performance of highly qualified athletes. This design is quite common in sports science [14, 17, 18]. An analysis of the state of highly qualified athletes allows you to clearly determine the specifics of the influence of sports loads on the body, to find out what qualities are leading to success [17, 19].

A similar study design was used by Horoshuha et al. [11] to determine the effect of training loads on the development of visual memory function in athletes of different sports of different directions. We analyzed the performance of athletes in speed-strength sports (boxing, wrestling, athletics: sprint, hurdling, jumping, shot put and discus throw), endurance sports (skiing, cycling, swimming 200, 400 and 1500 m) and compared them with a group of student-athletes of the same age who are involved in different sports. The parameters were determined using the “memory for geometric shapes” method. When performing this test, the subject was presented with 7 forms depicting geometric shapes; the task was to memorize their location for 30 seconds and then reproduce the numbers on a blank registration form for 45 seconds. A greater influence on the indicators of visual memory in sports associated with the manifestation of endurance has been determined [11].

As noted earlier [3], short-term memory is one of the leading components of the psychophysiological state of athletes. It ensures the adequacy of the response to changes in the situation, to a certain extent, allows you to predict its changes. Therefore, it is most important in sports where success depends on it. This is what led to the choice of participants in the study.

In our opinion, the absence of significant differences in the average indicators of short-term visual memory in athletes of various sports specializations proves the validity of this assumption.

This confirms the data of Grushko et al. about the fact that sports activities require equally high levels of perceptual and cognitive abilities from professionals. In a comparative analysis of representatives of sports games and esports, it was found that cyberathletes and gamers coped equally well with complex tests on attention control, short-term and working spatial memory, attention distribution, reaction time, and hand-eye coordination. Cyberathletes also surpassed gamers in the speed of visual search [14].

According to the coefficient of short-term visual memory, martial arts athletes showed the best result, short-track athletes showed the worst result. In our opinion, this trend is due to the higher situational nature of martial arts and the relatively large space in which objects important for perception are located during competitive activity. A similar situation was observed in relation to the average percentage of errors - martial artists made the smallest number of them among all three types with the highest efficiency coefficient.

More information about the specifics of the manifestation of short-term visual memory is provided by the analysis of these indicators at different stages of the test. For representatives of all three sports specializations, the reaction time improves with each stage of the test up to and including the fourth stage, and at the fifth stage it has a slight increase. This is due to the fact that the last stage involved the most difficult task of all five. The cyberathletes had the least number of errors exactly at the last, most difficult stage of the test.

The shortest average duration of the test was recorded in short track athletes. They also demonstrated the fastest reaction time across all test steps among the three specializations. Although in two of the four stages of the test, these athletes made more mistakes. That is, they tended to respond more quickly, which was associated with a decrease in the accuracy of the choice.

Figure 2 shows the same type of dynamics of the reaction of athletes from different sports at the stages of the test. All participants in the transition from stage 1 to stage 2 significantly reduced the reaction time to stimuli. In our opinion, this may be due to adaptation to the conditions of the test, a kind of involvement in the work. At subsequent stages, changes in reaction time did not exceed 10%, that is, they can be considered insignificant. This gives grounds for some conclusions. Firstly, the duration of the test must be recognized as adequate to the functional capabilities of the athletes, the test does not cause the formation of fatigue. Secondly, all participants had the same type of reaction time dynamics, regardless of the sport. It should also be construed as illustrating compliance with the sport-specific test.

The details in Figure 3 also lead to interesting conclusions. Cyberathletes were characterized by the greatest time dynamics of the 1st and 2nd stages, the second place was taken by combatants. This is a reflection of the best adaptive abilities of these participants, the ability to change as quickly and qualitatively as possible depending on the environment. In our opinion, this feature is specific for sports where there is a rapid change in circumstances, that is, martial arts and esports. For short track athletes, this feature is not important; these athletes do not need drastic changes in tactics during the race.

The results of Figure 4 allow us to evaluate another highlight of the studied sports. In our opinion, cyberathletes are characterized by the best ability to keep the reaction time at the required level. This can be explained by the peculiarities of sports activities in this sport. All participants are in a state of constant tension, but the state of cyberathletes has some differences. They expect information on hostile objects to appear on the screen, and the nature of this information is as close as possible to the conditions of the test. Therefore, the dynamics of the duration of the test stages in cyberathletes is more optimal than in representatives of other sports.

For representatives of martial arts and esports, as the number of visual signals increases, the percentage of errors increases proportionally. Short track athletes have a sharp increase in errors at the 5th stage. In our opinion, such a reaction may be associated with the fatigue of the analyzers caused by the need to simultaneously perceive a large number of signals. The results of Figure 5 also illustrate the specifics of the studied sports. In our opinion, they may be related to the fact that in short track the leading property is the pace of work (clicks), and not the accuracy of response to external stimuli, especially at the last stage, when there were more signals. It can be assumed that the specificity of the competitive activity of short track athletes does not require a large amount of perception, in contrast to situational sports, in particular martial arts.

The results of Figure 6 once again prove the assumptions made earlier. Cyberathletes perform the most difficult stage of the test best, since the specifics of this sport require constant monitoring of the state of objects on the screen. This load is more common for cyberathletes than for martial artists and short track athletes. That is, this criterion has significant diagnostic and prognostic significance and can be recommended for selection and prediction in esports.

In esports, competitive activity is associated with the need to visually control a significant number of signals on the monitor screen and quickly respond to them. Therefore, cyberathletes have an increase in the percentage of errors at stage 4, which may be a reaction to an increase in the number of visual signals. At the same time, a decrease in the percentage of errors at the fifth stage indicates their ability to be mobilized due to the stabilization of nervous processes and a certain level of stress resistance. This can be explained by the specifics of the activity in this sport. Being in a state of constant tension, lack of time, cyberathletes must be able to mobilize. The result is an optimization of the accuracy of the work. This is precisely the criterion that distinguishes highly qualified athletes.

The results of Figure 7 indicate a trend towards an increase in the percentage of errors with each subsequent stage of the test compared to the previous one. But it is noteworthy that at the end of the test, cyberathletes had the slightest difference between the number of errors compared to representatives of other sports. This once again proves the correctness of the assumptions made earlier on the specific ability of cyberathletes to perform actions quickly and with better accuracy.

Another factor influencing the development of the cognitive functions of athletes is the degree of sports contact. To compare pre-season and post-season changes between non-contact, contact, and collision sports over multiple seasons, Eckner et al. conducted batteries of clinical neurological studies [19]. Small but statistically significant overall differences in pre-/post-season changes were present between groups in Axon computerized neurocognitive test processing speed, attention and working memory speed (Axon-PS, Axon-Att, Axon-WMS), and total balance error scoring system score (BESS). Small seasonal drops, not exceeding thresholds for reliable change, were observed in the sports collision group compared to the contact and non-contact groups for the Axon-PS and Axon-Att scores. The collision and contact sports groups showed less pre/post-season improvement than the non-contact sports group for Axon-WMA and BESS, with smaller improvements in BESS also seen in the collision group compared to the contact sports group. In total, the longitudinal performance of all 10 outcome measures remained stable across all 3 groups over 4 years [19].

The work of Romanenko and others presents a comparative analysis of the short-term memory of martial arts athletes (taekwondo, karate, judo, sambo, Greco-Roman wrestling) of different skill levels [3, 16]. The results confirmed greater adaptation to stress in novice athletes. High-level athletes had a higher level of short-term memory and a greater ability to quickly process information. They also showed the highest degree of performance, the best ability to mobilize and save body functions [3]. This was confirmed by our results. This once again proves the validity of the assumption about the use of short-term visual memory as a criterion for differentiating athletes by skill level.

Kunzler and Carpes prove that intense exercise promotes long-term cognitive development [12]. They determined the acute effects of cycling at 60%, 80%, and 95% of maximum power output (MP) on selective attention, reaction time, and short-term memory in amateur cyclists. Short-term use of high-intensity exercise (95%) has been found to improve selective attention, but increase the variability of simple reactions without affecting short-term memory. High-intensity exercise improves the ability to manage more complex cognitive tasks, especially when task variability does not increase [12].

A study by Zoudji et al. was aimed at testing the effectiveness of the memory processes of experienced football players in a dual task, including the tasks of decision making in the subject area and the secondary memory load [20]. In their opinion, experienced athletes benefit from new, specific memory and information processing resources, such as long-term working memory, which allows them to overcome the limitation of short-term working memory for processing information under high levels of time or workload restrictions [20].

Blacker et al. have identified the positive impact of action video game activities on gamers' visual short-term memory and recommend using this genre to improve this function more broadly [21]. Chisholm and Kingstone proved that action game experience is associated with improvements in a number of cognitive tasks, namely video game players (AVGP) have greater control over the distribution of attentional resources than non-video game players (NVGP). Their results are not only consistent with the benefits of AVGP in terms of improved attentional control, but also suggest that the benefits of playing action video games extend across the full range of attention-mediated stimulus processes that affect human performance [22]. McDermott et al. used four tasks regarding specific areas of memory processing and found evidence of greater processing speed and improved short-term visual memory in AVGP and compared to NVGP [23]. They also found either equivalent or slightly reduced performance in AVGP on tasks that involve accessing long-term memory. In addition, differences in strategy for different tasks were noted, in particular, differences in the trade-off between speed and accuracy [23].

Scientists also pay attention to the study of the memory functions of athletes in extreme conditions. Billaut et al. investigated the effects of prolonged breath-hold diving training on attention processing, short-term memory, and long-term menistic and executive functions [24]. It has been established that training in breath-hold diving for several years can lead to mild but persistent short-term memory impairment [24]. Shi et al. assessed the impact of high-altitude conditions on sensory and short-term memory using interactive software [25]. The results indicate that a rapid ascent to 4,280 m and staying at that altitude for 3 hours resulted in sensory and short-term memory impairment, especially among participants who developed acute mountain sickness [25].

This study was conducted without tracking the dynamics of changes in short-term visual memory, which is a certain limitation. The determination of these indicators in different states of athletes, in particular in the conditions of sports activities, is a promising direction for further research.

Conclusions

In a comparative analysis of the indicators of short-term visual memory in athletes of short track, martial arts and esports, certain patterns were established. The closeness of the results obtained should be assessed as evidence of the high level of skill of the athletes. The same type of reaction time dynamics, regardless of the sport, illustrates the compliance with the test for their specificity. Cyberathletes and martial arts athletes were characterized by better adaptive abilities than short track athletes. This is due to the specificity of these sports, where there is a rapid change in circumstances, which requires drastic changes in tactics. Cyberathletes are also characterized by a better ability to keep reaction times at the right level. They are in a state of constant tension, waiting for information on hostile objects to appear on the screen, and the nature of this information is as close as possible to the conditions of the test. The specificity of sports activities of cyberathletes determined the best results of the most difficult stage of the test both in terms of speed and accuracy. This criterion can be recommended for esports selection and prediction.

The control of the cognitive functions of athletes is expedient in the course of monitoring their physical condition and is a promising direction for predicting the reliability and success of competitive activity.

Conflict of interests

The authors declare that there is no conflict of interests.

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