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A STUDY OF MOTOR FUNCTIONAL ASYMMETRY INDICATORS IN DIFFERENT SPORTSMANSHIP LEVEL ESPORTS ATHLETES

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Study purpose. The study purpose was to investigate and analyze the indicators of functional asymmetry in different sportsmanship level esports athletes.

Materials and methods. The study involved 20 middle-aged athletes (18±1.53 years old) divided into two groups according to their sportsmanship level. Group 1: elite players of semi-professional teams in CS:GO and DOTA 2 disciplines, n=10, aged 19.2±0.50 years. Group 2: amateur CS:GO and DOTA 2 players, n=10, aged 18.2±1.04 years. The functional asymmetry of the movements of the upper limbs was determined using a special program for tablet computers running iOS developed at the departments of martial arts, computer science and biomechanics of KhSAPC.

Results. It was established that, in terms of the number of clicks per unit of time, elite esports athletes are outperformed by amateurs by 5.54% on the left hand and by 5.14% on the right hand; in terms of visual motor reaction time, elite esports athletes prevail by 5.54% on the left hand and by 5.07% on the right hand; elite esports athletes showed a 13.3% shorter left-hand click duration, but amateurs showed a 6.83% shorter right-hand click duration.

Conclusions. Players with a higher level of preparedness tend to have less asymmetrical movements. In the proposed test, elite athletes demonstrate a greater number of movements per unit of time; at the 2nd stage of testing, the differences are significant ($p<0.05$). At the same time, the reaction time of more skilled players is less than that of amateurs; at the 2nd and 4th stages of the test, the differences are significant ($p<0.05$). Indicators of functional asymmetry of movements of the upper limbs informatively characterize the level of preparedness of esports athletes and can be included in the program for monitoring the physical condition of players in esports.

Keywords: esports, psychophysiological research, functional asymmetry, reaction time, elite esports athletes, amateur esports athletes.

Introduction

The popularity of esports as a competitive activity is growing every year due to the increase in the number of viewers, revenues, competitions and elite players (Hilvoorde, 2022). The difference between professional, semi-professional athletes, amateur esports athletes and ordinary gamers is becoming more and more noticeable (Hedlund, 2021).

Professional esports athletes are defined as players who are full-time esports players in the major league(s) of their game and are part of professional teams. Semi-professional athletes participate in esports part-time at a lower level/league than professional players and other forms of paid work. Amateurs are defined as part-time esports players at a lower level/league than semi-professional athletes (Hong & Connelly, 2022). Their experience of participating in tournaments of various levels, in particular international ones, distinguishes them from casual players. These categories of players are also united by a relatively narrow gaming specialization – focusing on one esports discipline, and professional and semi-professional players even have a corresponding gaming role (role) in the team, which also deepens the specificity of their activities (Bihari & Pattanaik, 2023). Gamers who usually practice various gaming disciplines do not necessarily have esports status. They experiment a lot with different genres and directions,

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the main motives of their gaming activities are pleasure, establishing social contacts, etc.

To become a professional athlete in the esports industry, 15 to 17 year old players train hard to acquire exceptional skills and qualities. The fight for a spot in a highly competitive industry is tough, with only a few thousand players reaching the status of a professional competitor out of an estimated 1.5 billion gamers (Toth et al., 2021). Esports athletes perform over 400 fine motor movements per minute, and professional and elite players report training and playing over 10 hours a day, which can lead to overuse, especially of the upper limbs. Carpal tunnel syndrome, lateral epicondylitis, and tendinopathies are reported to be the most common upper limb musculoskeletal disorders in esports athletes that can lead to career termination (McGee, & Ho, 2021). The health risks for players are also related to the duration of the gameplay. A study by Podrigalo L. et al. showed a significant difference in the biochemical status of video game players depending on the duration of the sessions. We observed an increase in the concentration of adrenaline in saliva, a significant decrease in the concentration of catalase, the level of SH-groups and reduced glutathione, that is, the depletion of the protective antioxidant system (Podrigalo et al., 2020). Such conditions of competitive activity require well-planned, thorough preparation of athletes for competitions, organization of the training process in compliance with the requirements of the modern system of sports training.

While the training of athletes in professional sports is based on many years of theoretical and practical scientific research, the training of esports athletes does not yet have permanent traditions and systems and is not covered by sports science. With a few exceptions, there is little research on esports training specifically. They concern, first of all, the search for effective ways to increase the efficiency of players and the definition of professional properties that ensure this efficiency (Mateo-Orcajada et al., 2023). Separate works concern the definition of the peculiarities of training athletes in various esports disciplines (Nagorsky & Wiemeyer, 2020). Particular attention deserves the construction of a long-term training system in esports, taking into account the age characteristics of players and the requirements of esports discipline. To implement this task, it is necessary to determine the most significant abilities and properties of esports athletes, allowing them to achieve maximum results in individual or team competition (Bubna et al., 2023).

Because esports games are controlled by HMI electronic systems such as keyboards and mice (Toth et al., 2021; Pluss et al., 2019), players must anticipate and respond to an opponent's stimulus as quickly and accurately as possible. Developed perceptual-motor abilities are necessary for success in e-sports, since deft control of the keyboard and mouse is the key to the effective execution of techniques (Pluss et al., 2020). At the same time, in many esports disciplines, the player must simultaneously perform different movements with the right and left hand to control the character and perform tactical tasks. Thus, high demands are placed on the speed and coordination of movements of professional players, in particular fine motor skills of the hands. This fact determines the importance of controlling the functional asymmetry of the movements of the upper limbs of athletes as a factor of professional suitability and selection parameters (Podrigalo O. et. al., 2020).

In sports science, considerable attention is paid to the study of various parameters of the body asymmetry of athletes in terms of improving the quality of performing technical actions (Krstulović et al., 2017; Warmenhoven et al., 2018; Chapelle et al., 2022), as well as from the side of possible injuries when significant indicators of asymmetry are detected (Keith et. al. 2014; Read et. al., 2018). The asymmetry of motor actions may be due to natural differences in the anatomical structure of the body, as well as the consequence of past diseases or injuries. Scientists note that a higher level of symmetry of movements indicates better sports preparedness and the level of physical development of athletes in various sports (Svetlana et al., 2018; Hernandez-Garcia et al., 2020; Romanenko et.al., 2020).

In a study by Pluss et al. (2020) determined the perceptual-motor abilities of esports athletes according to the level of experience separately for the dominant and non-dominant hand. They found that professional players have faster two-choice response times and better accuracy, and are less responsive to distracting stimuli.

Among a significant number of publications on the psychophysiological characteristics of esports athletes, insufficient attention is paid to the study of functional asymmetry of movements and features of sensorimotor reactions of the right and left hands.

Purpose of the research: to research and analyze of the indicators of functional asymmetry in esports athletes of different levels of sportsmanship.

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 Kharkiv State Academy of Physical Culture No. 38).

Participants

The study involved 20 athletes with an average age of (18±1.53) years, divided into groups according to their skill level. Group 1: elite players of semi-professional teams in the disciplines of Counter-Strike: Global Offensive (CS:GO) and DOTA 2, n=10, age (19.2±0.50) years. Group 2: amateur players with CS:GO and DOTA 2, n=10, age (18.2±1.04) years.

Procedure

With the help of the Rection SM Dual computer program, the level and features of the manifestation of motor functional asymmetry in esports athletes of different skill levels were determined. This program was developed at the departments of martial arts, computer science and biomechanics of KhSAPC for tablet computers running iOS. For testing, a test model was chosen from six stages, the duration of which was 20 s, the total test execution time was 120 s. The task of this model (model 5) during 6 stages provides for the sequential execution of actions with the hand, both hands under the influence of knocking signals and without them.

After the end of the test, the program provides the following indicators (for the left and right hands separately):

the number of clicks at each stage of the test (n); total number of clicks (n); visual-motor reaction time at each stage of the test (ms); touch duration when pressed at each stage of the test (ms); the average value of the duration of the touch when clicking on the test (ms); minimum and maximum values of visual-motor reaction for the test (ms); reaction time variation coefficient for the entire test (%); the duration of the touch when pressed at each stage of the test (ms); the average value of the duration of the touch when clicking on the test (ms); differences between hands in the speed of visual-motor reaction (ms); differences between the hands in the number of clicks (n).

Statistical analysis

Statistical processing of the results of the study 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 Student's criterion.

Results

It was found that according to the Shapiro-Wilk criterion, the distribution in both groups corresponds to the normal one at the level of α=0.05. For testing, a test model was chosen from six stages, the duration of which was 20 s, the total test execution time was 120 s. The task of this model during 6 stages provides for the sequential performance of actions with one hand, with both, under the influence of knocking signals and without them (Table 1).

Comparison of the test results of esports athletes of different levels of sportsmanship made it possible to establish the magnitude of the differences between the main test indicators. It was found that in terms of the number of clicks, elite esports athletes prevail by 5.54% on the left and 5.14% on the right hand; in terms of visual motor reaction time, elite cyber-athletes prevail by 5.54% on the left hand and 5.07% on the right hand; elite esports athletes showed a 13.3% shorter duration of pressing on the left hand, however, amateurs showed a 6.83% shorter duration of pressing on the right hand (Figure 1).

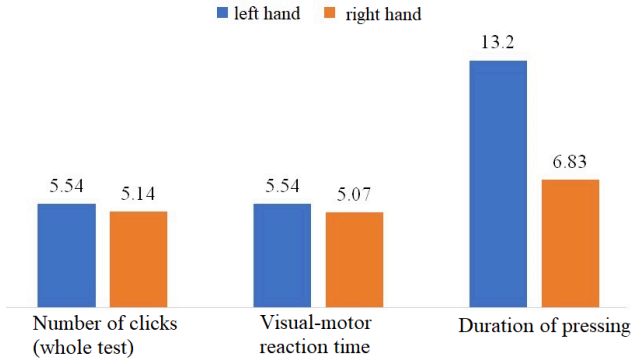

Fig. 1. Differences between the indicators of esports athletes of different levels of sportsmanship (%)

Amateur esports athletes showed a tendency to a greater asymmetry of movements with their right and left hands compared to elite athletes (Figure 2). Thus, the difference between the number of clicks with the right and left hand at different stages of the test for elite athletes is in the range from 0 to 0.14 clicks, and for amateurs – from 0 to 0.44 clicks. In both groups, more pressings were performed with the right hand. In elite athletes. three of the six stages show no difference between the number of movements of the right and left arms; amateurs have a zero difference only in 2 of the 6 stages.

The difference between the duration of pressing the right and left hand at different stages of the test for elite esports athletes is in the range from 0.29 to 3.13 ms, and for amateurs – from 6.76 to 13.14 ms (Figure 3). Elite athletes had a shorter duration of left hand pressing at all stages except the sixth. In the group of amateurs, the shorter duration of pressing was on the right hand at all stages of the

Table 1. Test results of motor functional asymmetry in esports athletes of different levels of sportsmanship (n=20)

Indicator	Hand	Elite esports athletes, n=10	Amateur esports athletes, n=10	t
		$\bar{x} \pm m$		
Number of clicks (whole test)	Left	225.86±5.30	214.00±5.11	1.61
	Right	226.29±5.34	215.22±4.98	1.51
Visual-motor reaction time (ms)	Left	53.39±1.21	56.34±1.31	1.66
	Right	53.30±1.22	56.00±1.24	1.55
Time variation coefficient (%)	Left	14.23±1.25	18.22±0.96	2.53*
	Right	13.81±1.31	17.22±0.86	2.18*
Min. response value (ms)	Left	37.81±2.64	38.52±2.90	0.18
	Right	38.89±1.36	41.57±1.27	1.44
Max. response value (ms)	Left	97.49±5.35	116.54±2.24	2.32*
	Right	93.46±5.64	115.70±7.18	2.44*
Duration of pressing (ms)	Left	56.69±4.04	64.17±2.96	1.49
	Right	58.49±2.49	54.74±2.98	0.96

Note: * significance of differences p<0.05

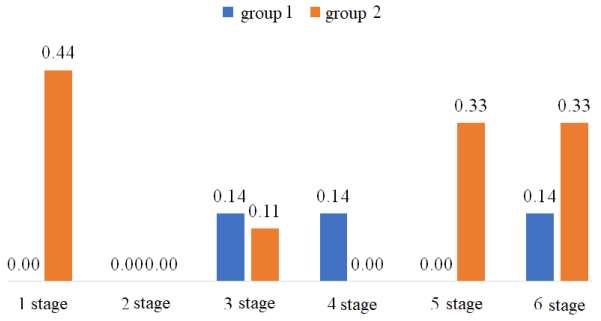

Fig. 2. The difference between the number of clicks with the right and left hand at different stages of the test among esports athletes of different levels of sportsmanship

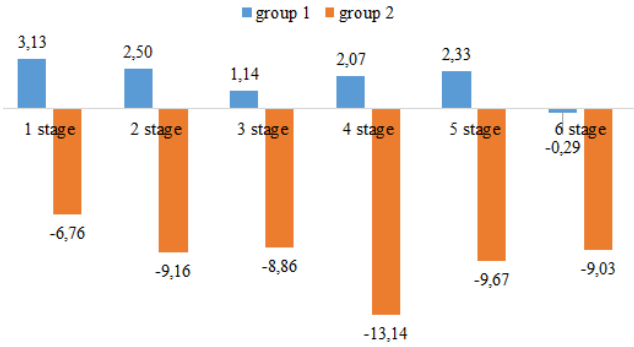

Fig. 3. Difference between the duration of pressing the right and left hand at different stages of the test in esports athletes of different levels of sportsmanship

test. At the same time, there is no difference in reaction time at all stages of the test in both groups.

Comparison of the test results of esports athletes of different skill levels made it possible to establish the magnitude of the differences between the number of clicks at different stages of the test. It has been established that elite cyber-athletes outperform amateurs in terms of results at all stages of the test. So, at the 1st stage of the test, elite cyber-athletes prevail by 1.54% on the left and 0.46% on the right hand; on the 2nd – by 9.24% on the left and right hand (differences are significant, $p<0.05$); on the 3rd – by 4.51% on the left and 4.58% on the right hand; on the 4th – by 7.07% on the left and 7.51% on the right hand; on the 5th – by 5.57% on the left and 4.65% on the right hand; on the 6th – by 6.63% on the left and 5.98% on the right hand (Figure 4).

Analyzing the reaction time at different stages of the test, it was found that elite esports athletes have a shorter reaction time compared to amateurs at all stages of the test. So, at the 1st stage of the test, elite cyber-athletes prevail by 2.94% on the left and 2.26% on the right hand; on the 2nd – by 9.28% on the left and 9.52% on the right hand (differences are significant, $p<0.05$); on the 3rd – by 4.11% on the left and 4.70% on the right hand; on the 4th – by 8.10% on the left and 7.64% on the right hand (differences are significant, $p<0.05$); on the 5th – by 4.20% on the left and 4.44% on the right hand; on the 6th – by 6.27% on the left and 5.10% on the right hand (Figure 5).

As a result of comparing the duration of pressing at different stages of the test, it was found that elite esports athletes have a shorter duration on the left hand compared to amateurs at all stages of the test; on the right hand, amateurs

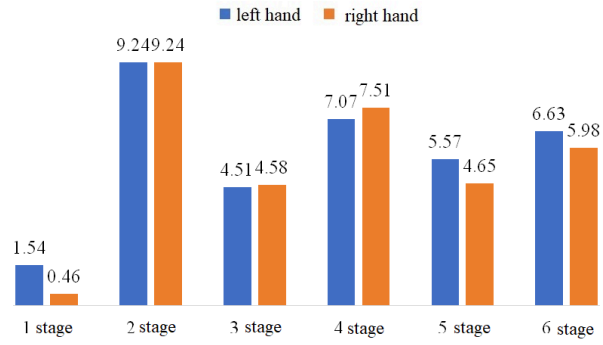

Fig. 4. Differences between the number of clicks at the stages of the test among esports athletes of different levels of sportsmanship (%)

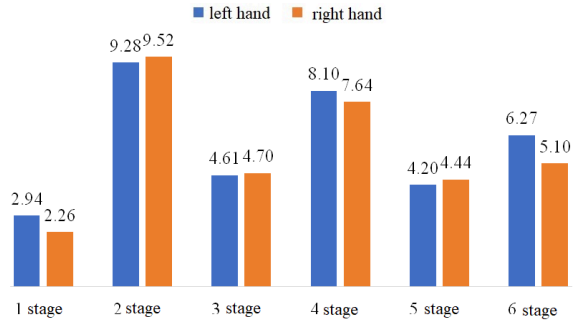

Fig. 5. Differences between the reaction time at the stages of the test for esports athletes of different levels of sportsmanship (%)

showed a shorter duration of pressing at all stages of the test. Thus, at the 1st stage of the test, elite esports athletes showed a shorter duration of pressing by 5.38% on the left hand; on the 2nd – by 11.93%; on the 3rd – by 14.14%; on the 4th – by 18.05%; on the 5th – by 15.81%; on the 6th – by 14.81%. Amateur esports athletes at the 1st stage of the test showed a shorter duration of pressing by 11.17% on the right hand; on the 2nd – by 9.30%; on the 3rd – by 2.88%; on the 4th – by 9.94%; on the 5th – by 5.90%; on the 6th – by 1.37% (Figure 6).

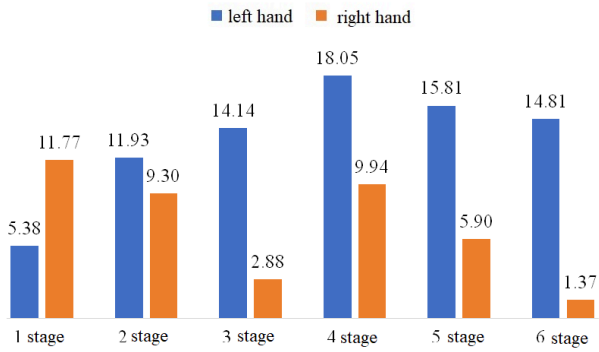

Fig. 6. Differences between the duration of pressing at the stages of the test for esports athletes of different levels of sportsmanship (%)

Discussion

The design of the study involved a comparison of athletes involved in the same sport, differing in the level of sportsmanship. This allows you to appreciate the importance

of asymmetry to achieve a high level of skill. A similar design was used by Rovnaya et al. (2016) to compare the functional state of female athletes of aesthetic swimming of different skill levels, which made it possible to identify quality predictors of academic performance. The study of the psychophysiological characteristics of athletes allows us to identify the most important factors influencing the effectiveness of competitive activity. The results in a certain way reflect the specific impact of a sport on the state of the body of athletes (Podrigalo, O. et al., 2020). A similar design variant was used by Podrigalo L. et al. when comparing the biochemical parameters of children depending on the frequency and duration of contact with video games. This approach made it possible to identify significant differences in homeostatic indicators in children belonging to the group of active players compared to those who do not have contact with computer games. Activation of the sympathoadrenal system and lipid peroxidation were accompanied by a decrease in antioxidant protection and inhibition of nonspecific resistance of the body (Podrigalo L. et al., 2020).

In this study, a modern, effective and convenient tool for the study of functional asymmetry in the upper limb was used – the "Reaction SM Dual" program for tablet computers. Despite its universality, the expediency of its use for the study of esports athletes is due to the structure of movements familiar to them, which is the basis of the test. The frequency and nature of the signals that appear on the screen during testing are also somewhat similar to the stimuli in the game. The study involved athletes specializing in the disciplines CS:GO and DOTA 2. The legitimacy of their association in one group is explained by the fact that in both disciplines the players perform basic techniques using a computer mouse and keyboard. The touch control panel that was used in testing is not a specific way to control any of the games, so all athletes were on a relatively equal footing.

In es ports, both specific and general components of motor actions play an important role. The game is controlled by specific sensorimotor actions (skills) on interfaces and sensors, such as hand-mouse, finger-keyboard or hand-joystick interaction, as well as body-camera or body-force-platform interaction (Hebbel-Seeger A., 2012). To move avatars, change or use weapons, or control vehicles, you need to control input devices such as mouse, gamepad, and keyboard in some way. Therefore, esports includes complex physical interactivity, but adapted to the specific perceptual and sensorimotor conditions of the virtual world (McCutcheon. 2017). For successful and purposeful interaction, either hand and finger movements ("manual dexterity") or body movements are used.

The results of the study indicate that elite players tend to have better rates of movement frequency, reaction time, and greater symmetry of motor actions with the right and left hand. No significant differences were found in the average test results, however, the analysis of these values at all stages of the test indicates the best results of more qualified athletes. Also, elite athletes have significantly better maximum reaction times in the test ($p<0.05$). In terms of reaction time variation, there are also significant differences with amateurs – the group of elite athletes turned out to be more homogeneous in terms of reaction time ($p<0.05$). Better test scores for more qualified athletes reflect their better performance levels. Experienced athletes are quicker to cope with the task. Therefore, they show a greater number of clicks per unit of time, a shorter response time to a signal. The best mobilization score is also displayed when you reduce the time you tap on the device screen. That is, according to all indicators of the test, experienced athletes have an advantage. This is confirmed by preliminary studies of qualified athletes in tkhekwondo, taekwondo, karate (Podrigalo L. et.al., 2019; Romanenko et al., 2020), judo (Krstulović et al., 2017), rowing (Warmenhoven et. al., 2018).

The study of asymmetry is an actual area of research in sports. Hernandez-Garcia et al. (2020) emphasize that asymmetry analysis is a simple, economical and informative tool for monitoring the condition of athletes. In particular, the study of the asymmetry indicators of athletes of different skill levels allows us to determine their characteristics and apply this knowledge in the construction of training programs. In this case, the goal is to achieve greater symmetry between the right and left parts of the body (Warmenhoven et. al., 2018; Romanenko et.al., 2020).

Hilvoorde and Pot (2016) consider that snooker and billiards show some similarities with esports, since the main skill is associated with skillful aiming and indirect movement of objects. Although the intensity of the movements may vary, these sports involve the development of complex coordination skills and the ability to move the body and/or the tool used to move the object. Although in e-sports the whole body is not displaced, but the existing indirect nature of the action aimed at controlling the virtual object. In billiards, players must also master the technique of hitting the ball from different positions of the table with both hands, but there are no requirements for the speedy execution of techniques.

Kim H. et al. (2022) investigated the perceptual-motor abilities of professional esports athletes and amateurs. Professional esports athletes demonstrated better latency and peripheral perception (wider field of view in degrees) than amateurs. Professional esports athletes constantly pressed the button before the stimulus arrived, but the eye-hand coordination was the same as amateurs. These results indicate that esports can further develop perceptual motor skills and lead to higher levels of certain perceptual motor skills.

Ersin et al. (2022) assessed the auditory, visual and aim reaction time of the players according to the duration of the playing time. Visual and aim reaction times were higher for gamers who practiced for more than 14 hours. The study showed that the visual and aim reaction time had a greater effect on the game time than on the players' auditory reaction time.

In the work of Nagorsky and Wiemeyer (2020), a six-factor structure of esports competencies was defined: 1) physical skills (conditional training); 2) sensorimotor or coordination competencies; 3) strategically cognitive competencies; 4) mental competencies; 5) social competencies; 6) competencies related to media. In the course of the following analysis, the factor structure of the critical components of training in e-sports was determined: 1) the speed of actions; 2) strategy and psychophysical readiness; 3) sensorimotor control. This study confirms our data on the importance of sensorimotor qualities in esports.

The new generation of first-person shooter (FPS) games (compared to previous generation games) is not only about

pressing one button at the right time, but also requires players to have flexible thinking, allowing them to participate in complex scenarios, quickly respond to moving visual and sudden acoustic events. as well as switching between different subtasks (Colzato et al., 2010). So, cognitive properties occupy an important place in the professional profile of a cyberathlete.

Previous research has also shown that experienced video game players outperform amateurs on cognitive and perceptual tasks related to visual selective attention (Leigh & Clark, 2022), visual stimulus detection and visual search performance (Pluss et al., 2020) contrast sensitivity (Kim et al., 2022), cognitive flexibility (Colzato et al., 2010), visual short-term memory (Bubna et al., 2023), decision making and attention switching (Bihari & Pattanaik, 2023).

Green and Bavelier (2010) have shown that action games improve behavioral performance in a wide range of perceptual tasks, from those that require efficient allocation of attentional resources across a visual scene to those that require successful identification of fleeting stimuli. This effect has not only been observed in experienced esports athletes, but a causal relationship has also been established between playing video games and improved information processing.

Conclusions

The competitive activity of athletes in a number of eSports disciplines, in particular CS:GO and DOTA 2, requires fast and accurate finger and hand movements. Such movements predetermine the performance of technical methods, which consist in controlling a virtual game character. Technical actions are performed simultaneously with both hands on the keyboard and mouse. In right-handed people, the mouse is usually supervised by the right hand, and the keyboard by the left. Left-handers have different ways of arranging control devices – similar to right-handers or located the other way around. The requirements of competitive activity lead to the need for well-coordinated work of hands and quick sensorimotor reactions of athletes. Therefore, the study of functional asymmetry indicators is an important area of scientific research in esports.

The study of the functional asymmetry of the upper limbs in esports athletes was carried out using the "Reaction SM Dual" program for tablet computers. This program is a reliable, informative and convenient tool for assessing the indicators of sensorimotor reactions and the frequency of movements per unit of time with the right and left hands.

Comparison of the results of testing esports athletes of different skill levels showed that players with a higher level of preparedness demonstrate a tendency to less asymmetric movements. In the proposed test, elite athletes demonstrate a greater number of movements per unit of time; at the 2nd stage of testing, the differences are significant ($p<0.05$). At the same time, the reaction time of more skilled players is shorter compared to amateurs; at the 2^{nd} and 4^{th} stages of the test, the differences are significant ($p<0.05$).

Indicators of functional asymmetry of movements of the upper limbs informatively characterize the level of preparedness of esports athletes and can be included in the program for monitoring the physical condition of players in cybersport.

Conflict of interests

The authors declare no conflict of interest.

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ДОСЛІДЖЕННЯ ПОКАЗНИКІВ МОТОРНОЇ ФУНКЦІОНАЛЬНОЇ АСИМЕТРІЇ КІБЕРАТЛЕТІВ РІЗНОГО РІВНЯ МАЙСТЕРНОСТІ

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Реферат. Стаття: 8 с., 1 табл., 6 рис., 31 джерело.

Мета дослідження. Дослідити та проаналізувати показники функціональної асиметрії у кібератлетів різного рівня майстерності.

Матеріали і методи. У дослідженні взяли участь 20 атлетів середній вік (18±1,53) років, розподілених на групи відповідно до рівня майстерності. 1 група: елітні гравці напівпрофесійних команд з дисциплін CS:GO і DOTA 2, n=10, вік (19,2±0,50) років. 2 група: гравці-аматори з CS:GO і DOTA 2, n=10, вік (18,2±1,04) років. Функціональну асиметрію рухів верхніх кінцівок визначали за допомогою спеціальної програми для планшетних комп›ютерів під управлінням iOS, розробленої на кафедрах єдиноборств, інформатики та біомеханіки ХДАФК.

Результати. Встановлено, що за кількістю натискань за одиницю часу елітні кібератлети переважають аматорів на 5,54% на лівій та 5,14% на правій руці; за часом зорово-моторної реакції елітні кібератлети переважають на 5,54% на лівій та 5,07% на правій руці; елітні кібератлети показали меншу на 13,3% тривалість натискань на лівій руці, проте аматори показали меншу на 6,83% тривалість натискань на правій руці.

Висновки. Гравці вищого рівня підготовленості демонструють тенденцію до меншої асиметричності рухів. У запропонованому тесті елітні атлети демонструють більшу кількість рухів за одиницю часу, на 2-му етапі тестування відмінності мають достовірний характер ($p<0,05$). При цьому час реакції більш кваліфікованих гравців є меншим у порівнянні із аматорами, на 2-му та 4-му етапах тесту відмінності мають достовірний характер ($p<0,05$). Показники функціональної асиметрії рухів верхніх кінцівок інформативно характеризують рівень підготовленості кібератлетів та можуть бути включені до програми моніторингу фізичного стану гравців у кіберспорті.

Ключові слова: кіберспорт, психофізіологічне дослідження, функціональна асиметрія, час реакції, елітні кібератлети, кібератлети аматори.

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