Fighting Style of Qualified Veteran Boxers. Monograph

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The monograph presents reveaingl the fighting style of veteran boxers based on the individual factor structure of psychophysiological and biomechanical indicators.The study involved 42 qualified veteran boxers (aged 45-50). A biomechanical analysis of the indicators of the movement speed of various points and the values of the joint angles while performing a direct blow by boxers has been used as a research method. The psychophysiological method has been used to determine the time of a simple and complex reaction under standard conditions and in various testing modes. Descriptive Statistics and Factor Analysis have been applied as methods of statistical analysis. Two main factors have been identified in the structure of the complex performance of qualified veteran boxers,. Factor 1 (55.063% of the total aggregate variance) is named "Speed". Factor 2 (44.937% of the total aggregate variance) stands for “Speed Endurance”. Individual factor structure, which is characterized by the distinctive factor "Speed and Coordination Endurance" by more than 80% as well as by the marked factor "Speed" by less than 30% is considered to be a particularity of the tempo style boxers. Individual factor structure, which is characterized by the intensity of the factor "Speed" by more than 80%, and by the distinctive factor "Speed and Coordination Endurance" by less than 30% is considered to be typical for the playing style boxers. The individual factor structure, which is characterized by the marked factor "Speed" by more than 50%, and by the intencity of the factor "Speed and Coordination Endurance" by less than 30% is seen to be peculiar to the strength style boxers. It is shown that the psychophysiological features of boxers of different fighting styles are reflected in the features of the direct strike technique. The lack of speed at the beginning of the movement in tempo style boxers is supplemented and compensated by the high speed of movement. Playing style boxers are characterized by a high speed of movement at the very beginning of the strike. Strength style boxers are characterized by the gradual development of movement speed.

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CONTENT

Introduction

Currently, the development of veteran sports is being observed. Boxing is no exception [1, 2]. Boxing for middle-aged and elderly people has different motives: maintaining physical fitness, maintaining and acquiring skills and abilities of self-defense, relieving psychological stress, and others [2]. Boxing is of particular importance for athletes who have already finished their sports career and who have a certain sports qualification [3–5]. For qualified veteran boxers, in addition to the motives of maintaining their physical shape, maintaining and improving self-defense skills, relieving psychological stress, continuing boxing is important to improve individual skill, sharpening technique, the ability to continue fighting in the ring with equal and superior opponents, the opportunity to feel at the peak struggle and feel like a winner [2, 5].

The continuation of sports by qualified athletes has certain specific features. This is due to the fact that with age after 30 years, sarcopenia occurs - a decrease in muscle mass [6]. This is mainly due to the loss of fast muscle fibers, which are responsible for the development of speed and strength. [7, 8] In this case, endurance decreases in a different way than strength and speed, in some cases, up to 35-40 years, endurance even increases [8].

How does the compensation for the loss of strength and speed occur in middle-aged and elderly people who continue boxing? Masters of ancient martial arts continued active classes all their lives, improving their technical skills [1]. This indirectly helps to preserve physical qualities as well [9]. In this regard, the study of the individual technical skill of qualified veteran boxers is important not only for building the training process of middle-aged and elderly boxers, but also from the point of view of a deep understanding of the patterns of individual skill development as sports continue.

The famous martial artist Bruce Lee pointed out that any movement is a manifestation of the human soul [1]. This means that as technical skill improves, there is also an increase in the manifestation of individual psychological and psychophysiological characteristics that characterize the features inherent only in this particular person [3, 10, 11]. Therefore, it is important to study the relationship between the individual characteristics of the technical skill of qualified veteran boxers and their psychophysiological functions. Psychophysiological indicators are a physiological reflection of mental processes, that is, manifestations of the soul, which can be measured instrumentally using objective research methods [12]. A number of studies have shown that psychophysiological indicators are the basis for the style of fighting boxers [3, 12, 13].

In the modern European tradition, there are several classifications of fighting styles in boxing [3, 14]. For example, the classical international classification of styles in boxing mixes such categories as the distance between opponents and the nature of the blows [15]. This classification distinguishes between outfighters, punchers, swarmers (infighters), sluggers. The outfighter uses fast long strikes. Fighters of this style must have a high impact speed and excellent reaction. The puncher strives to fight

at medium range and tries to defeat the opponent with a series of punches. Swarmers or infighters deliver multiple combinations of punches. The most important qualities of a swarmer: Speed and coordination endurance and the ability to maintain good coordination of movements and aggressiveness for a long time to impose a tempo on the opponent. A slugger or brawler often lacks good footwork, which is compensated for by the force of the blow. The most important qualities for a slugger are strength and reaction speed. In the classification adopted in the CIS countries, fighting styles are based on physical qualities [3]. Thus, boxers who win through strong knockout blows are distinguished by high blow power. Power is determined by the product of strength and speed. Therefore, these boxers are characterized by the manifestation of speed-strength abilities, mainly due to strength. This style of fighting is called power. Boxers who win due to their high speed abilities and agility, as well as due to the ability to quickly vary their actions, belong to the playing style of the fight. Boxers who impose a tempo on the opponent and are able to maintain this tempo for a long time to wear down their opponents belong to the tempo style of fighting [16].

Currently, no studies have been carried out to identify analogies between the European classification and the classification adopted in the CIS countries. However, both the European classification and the classification adopted in the CIS countries have some common features. So, the reaction speed is one of the defining qualities for the formation of the style of the duel [17–20]. The reaction speed is one of the manifestations of psychophysiological functions that determine the style of fighting [3, 12, 19].

There are many different methods for measuring psychophysiological functions: direct methods that are directly related to surgical intervention in the brain and indirect, but no less objective [21-24]. For example, indirect methods for studying the psychophysiological characteristics of a person include measuring the speed of reaction to a viewed object, to sound, to an object that changes its position in space, the ability to accurately reproduce certain intervals of time, and others [21, 23]. At present, methods of studying psychophysiological functions are becoming more widespread, which make it possible to determine not only the reaction rate, the sense of time, but also the typological properties of the nervous system: strength, mobility, resistance to stimuli in time. It can be noted that at present psychophysiological methods of research make it possible to instrumentally objectively record the manifestations of the “soul” [12, 13].

The features of a technical master, which are the basis for the style of activity, are determined using biomechanical research methods, which involve video analysis of the trajectory, speed, time of movement of various points of the body in space, as well as analysis of criminality in the joints in the dynamics of movements [15, 25–27].

Currently, the study of psychophysiological functions in connection with the individual characteristics of the technique of movements according to biomechanical indicators is of great importance. This makes it possible to quantitatively determine how and how the peculiarities of brain activity affect the formation of an individual style of human activity [3, 12, 13]. For this purpose, qualified veteran boxers are one of the most suitable contingents for such studies for several reasons: 1 - as a person's age increases, there is an improvement in technical skill while continuing to engage in

a certain type of activity, including sports; 2 - as the age increases, the manifestation of individual psychological and psychophysiological traits occurs; 3 - the study of the peculiarities of technical mastery of qualified athletes of middle and elderly age in conjunction with the individual characteristics of psychophysiological functions is important as a tool for cognition of motor and psychophysiological manifestations of various styles of activity [2].

However, there is much less scientific research on veteran athletes today than on younger active athletes. This provision concerns all aspects of studying the characteristics of the training process of qualified athletes: the development of physical qualities (strength, speed, endurance, flexibility, dexterity), psychological preparation, improvement of technical skill, alternation of load and rest, the use of various methods of restoration of working capacity and other aspects [28] ... Despite the high relevance, the least studied issue is the relationship between the characteristics of technical skill and psychological (psychophysiological) functions. Therefore, the determination of the relationship between psychophysiological and biomechanical indicators at the present stage is a relatively new, previously not studied, task.

The study of relationships is traditionally carried out using correlation analysis [29]. At the present stage, the use of factor analysis is also very widespread [30]. Factor analysis is used when it is necessary to identify the relationship between a large number of indicators and reduce these indicators to a smaller number of factors. Each factor brings together a group of the most interrelated indicators. Indicators included in different groups, while little related to each other. Thus, the determination of the factor structure of various aspects of any state (including the fitness of athletes) allows us to reveal the hidden relationships between different indicators reflecting different aspects of this state, in our case, the fitness of athletes [31].

In sports, it is also relevant to identify the individual severity of each factor for each case (athlete). This makes it possible to analyze the characteristics of the readiness of each athlete not only by individual indicators, but in a complex way, by groups of interrelated indicators. Thus, an individual factorial structure of athletes' fitness is obtained [31, 32].

In this regard, in order to identify the relationship between the peculiarities of the nervous system and the technical skill of athletes, it is most expedient at present to determine the general and individual factor structure of readiness based on the analysis of biomechanical and psychophysiological indicators.

Individual Factorial Structure of Biomechanical and Psychophysiological Indicators as a Basis for Determining the Fighting Style of Qualified Veteran Boxers

Introduction

Currently, the development of veteran sports is being observed. Boxing is no exception [1, 2]. Boxing for middle-aged and elderly people has different motives: maintaining physical fitness, maintaining and acquiring skills and abilities of self-defense, relieving psychological stress, and others [2]. Boxing is of particular importance for athletes who have already finished their sports career and who have a certain sports qualification [3–5]. For qualified veteran boxers, in addition to the motives of maintaining their physical shape, maintaining and improving self-defense skills, relieving psychological stress, continuing boxing is important to improve individual skill, sharpening technique, the ability to continue fighting in the ring with equal and superior opponents, the opportunity to feel at the peak struggle and feel like a winner [2, 5].

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In this regard, in order to identify the relationship between the peculiarities of the nervous system and the technical skill of athletes, it is most expedient at present to determine the general and individual factor structure of readiness based on the analysis of biomechanical and psychophysiological indicators.

Purpose: to reveal the fighting style of veteran boxers based on the individual factor structure of psychophysiological and biomechanical indicators.

Material and methods

Participants

The study involved 42 qualified veteran boxers (age 45-50 years, body length - 178.67 ± 8.26 cm, body weight - 70.96 ± 9.38 kg). The total experience of boxing for the participants was 20-25 years. Athletes differed in the following way: a prerequisite for participation in the study was the presence of a sports qualification in the past not lower than a candidate for master of sports (winners of competitions not lower than the city and regional level) and the regularity of training for the last 10 years 3-4 times a week. The study was carried out on the basis of sports clubs "KhTZ", "Vostok", "Metalist" in Kharkov, Ukraine.

All participants were aware of the objectives of the study and agreed to participate.

Procedure

The study was conducted from April 18 to May 25, 2021. At first, video filming of athletes was carried out when performing a direct blow in boxing. Each athlete performed a series of strikes alternately with the right and left hands in the training session against the background of a visible object for subsequent calibration with known dimensions. Video filming was carried out at training sessions from 18-00 after a short warm-up in the boxing gym of the KhTZ sports club. During one training session, 10-12 people were filmed. The next day after the video filming, the athletes underwent psychophysiological testing also from 18-00. When conducting psychophysiological testing, athletes were initially asked to pass the proposed tests in a training mode. Psychophysiological testing was carried out in the classroom for theoretical studies of the sports club "KhTZ".

Biomechanical Analysis of Direct Punch Technique in Boxing

We have chosen the direct punch as the main element for the analysis of the athletic technique of qualified veteran boxers. The choice of direct hit was due to the fact that it is the main technical element in boxing. This stroke is the most standardized of all boxing elements and provides the least variability in execution. This element is perfectly mastered by all qualified boxers, in particular - veteran boxers. Also, the individual style of movements is most traced precisely in those movements that are performed most automatically, that is, with minimal control from the side of consciousness. This blow is the most convenient for biomechanical analysis using video filming, since it is performed practically in the same plane.

Biomechanical analysis of the direct kick technique in qualified veteran boxers was carried out using the Kinovea software, version 0.8.15. (Fig. 1). Kinovea software allows you to perform video motion analysis. It is intended for athletes, coaches, health professionals, and sports research. Also, the software can be useful for specialists in the field of ergonomics or animation. The main function of Kinovea is to view and

analyze sports videos. The main tools used by users are "Line", "Chronometer", "Tracking", "Angles". The Line and Chronometer functions allow you to measure distance and time, while the Semi-automatic tracking tool can track both path and time. When working with Kinovea, you can use video from external sources: video cameras, smartphones, and so on [33, 34].

To analyze the biomechanical parameters of the direct strike technique of qualified veteran boxers, 6 frames were selected at a speed of 26 frames per second. Thus, the time of one frame was 0.03-0.04 s (Fig. 1-3). The duration of the direct impact was 0.13-0.16 s, depending on how many frames were analyzed (5 or 6, respectively). The distance was calibrated along the length of a special device, against the background of which video filming was carried out (138 cm). The movement time was determined by the stopwatch indicators in the program. The speed of movement of the fist, shoulder joint, elbow joint, knee joint was determined (V, ms-1) (Fig. 1). We also determined the angles between the shoulder and the torso (angle at the shoulder joint), between the shoulder and forearm (angle at the elbow joint), between the thigh and lower leg (angle at the knee joint) (degrees) (Fig. 1).

A total of 10 videos of a direct hit were analyzed for each athlete. Of the 10 videos, the best movement speed metrics were analyzed for each athlete. The total number of video recordings was 420. The point of greatest extension of the striking arm in the elbow and shoulder joints was chosen as the end of the impact. In each video, 6 frames were selected for analysis (duration of a direct impact). If the impact ended on the fifth frame, then the sixth frame was excluded from the analysis. Earlier in the fifth frame, more than one athlete did not end up with a direct hit. Thus, the total duration of a direct blow in boxing among qualified veteran boxers was 0.13-0.16 s: the first frame - 0 s (start of movement), the second frame - 0.03 s, the third frame - 0.06 s, the fourth frame is 0.10 s, the fifth frame is 0.13 s, and the sixth frame is 0.16 s. The point of the minimum angle between the shoulder and the torso (shoulder joint), from which the movement of the striking arm begins, was chosen as the start of the strike. Some athletes performed a swing first and pulled their arm back before starting the strike. For these athletes, the point was taken as the beginning of the strike, from which the forward movement of the striking arm began. The angle at the shoulder joint in this case had a negative value.

To analyze the angles in the joints, the "Angles" tool was selected on the toolbar of the Kinovea 0.8.15 program. The point of the apex of the angle was selected, then the angle for analysis was determined. The angle chosen for analysis was determined in each frame (Fig. 1).

Fig. 1. Determination of the speed of movement of various points of the body and angles in the joints when performing a direct blow in boxing using the program Kinovea 08.15

Tracking the trajectory for the subsequent analysis of the distance and speed of movement of each point, we carried out as follows (Fig. 1): 1 - select a point for analysis; 2 - select the "Track Path" option; choose the "End Path Edition" function; 3 - the analyzed point was corrected for each frame; 4 - Select the "Configuration" function and set the "Distance" function. The display showed the distance from the beginning of the movement to the selected segment of the path. To measure the speed of a point, we selected the “Configuration” function, and then we selected the “Speed” function. We chose meters per second as the unit of measurement. The measurement results were exported to the EXCEL program.

Psychophysiological methods

With the help of the computer program "Psychodiagnostics" (Kharkiv, Ukraine, KhNPU), the following parameters were established that characterize the psychophysiological state, typological features of the nervous system, indicators of the performance of the nervous system and indicators of attention [35]:

- a set of indicators of the time of a simple visual-motor reaction (average value of 30 attempts (ms), standard deviation (ms), number of errors; duration of exposure (signal) - 900 ms.
- a set of indicators of a complex visual-motor reaction of choosing 2 elements out of 3 (average value of 30 attempts (ms), standard deviation (ms), number of errors; duration of exposure (signal) - 900 ms.
- a set of indicators of a complex visual-motor reaction of the choice of 2 elements out of 3 in the feedback mode, i.e. when the response time changes, the signaling time changes.

The "short version" is carried out in the feedback mode, when the duration of exposure changes automatically depending on the response of the subject: after the correct answer, the duration of the next signal is reduced by 20 ms, and after the wrong one, it increases by the same amount. The range of variation of the signal exposure during the work of the subject is 20–900 ms, with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button when displaying a certain exposure (image) or during a pause after the current exposure. In this test, the time to reach the minimum signal exposure and the time to the minimum signal exposure reflect the functional mobility (speed) of nervous processes; the number of errors reflects the strength of nervous processes (the lower these parameters, the higher the speed endurance of the nervous system) [12, 13, 36]. The duration of the initial exposure is 900 ms; the value of the change in the duration of signals with correct or erroneous answers is 20 ms; pause between signal presentation - 200 ms; number of signals - 50. Indicators. which were recorded: the average value of the latency period (ms); standard deviation (ms); number of mistakes; test execution time (s); minimum holding time (ms); time to reach minimum signal exposure (s).

Statistical analysis

We used the following statistical analysis methods using the SPSS - 17.0 program.

1. Descriptive statistics (Analyze - Descriptive Statistics). We used this method to get an overview of the analyzed sample of qualified veteran boxers. We calculated the following indicators: Minimum, Maximum, Mean value $(\overline{x})$, standard deviation (S). In total, 52 indicators were analyzed, of which - 42 indicators of the biomechanics of the direct hitting technique in boxing and 10 indicators of the psychophysiological capabilities of athletes.

2. Factor analysis by the method of principal components. We used factor analysis to identify hidden relationships between variables and to reduce 52 analyzed indicators to fewer factors. We also used factor analysis to determine the individual severity of each factor for each athlete. For each athlete, the values of a large number of variables were translated into values of a small number of factors.

Before carrying out the factor analysis, all indicators of the examined athletes were checked using the Chi-square test for compliance with the normal distribution. After obtaining the results confirming the compliance with the normal distribution of all indicators used in factor analysis, further calculations were carried out, requiring compliance with the normal distribution of the analyzed indicators.

At the beginning of the factor analysis procedure, we analyzed the correlation matrix. Correlation analysis showed that most indicators are closely correlated with each other ($r = 0.7\text{-}0.9$; $p < 0.05$; $p < 0.01$ $p < 0.001$) (Appendix 1).

Factor analysis was performed using the following SPSS 17.0 software options: Analyze - Dimension Reduction - Factor. We have chosen to infer the following data: Initial solution, Correlation matrix, eigenvalues of factors. When generating the factors, the default option was left: the eigenvalues of the factors are greater than 1. Thus, in the explained Total Variance Explained, the factors were formed only by those

components whose eigenvalues are greater than 1. The maximum number of iterations for convergence was also left the default is 25. The rotation method was chosen Varimax with Kaiser normalization. The option was used to derive factor loadings (correlation coefficients between individual variables and factors) after rotation. Factor loads were sorted in descending order. The derivation of factor loadings (correlation coefficients of indicators with factors) less than 0.7 was excluded. The derivation of indicators with unreliable factor loadings was also excluded. Based on the analysis of the indicators that were included in each factor, we gave names to the factors.

We used the values of the factors for each case (for each athlete) in absolute values and in values expressed as a percentage of the maximum value for a given sample. Thus, we have obtained a general and individual factor structure of the complex readiness of qualified veteran boxers based on the analysis of biomechanical and psychophysiological indicators.

Results

The analysis of biomechanical and psychophysiological indicators of qualified veteran boxers showed the following (Table 1). The average values of the speed of a simple visual-motor reaction, a choice reaction, a choice reaction in the feedback mode, the time to reach the minimum signal exposure, the time of the minimum signal exposure, the total test execution time among qualified veteran boxers does not differ from the values of qualified boxers and representatives of other martial arts aged 18-25 years [3, 11]. However, the number of errors in the selection reaction test in the feedback mode in our sample was less than in younger athletes. For young qualified boxers this value was 22-23 errors, for veteran boxers this value was 18.67 ± 1.26, Minimum = 17, Maximum = 20. The data obtained indicate that qualified veteran boxers have a higher ability to maintain high efficiency of the nervous system when performing tasks that require high speed and accuracy within a certain period of time (90-120 s). This also indicates that qualified veteran boxers have higher speed and coordination endurance of the nervous system.

The greatest scatter in the values of the angles in the joints was detected at 1-2 frames (0-0.03 s from the beginning of the movement) (Table 1). This is due to the fact that some boxers, at the beginning of a direct blow, perform a backward movement with their hand for a swing. As a result, the maximum angle at the shoulder joint at the beginning of the movement is (-7.00) degrees. However, most athletes perform this movement from a positive shoulder position. At the end of the movement (4-6 frames, 0.10-0.16 s from the beginning of the movement) the value of the angle in the shoulder joint is 65.33 ± 0.95 degrees (Table 1). The angles in the elbow joint range from 65.33 ± 0.95 to 158.33 ± 10.66 degrees. The angles in the knee joint are 135.00 ± 7.16 degrees to 154.67 ± 12.04 degrees (Table 1).

Thefist movement speed ranges from 2.28 ± 0.83 m·s-1 to 9.78 ± 1.64 m·s-1. The shoulder movement speed ranges from 1.60 ± 0.66 $m \cdot s^{-1}$ to 3.34 ± 1.73 $m \cdot s^{-1}$. The elbow movement speed ranges from 1.68 ± 0.20 $m \cdot s^{-1}$ to 5.75 ± 1.84 $m \cdot s^{-1}$. The knee movement speed ranges from 0.55 ± 0.16 $m \cdot s^{-1}$ to 2.31 ± 0.18 $m \cdot s^{-1}$ (Table 1).

Table 1

Values of biomechanical and psychophysiological indicators of qualified veteran boxers

Indicators	Minimum	Maximum	$\bar{x}$	S
Simple visual-motor reaction time (ms)	292.00	314.00	302.00	9.20
Selection response time (ms)	525.00	590.00	561.00	27.32
Errors in the test for reaction of choice (number)	1.00	13.00	8.67	5.50
Standard deviation of selection response time (ms)	3.61	3.72	3.65	0.05
Selection response time in feedback mode (ms)	449.00	513.00	471.67	29.63
Errors in the selection reaction test in the feedback mode (number)	17.00	20.00	18.67	1.26
Standard deviation of response time of selection in feedback mode (ms)	3.84	4.05	3.98	0.10
The minimum signal exposure time in the test for the selection reaction in the feedback mode (ms)	400.00	540.00	460.00	59.59
Total time to complete the test for the selection reaction in the feedback mode (s)	94.00	107.00	99.33	5.63
Time to reach the minimum exposure of the signal in the test for the selection reaction in the feedback mode (s)	43.00	73.00	55.33	12.97
Shoulder angle at position * 1 (degrees)	-12.00	37.00	12.25	16.45
Shoulder angle at position 2 (degrees)	-7.00	38.00	15.50	17.63
Shoulder angle at position 3 (degrees)	55.00	77.00	67.00	9.20
Shoulder angle at position 4 (degrees)	78.00	86.00	82.33	3.34
Shoulder angle at position 5 (degrees)	75.00	96.00	86.33	8.76
Shoulder angle at position 6 (degrees)	75.00	96.00	86.33	8.76
Elbow angle at position 1 (degrees)	58.00	91.00	70.67	14.70
Elbow angle in position 2 (degrees)	64.00	66.00	65.33	0.95
Elbow angle at position 3 (degrees)	49.00	82.00	69.33	14.70
Elbow angle at position 4 (degrees)	107.00	160.00	130.67	22.27
Elbow angle at position 5 (degrees)	144.00	169.00	158.33	10.66
Elbow angle at position 6 (degrees)	122.00	177.00	150.00	22.74
Knee angle in position 1 (degrees)	119,00	147,00	137,00	12,91
Knee angle in position 2 (degrees)	125.00	140.00	135.00	7.16
Knee angle in position 3 (degrees)	128.00	148.00	137.67	8.28
Knee angle in position 4 (degrees)	142.00	157.00	147.33	6.93
Knee angle in position 5 (degrees)	143.00	163.00	151.67	8.48
Knee angle in position 6 (degrees)	143.00	171.00	154.67	12.04
Fist movement speed in position 1 ($m \cdot s^{-1}$)	0.00	0.00	0.00	0.00
Fist movement speed in position 2 ($m \cdot s^{-1}$)	1.15	3.09	2.28	0.83
Fist movement speed in position 3 ($m \cdot s^{-1}$)	4.63	17.52	9.78	1.64
Fist movement speed in position 4 ($m \cdot s^{-1}$)	6.47	11.50	8.37	1.26

Fist movement speed in position 5 ($m \cdot s^{-1}$)	2.07	8.74	5.56	1.76
Fist movement speed in position 6 ($m \cdot s^{-1}$)	0.86	3.31	2.47	0.15
Shoulder speed in position 1 ($m \cdot s^{-1}$)	0.00	0.00	0.00	0.00
Shoulder speed in position 2 ($m \cdot s^{-1}$)	1.29	2.37	1.88	0.45
Shoulder speed in position 3 ($m \cdot s^{-1}$)	1.74	5.71	3.34	1.73
Shoulder speed in position 4 ($m \cdot s^{-1}$)	1.06	2.52	1.60	0.66
Shoulder speed in position 5 ($m \cdot s^{-1}$)	1.06	2.41	1.79	0.56
Shoulder speed in position 6 ($m \cdot s^{-1}$)	0.66	0.91	0.80	0.11
Elbow speed in position 1 ($m \cdot s^{-1}$)	0.00	0.00	0.00	0.00
Elbow speed in position 2 ($m \cdot s^{-1}$)	1.65	2.89	2.45	0.57
Elbow speed in position 3 ($m \cdot s^{-1}$)	3.17	7.04	5.75	1.84
Elbow speed in position 4 ($m \cdot s^{-1}$)	4.32	5.94	5.36	0.75
Elbow speed in position 5 ($m \cdot s^{-1}$)	1.51	4.74	3.27	1.35
Elbow speed in position 6 ($m \cdot s^{-1}$)	1.50	1.96	1.68	0.20
Knee speed in position 1 ($m \cdot s^{-1}$)	0.00	0.00	0.00	0.00
Knee speed in position 2 ($m \cdot s^{-1}$)	1.39	3.81	2.31	0.18
Knee speed in position 3 ($m \cdot s^{-1}$)	0.83	5.10	2.29	2.01
Knee speed in position 4 ($m \cdot s^{-1}$)	0.36	3.81	1.70	1.53
Knee speed in position 5 ($m \cdot s^{-1}$)	0.29	0.91	0.55	0.16
Knee speed in position 6 ($m \cdot s^{-1}$)	0.23	1.69	1.11	0.64

Notes: * position 1 - frame 1, 0 s from the beginning of the movement (the beginning of the movement); position 2 - frame 2, 0.03 s from the beginning of the movement; position 3 - frame 3, 0.06 s from the beginning of the movement; position 4 - frame 4, 0.10 s from the beginning of the movement; position 5 - frame 5, 0.13 s from the beginning of the movement; position 5 - frame 6, 0.16 s from the beginning of the movement

The test for normality of distribution of test indicators showed that all test indicators correspond to the normal distribution (Asymptomatic significance according to the χ^2 test>0.05; significance according to the Monte Carlo test> 0.05). The distribution of indicators of the analyzed sample does not significantly differ from the Gaus normal distribution (Table 2).

Table 2

χ^2 testtest results of biomechanical and psychophysiological indicators of qualified veteran boxers (n = 42)

Indicators	Simple visual-motor reaction time (ms)	Selection response time (ms)	Selection response time in feedback mode (ms)	Errors in the selection reaction test in the feedback mode	The minimum exposure time of the signal to the test for the selection	Time to reach the minimum exposure of the signal in the test for	Total time to complete the test for the selection reaction in the
χ^2	1.71	3.71	0.00	4.286	0.00	0.00	0.00
df	41	41	41	41	41	41	41
Asymp. Sig.	0.2	0.90	0.009	0.09	0.99	0.99	0.99

Monte Carlo Sig.	Sig.	0.48	0.90	0.999	0.525	0.99	0.99	0.99							
95% Confidence Interval	Lower Bound	0.47	0.00	0.976	0.515	0.97	0.97	0.97							
	Upper Bound	0.49	0.01	0.999	0.534	0.99	0.99	0.99							
Chi-Square		0.00	1.71	7.71	0.00	4.286	4.286	0.00	0.00	4.286	2.571	5.143	0.00	5.143	0.00
df		41	41	41	41	41	41	41	41	41	41	41	41	41	41
Asymp. Sig.		0.99	0.42	0.90	0.99	0.509	0.50	0.99	0.99	0.50	0.46	0.27	0.99	0.273	0.99
Monte Carlo Sig.	Sig.	0.99	0.48	0.00	0.99	0.525	0.52	0.99	0.99	0.52	0.49	0.27	0.99	0.279	0.9
95% Confidence Interval	Lower Bound	0.97	0.47	0.00	0.97	0.515	0.51	0.97	0.97	0.51	0.48	0.27	0.99	0.27	0.97
	Upper Bound	0.99	0.49	0.01	0.99	0.534	0.53	0.99	0.99	0.53	0.50	0.28	0.99	0.288	0.99

Notes: * position 1 - frame 1, 0 s from the beginning of the movement (the beginning of the movement); position 2 - frame 2, 0.03 s from the beginning of the movement; position 3 - frame 3, 0.06 s from the beginning of the movement; position 4 - frame 4, 0.10 s from the beginning of the movement; position 5 - frame 5, 0.13 s from the beginning of the movement; position 5 - frame 6, 0.16 s from the beginning of the movement

At the beginning of the factor analysis procedure, we analyzed the correlation matrix. Correlation analysis showed that most indicators are closely correlated with each other ($r = 0.7\text{-}0.9$; $p < 0.05$; $p < 0.01$ $p < 0.001$) (Appendix 1).

With the help of factor analysis, carried out by the method of principal components, in the structure of the complex readiness of qualified veteran boxers, 2 main factors were identified by the methods of Total Variance Explained and Kettel's "scree" (Table 3, Fig. 2). It should be noted that the total variance explains almost 100% of the squares of factor loadings (Table 3). This testifies to the large number and high reliability of the relationships between the indicators selected for factor analysis. To characterize each factor, the indicators included in it were analyzed.

The first factor (55.063% of the total total variance) (Table 3) included the following indicators: the angle at the shoulder joint at the beginning of movement ($r = 0.999$), the speed of the fist at the beginning of the movement ($r = 0.974$), the speed of the shoulder at the beginning movement ($r = 0.972$), angle at the knee joint at the end of the movement ($r = 0.67$), choice reaction time ($r = -0.956$), time of simple visual-motor reaction ($r = -0.802$), shoulder movement speed at the end movements ($r = -0.789$), errors in the selection reaction in the feedback mode ($r = 0.782$), the total time of the test for the selection reaction in the feedback mode ($r = -0.707$) (Table 4).

It should be noted that the first factor included indicators reflecting the level of speed of the nervous system (the time of a simple visual-motor reaction, the reaction time of choice, the total time of the test in the feedback mode) with a negative correlation coefficient. The shorter the reaction time, the higher the speed of the nervous system. For this, it can be noted that the first factor includes indicators reflecting the speed of the nervous system. In addition, the first factor included

indicators reflecting the speed of movements at the beginning of a direct blow in boxing (shoulder speed and speed of fist movement) with a positive correlation coefficient and the speed of shoulder movement at the end of a direct blow in boxing with a negative correlation coefficient.

That is, the speed of the nervous system is positively related to the speed of movements at the beginning of a direct strike and is negatively related to the speed of shoulder movement at the end of a direct strike. It is no coincidence that the first factor included the indicator of the angle in the shoulder joint at the beginning of the strike with a positive relationship. The greater the speed of movement of the shoulder, the greater the value and angle in the shoulder joint. But the first factor also included the indicator of the number of errors in the test for the response of choice in the feedback mode. This indicates that with an increase in the speed of movements and the speed of the nervous system, the speed endurance of the nervous system decreases, that is, the ability to maintain high accuracy with increasing speed over time. As for motor abilities, this fact has an explanation, since endurance and speed are antagonists [31, 32].

From the data obtained, it follows that the work of the nervous system has the same regularities as the work of the muscular apparatus. This is not accidental, since the muscular work characteristic of any movement is guided by the nervous system [37–39]. And therefore, the properties of the nervous system also affect the speed and accuracy of movements over time. Thus, the first factor included indicators that reflect the speed of movements at the beginning of a direct blow in boxing, the speed of the nervous system and are negatively associated with the speed endurance of the nervous system. Based on the analysis of the indicators included in the first factor, this factor was named "Speed".

The second factor (44.937% of the total total variance) (Table 3) included the following indicators: the speed of the shoulder movement at the end of the movement ($r = 0.892$), the number of errors in the selection reaction test in the feedback mode ($r = -0.985$), the total time of the test for the selection reaction in the feedback mode ($r = 0.707$), the angle at the shoulder joint at the end of the movement ($r = 0.995$), the speed of the fist at the end of the movement ($r = 0.982$), the angle at the elbow joint at the end of the movement ($r = 0.978$), the minimum signal exposure time in the test for the selection reaction in the feedback mode ($r = 0.96$), the speed of the knee ($r = 0.918$) and elbow ($r = 0.914$) movements at the end of the movement, the speed of the elbow at the beginning movement ($r = 0.886$), time to reach the minimum signal exposure ($r = 0.874$), angle in the knee joint at the beginning of movement ($r = -0.845$), speed of knee movement at the beginning of movement ($r = 0.766$) (Table 4).

It should be noted that the second factor included indicators that reflect the endurance of the nervous system, if necessary, to maintain a high speed and accuracy of response (the number of errors in the selection reaction in the feedback mode with a negative correlation coefficient). The second factor included indicators opposite to the speed of the nervous system under short-term stimuli, reflecting the mobility of the nervous system (total time of the test for the speed of reaction in the feedback mode, the reaction time in the test for the speed of reaction in the feedback mode, the

time for reaching the minimum exposure of the signal in the test for the speed of reaction in the feedback mode) with positive correlation coefficients.

Accuracy of movements and accuracy of the nervous system is a manifestation of coordination [13]. Speed and coordination (precision) endurance is oppositely related to the mobility and mobility of the nervous system. This also follows from the general laws of the relationship of various qualities: endurance and speed are antagonists [32]. Also, the second factor included indicators of the speed of movements of the shoulder, elbow and fist at the end of the movement with a positive correlation coefficient. This indicates that the second factor reflects the ability to develop speed at the end of the movement, which is typical for people with a large development of endurance. But the second factor also includes the rate of elbow movement at the beginning of the movement, which is a reflection of the speed. In combination with other indicators of the second factor, this is a reflection of speed endurance. That is, the second factor is characterized by a high level of speed and coordination endurance at a relatively lower speed of the nervous system at the beginning of movements and during short-term tasks.

The second factor also included the indicator of the angle in the knee joint with a negative correlation coefficient and the indicator of the knee movement speed with a positive correlation coefficient. That is, to ensure a high level of speed and coordination endurance at a relatively low speed of a simple visual-motor reaction and a choice reaction, leg work acts as a compensatory mechanism. This leads to an increase in the speed of movement, requires greater flexion of the legs in the hip and knee joints and a decrease in the angles in the joints of the legs, in particular, a decrease in the angle in the knee joint [15]. Based on the analysis of the indicators that were included in the second factor, this factor was named "Speed endurance".

Table3

Explained total variance in factor analysis of biomechanical and psychophysiological indicators of qualified veteran boxers

Total Variance Explained								
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance	Total	% of Variance	Cumulative %
1	28.54	63.421	63.421	28.54	63.421	24.778	55.063	55.063
2	16.46	36.579	100	16.46	36.579	20.222	44.937	100
3	2.77E-15	6.15E-15	100					
4	2.65E-15	5.90E-15	100					
5	2.41E-15	5.35E-15	100					
6	2.18E-15	4.83E-15	100					
7	2.06E-15	4.57E-15	100					
8	1.85E-15	4.11E-15	100					
9	1.75E-15	3.88E-15	100					

10	1.64E-15	3.64E-15	100					
11	1.38E-15	3.07E-15	100					
12	1.34E-15	2.98E-15	100					
13	1.27E-15	2.82E-15	100					
14	1.02E-15	2.26E-15	100					
15	8.17E-16	1.82E-15	100					
16	7.51E-16	1.67E-15	100					
17	6.84E-16	1.52E-15	100					
18	4.99E-16	1.11E-15	100					
19	3.82E-16	8.48E-16	100					
20	3.46E-16	7.68E-16	100					
21	2.01E-16	4.46E-16	100					

Notes. Extraction Method: Principal Component Analysis.

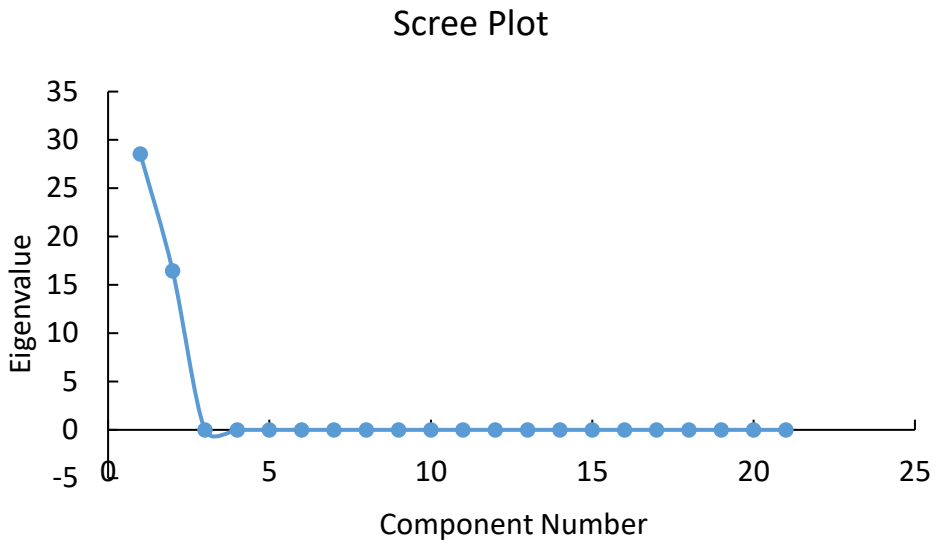

Fig. 2. Component Eigenvalue Plot - Kettell Scree

Table4

Rotated component matrix in factor analysis of biomechanical and psychophysiological indicators of qualified veteran boxers

Indicators	Rotated Component Matrix(a)	
	Component	
	1 «Speed»	2 «Speed and coordination endurance»
Shoulder angle at position * 3 (degrees)	0.999	
Fist movement speed in position 3 ($m \cdot s^{-1}$)	0.974	
Shoulder speed in position 3 ($m \cdot s^{-1}$)	0.972	
Knee angle at position 5 (degrees)	0.967	
Selection response time (ms)	-0.956	

Simple visual-motor reaction time (ms)	-0.802	
Shoulder speed in position 5 ($m \cdot s^{-1}$)	-0.789	0.892
Errors in the test for reaction of choice (number)	0.782	-0.985
Total time to complete the test for the selection reaction in the feedback mode (s)	-0.707	0.707
Shoulder angle at position 5 (degrees)		0.995
Fist movement speed in position 5 ($m \cdot s^{-1}$)		0.982
Elbow angle at position 5 (degrees)		0.978
The minimum exposure time of the signal to the test for the selection reaction in the feedback mode (ms)		0.96
Knee speed in position 5 (m·s-1)		0.918
Elbow speed in position 5 ($m \cdot s^{-1}$)		0,914
Elbow speed in position 3 ($m \cdot s^{-1}$)		0.886
Time to reach the minimum exposure of the signal in the test for the selection reaction in the feedback mode (s)		0.874
Knee angle in position 2 (degrees)		-0.845
Knee speed in position 2 ($m \cdot s^{-1}$)		0.766

Notes. Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Shown are the correlation coefficients of indicators with factors (factor loadings) greater than 0.7
* position 1 - frame 1, 0 s from the beginning of the movement (the beginning of the movement); position 2 - frame 2, 0.03 s from the beginning of the movement; position 3 - frame 3, 0.06 s from the beginning of the movement; position 4 - frame 4, 0.10 s from the beginning of the movement; position 5 - frame 5, 0.13 s from the beginning of the movement; position 5 - frame 6, 0.16 s from the beginning of the movement

Further, the individual factor structure of the athletes' fitness was determined. For this, the percentage values of the severity of each factor were determined for each boxer (Table 5). Table 5 shows that all athletes have different severity of both factors, which indicates the presence of significant individual differences. This should be manifested in different fighting styles and in the need for individual training programs for qualified veteran boxers.

Table 5

Individual severity of the factors of complex readiness of qualified veteran boxers based on the analysis of biomechanical and psychophysiological indicators

Case	Absolute individual values of factors		Individual values of factors, expressed as a percentage of the maximum values in the sample of athletes	
	Factor 1	Factor 2	Factor 1	Factor 2
1	35.50	21.50	84.52	51.19
2	7.50	35.50	17.86	84.52
3	21.50	7.50	51.19	17.86
4	34.68	20.72	83.19	50.26

5	7.68	35.79	19.65	85.64
6	19.86	6.48	52.28	18.75
7	35.50	21.50	84.52	51.19
8	7.50	35.50	17.86	84.52
9	21.50	7.50	51.19	17.86
10	34.68	20.72	83.19	50.26
11	7.68	35.79	19.65	85.64
12	19.86	6,48	52.28	18.75
13	35.50	21,50	84.52	51.19
14	7.21	38,64	15.59	85.58
15	21.50	7.50	51.19	17.86
16	34.68	20.72	83.19	50.26
17	7.21	38.64	15.59	85.58
18	19.86	6.48	52.28	18.75
19	34.68	20.72	83.19	50.26
20	7.50	35.50	17.86	84.52
21	21.50	7.50	51.19	17.86
22	35.50	21.50	84.52	51.19
23	7.21	38.64	15.59	85.58
24	21.67	8.50	56.19	18.86
25	34.68	20.72	83.19	50.26
26	7.50	35.50	17.86	84.52
27	21.50	7.50	51.19	17.86
28	34.68	20.72	83.19	50.26
29	7.68	35.79	19.65	85.64
30	19.86	6.48	52.28	18.75
31	35.50	21.50	84.52	51.19
32	21.67	8.50	56.19	18.86
33	21.67	8.50	56.19	18.86
34	35.50	21.50	84.52	51.19
35	7.21	38.64	15.59	85.58
36	21.50	7.50	51.19	17.86
37	35.50	21.50	84.52	51.19
38	35.50	21.50	84.52	51.19
39	21.50	7.50	51.19	17.86
40	34.68	20.72	83.19	50.26
41	7.21	38.64	15.59	85.58
42	21.67	8.50	56.19	18.86

The analysis of table 5 shows that some athletes (group 1) have a predominant severity of the factor "Speed and coordination endurance" (more than 80% of the maximum value) and insignificant (less than 30% of the maximum) severity of the factor "Speed" (athletes 2; 5; 8; 11; 14; 17; 20; 23; 26; 29; 41) (n = 11)) (Table 5, Fig. 3). This means that these athletes are distinguished by their ability to maintain high speed and accuracy (coordination) of actions for a long time. That is why we named this group “Speed and coordination endurance”. This group of athletes, according to their indicators, can be attributed to the style of fighting, requiring a high level of endurance with the support of a relatively high speed of movements. It is logical to assume that these athletes gravitate towards the tempo style of fighting.

In athletes of the second group, the severity of the factor "Speed" prevails (more than 80% of the maximum) and the average (about 50% of the maximum) severity of the second factor "Speed and coordination endurance" (athletes No. 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31; 32; 34; 37; 38, 40 (n = 16)) (Table 5, Fig. 3). That is, these athletes are capable of high-speed actions at the beginning of movements and in average severity of speed and coordination endurance. These qualities are most typical for boxers with a playing style of fighting.

There is also a group of athletes (group 3) in whom the factor "Speed" is less pronounced than in athletes of the second group and more than in athletes of the first group (about 50% of the maximum), with a slight severity of the factor "Speed and coordination endurance" (less than 30% of the maximum) (athletes No. 3; 6; 9; 12; 15; 18; 21; 24; 27; 30; 33; 35; 36; 39; 42 (n = 15)) (table . 5, Fig. 3). Since all the athletes who participated in the experiment were equally successful in sparring in the ring, it can be considered that the athletes of the third group achieve success due to other qualities, in particular, speed-strength qualities. Speed-strength qualities require the development of maximum power, which is defined as the product of strength and speed [31, 32]. According to Hill's equation, strength and speed are antagonistic qualities and are in a hyperbolic relationship with each other [31, 32]. Therefore, the maximum value of the product of strength and speed is found with an average expression of both qualities. We did not measure strength in this study because biomechanical analysis does not represent strength capability. We can draw conclusions indirectly about the manifestation of strength abilities. These athletes are characterized by an average manifestation of speed with low endurance. Therefore, we can conclude that these athletes are dominated by strength and speed. This most characterizes the power style of fighting, since the maximum impact force requires the development of power, that is, strength and speed [3, 11].

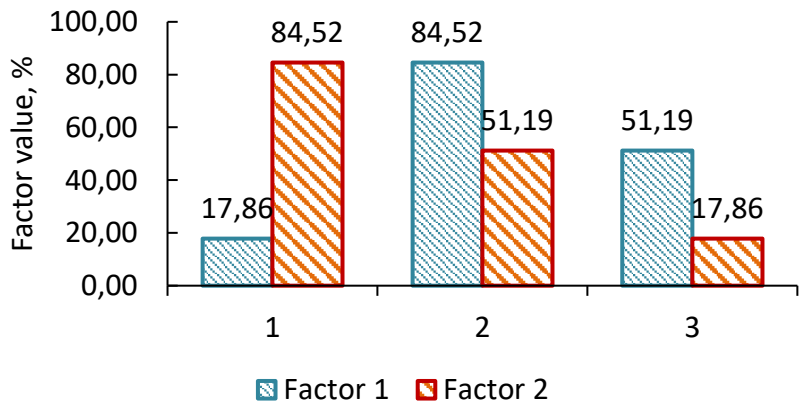

Fig. 3. Individual values of the factors of athletes (examples)

1 - athlete 1, the factor "Speed and coordination endurance" prevails with a slight severity of the factor "Speed" (tempo style of fighting);

2 - athlete 2, the factor "Speed" prevails with an insignificant severity of the factor "Speed and coordination endurance" (playing style of conducting a duel);

3 - athlete 3, the average severity of the "Speed" factor with an insignificant severity of the "Speed and coordination endurance" factor (strength style of fighting)

The analysis of the indicators that were included in each factor, in accordance with the individual severity of the factors, made it possible to determine the individual biomechanical characteristics of athletes - representatives of different styles of fighting. The indices, which formed each factor, determine the peculiarities of the fighting style of qualified veteran boxers. The greatest differences among athletes of different styles of fighting are observed in the angle of the knee joint (the angle between the thigh and the lower leg): the smallest value both at the beginning and at the end of the movement is observed among boxers of the tempo style - “Speed and coordination endurance” (Fig. 4). The same applies to the speed of movement, that is, the speed of movement of the point of the knee joint (Fig. 5). The obtained facts can be explained by the fact that tempo-style boxers compensate for the lower level of speed of nervous processes by the speed of movement, which requires more flexion of the legs in the knee and hip joints.

The speed at the beginning of the movement (0-0.06 s from the beginning of the movement) of the fist and shoulder is the highest among the representatives of the “Speed” group (playing style) (Fig. 5). That is, the speed capabilities determine the execution of movements at maximum speed at the beginning of the movement. Representatives of the groups of tempo style (“Speed and coordination endurance”) and power style (“Strength and speed”) develop the highest speed at the end of the movement (Fig. 5).

According to the indices included in each factor (Table 4), qualified veteran boxers with a high level of speed and coordination endurance manifestation (tempo style of fighting) are characterized by the least number of errors when performing the test for choice reaction in the feedback mode and average speed development reaction, work in a low stance with a high speed of movement and the development of maximum speed at the end of the movement or evenly throughout the movement.

Qualified veteran boxers with a high level of manifestation of speed capabilities and an average level of manifestation of speed and coordination endurance (playing style of fighting) are characterized by a high level of development of reaction speed, a relatively large number of errors in the test for the choice reaction in the feedback mode, work in a high stance and development of maximum speed at the beginning of the movement.

Qualified veteran boxers with an average level of speed abilities and a low level of speed and coordination endurance manifestation (strength style of fighting) are characterized by a high number of errors when performing the test for the choice reaction in the feedback mode and a high level of development of reaction speed, work in a high stance and development of maximum speed at the end of the movement.

Thus, the psychophysiological features of boxers of different styles of fighting are reflected in the features of the direct strike technique. The lack of speed at the beginning of the movement in tempo style boxers is supplemented and compensated by the high speed of movement. This ensures the maintenance of speed throughout the entire fight and creates the conditions for victory due to the fact that boxers of other fighting styles cannot maintain high endurance for accurate and fast actions for a long time, realizing their potential at the very beginning of the movement. Playing style boxers are characterized by a high speed of movement at the very beginning of the strike. This provides the possibility of short rest breaks and thus creates conditions for variability of actions. Power style boxers are distinguished by the gradual development of the speed of movement, which creates conditions for the implementation of the power of the blow.

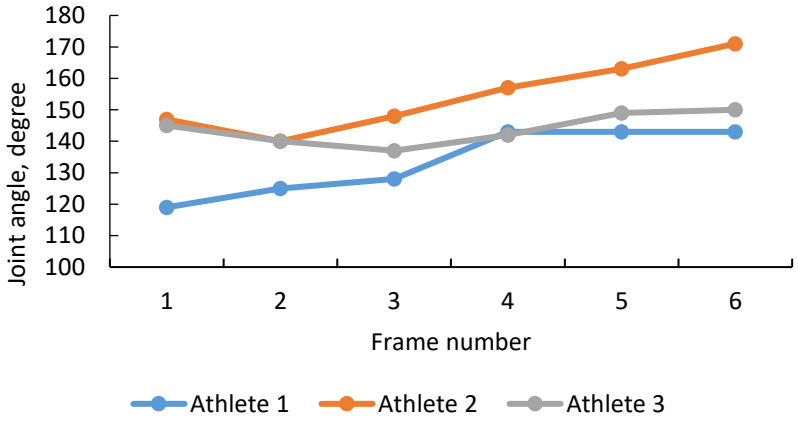

Fig. 4. Examples of the values of the angles between the thigh and the lower leg in qualified veteran boxers of different styles of fighting:
Athlete 1: the factor "Speed and coordination endurance" prevails with a slight severity of the factor "Speed" (tempo style of fighting);
Athlete 2: the factor "Speed" prevails with a slight severity of the factor "Speed and coordination endurance" (playing style of the fight);
Athlete 3: average severity of the "Speed" factor with an insignificant severity of the "Speed and coordination endurance" factor (strength style of fighting);
1 - the initial value of the movement, 0.00 s;
2 - second frame from the beginning of the movement, 0.03 s;
3 - third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s

6 - the sixth frame from the beginning of the movement, 0.16 s

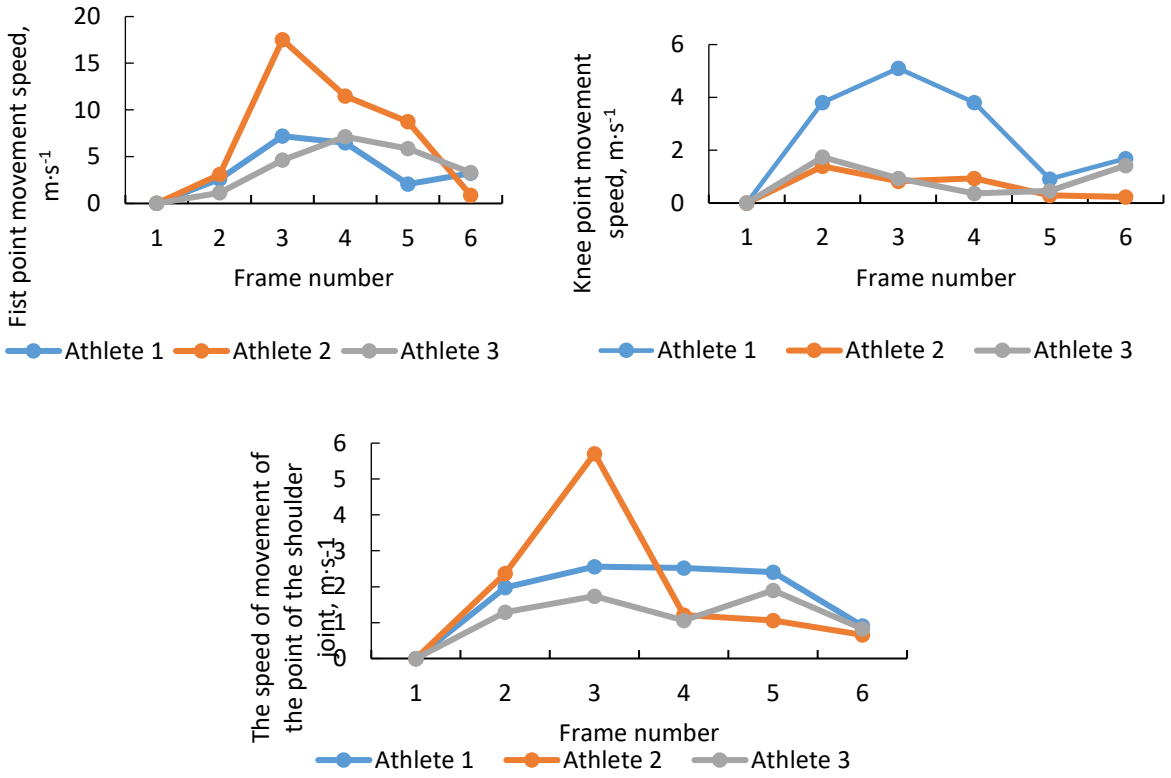

Fig. 5. Examples of the values of the speed of movement of the knee joint, fist and shoulder joint among qualified veteran boxers of different styles of fighting:
Athlete 1: the factor "Speed and coordination endurance" prevails with a slight severity of the factor "Speed" (tempo style of fighting);
Athlete 2: the factor "Speed" prevails with a slight severity of the factor "Speed and coordination endurance" (playing style of the fight);
Athlete 3: average severity of the "Speed" factor with an insignificant severity of the "Speed and coordination endurance" factor (strength style of fighting);
1 - the initial value of the movement, 0.00 s;
2 - second frame from the beginning of the movement, 0.03 s;
3 - third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s
6 - the sixth frame from the beginning of the movement, 0.16 s

Discussion

As far as we know, this study is one of the first in several respects. This is the first study to determine the style of fighting by combining psychophysiological and biomechanical indicators. It is also one of the first studies to determine the fighting style of veteran boxers. The purpose of our research was to identify the style of fighting veteran boxers based on the individual factor structure of psychophysiological and biomechanical indicators. The set goal assumed that the determination of the individual factor structure of the complex readiness of veteran boxers on the basis of psychophysiological and biomechanical indicators will make it possible to determine the hidden relationships between a wide range of psychophysiological and biomechanical indicators, combining the analyzed indicators into groups (factors) and determine the individual severity of each factor in each athlete ...

After analyzing the individual severity of each factor for each athlete, we identified 3 groups of athletes: group 1 - the severity of the factor "Speed and coordination endurance" prevails (more than 80% of the maximum value) and insignificant (less than 30% of the maximum) severity of the factor " Speed". This means that these athletes are distinguished by their ability to maintain high speed and accuracy (coordination) of actions for a long time [37–39]. That is why we named this group “Speed and coordination endurance”. This group of athletes, according to their indicators, can be attributed to the style of fighting, requiring a high level of endurance with the support of a relatively high speed of movements. It is logical to assume that these athletes gravitate towards the tempo style of fighting.

In athletes of the second group, the severity of the factor "Speed" prevails (more than 80% of the maximum) and the average (about 50% of the maximum) severity of the second factor "Speed and coordination endurance" That is, these athletes are capable of high-speed actions at the beginning of movements and in average expressiveness of speed and coordination endurance [40, 41]. These qualities are most typical for boxers with a playing style of fighting.

There is also a group of athletes (group 3) in whom the factor "Speed" is less pronounced than in athletes of the second group and more than in athletes of the first group (about 50% of the maximum), with a slight severity of the factor "Speed and coordination endurance" (less than 30% of the maximum). Since all the athletes who participated in the experiment are equally successful in sparring in the ring, we can assume that the athletes of the third group achieve success at the expense of other qualities, in particular, speed-strength qualities. Speed-strength qualities require the development of maximum power, which is defined as the product of strength and speed. According to Hill's equation, strength and speed are antagonistic qualities and are in a hyperbolic relationship with each other [30–32]. Therefore, the maximum value of the product of strength and speed is found with an average expression of both qualities. We did not measure strength in this study because biomechanical analysis does not represent strength capability. We can draw conclusions indirectly about the manifestation of strength abilities. These athletes are characterized by an average manifestation of speed with low speed endurance. Therefore, we can conclude that these athletes are dominated by strength and speed. This most characterizes the power

style of fighting, since the maximum power of the blow requires the development of power, that is, strength and speed.

The goal set in the work was achieved: the styles of conducting a duel of veteran boxers were determined on the basis of the individual factor structure of biomechanical and psychophysiological indicators. We identified 3 groups of athletes, which are characterized by the following manifestations of psychophysiological functions in combination with biomechanical indicators: group 1 - endurance to speed and coordination actions; group 2 - speed at short time intervals; group 3 - power (combination of speed and strength) with a predominance of strength.

It should be noted that the traditional definition of the strength of the nervous system implies 2 manifestations: 1 - resistance to a one-time strong stimulus; 2 - resistance to a long-acting stimulus of medium or low strength [12, 13]. In our opinion, the concepts of "strength" and "endurance" of the nervous system should be separated by analogy with the classification of physical qualities. This seems to us quite logical, since the muscular apparatus is controlled by the nervous system. Therefore, it is quite natural that the properties of the nervous system, traditionally divided into "strength", "mobility", "poise", should be divided into categories similar to physical qualities: "strength", "endurance", "speed" (quickness) and "switchability" (agility). As for the "speed" of nervous processes, it will be logical that the speed of nerve impulses determines the speed of muscle contractions and, accordingly, the physical quality of speed. The ability to quickly switch from one task to another can also be attributed to the manifestation of the speed of the nervous system. This is typical for the mobility of the nervous system and the physical quality "dexterity" [12, 13]. These provisions are based on the relationships identified in our study using factor analysis between psychophysiological and biomechanical indicators.

In this regard, it is logical that the strength and speed of the nervous system are antagonists in the same way as physical qualities. Many movements require the development of both strength and speed (jumping, throwing, lifting the barbell). These movements are referred to as movements requiring high power (the product of force and speed). Maximum power is achieved at the level of average development from maximum strength and speed. The same is true for the combinations of endurance and strength, endurance and speed (quickness). The less the strength or speed of the muscle contraction (and, accordingly, the nerve impulse), the longer the muscle contraction can take place. In this case, we are talking about endurance, both physical quality and endurance of the nervous system. Therefore, it is quite logical to define the ability to maintain a relatively high speed of movements for a long time as "speed endurance" and to correlate this concept with both physical qualities and the properties of the nervous system. This can explain the fact, obtained in our study, that the maximum speed endurance is observed at relatively low speed indicators.

Thus, the classification of boxers' fighting styles can be represented as a manifestation of physical qualities and properties of the nervous system: "High-speed athletes" (speed prevails), "Endurance athletes" (endurance prevails with average speed development), "Powerful athletes" (average severity prevails) strength and speed). Accordingly, the styles of the duel reflect the manifestations of these physical qualities

and properties of the nervous system: tempo style - speed endurance; power style - power (strength and speed), play style - speed and switchability (agility).

Prospects for further research

Further research suggests:
- checking the distribution of qualified veteran boxers by means of cluster analysis;
- identification of differences between boxers of different styles of fighting according to biomechanical and psychophysiological indicators;
- development and substantiation of recommendations regarding the construction of the training process of qualified veteran boxers of different styles of fighting.

Limitations

The study was conducted on qualified veteran boxers, therefore, the data obtained apply only to the studied contingent. Additional research is needed to disseminate the obtained data to boxers of other age and social groups, as well as to representatives of other sports.

Conclusions

1In the structure of the complex readiness of qualified veteran boxers, 2 main factors have been identified. The first factor (55.063% of the total variance) according to the indicators included in it, was named "Speed". The second factor (44.937% of the total variance) according to the indicators included in it, was named "Speed endurance". The styles of fighting qualified veteran boxers were revealed on the basis of the analysis of the general and individual factor structure of biomechanical and psychophysiological indicators. It is shown that the individual factor structure, which is characterized by the expressiveness of the factor "Speed and coordination endurance" by more than 80%, and the severity of the factor "Speed" by less than 30%, is typical for boxers of the tempo style. The individual factor structure, which is characterized by the expressiveness of the factor "Speed" by more than 80%, and by the severity of the factor "Speed and coordination endurance" by less than 30%, is typical for boxers of the playing style. Individual factorial structure, which is characterized by the expressiveness of the factor "Speed" by more than 50%, and by the severity of the factor "Speed and coordination endurance" by less than 30%, is typical for boxers of the strength style.

2. Qualified veteran boxers with a high level of speed and coordination endurance manifestation (tempo style of fighting), are characterized by the least number of errors when performing the test for the choice reaction in the feedback mode and the average development of the reaction speed, work in a low stance with a high speed of movement and development of maximum speed at the end of the movement or evenly throughout the movement.

Qualified veteran boxers with a high level of manifestation of speed capabilities and an average level of manifestation of speed and coordination endurance (playing style of fighting) are characterized by a high level of development of reaction speed, a relatively large number of errors in the test for the choice reaction in the feedback mode, work in a high stance and development of maximum speed at the beginning of the movement.

Qualified veteran boxers with an average level of speed abilities and a low level of speed and coordination endurance manifestation (strength style of fighting) are characterized by a high number of errors when performing the test for the choice reaction in the feedback mode and a high level of development of reaction speed, work in a high stance and development of maximum speed at the end of the movement.

3. It is shown that the psychophysiological characteristics of boxers of different styles of fighting are reflected in the characteristics of the technique of direct blow. The lack of speed at the beginning of the movement in tempo style boxers is supplemented and compensated by the high speed of movement. Playing style boxers are characterized by a high speed of movement at the very beginning of the strike. Power style boxers are characterized by the gradual development of movement speed.

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Determination of fighting styles of qualified veteran boxers based on cluster analysis of biomechanical and psychophysiological indicators

Introduction

At the present stage of boxing development, the style of fighting is a characteristic feature of every professional boxer [1, 2, 3]. Yes, there are boxers who are very forceful in the fight. They are distinguished by the great force of the blow, the desire for power victory of the enemy. Such boxers include Mike Tyson, Vitali Klitschko, George Foreman, David Tua and other attacking "security officers" [4, 5, 6]. Some boxers fight, constantly varying their actions, using a lot of feints, strikes in the most unexpected moments. These are boxers of game style - Roy Jones, Mohammed Ali, Floyd Mayweather [2, 3, 4]. There are boxers who "exhaust" the opponent at a high pace for many rounds, and win when the opponent is no longer able to withstand the imposed pace. These are boxers of tempo style - Manny Pacquiao, Joe Fraser and others [7, 8]. The most successful option is the ability to combine different styles, and in different battles to show different ways of fighting. However, the most characteristic features of the movements of athletes remain unchanged, which gives reason to talk about the predominant individual style of fighting.

The doctrine of activity styles and, in particular, of fighting styles, has its roots in antiquity [1, 2, 9]. To date, the nature of the origin of different styles is not fully understood. There are hypotheses that suggest that the styles occurred as a result of separate training of certain groups of people [1, 9]. There are also historical facts that indicate the origin of the styles of dueling as an imitation of the manners of movement and survival strategies of different animals [9]. Thus copying was carried out both external movements, and internal states. Martial arts from the "crane style" have come down to our time, as well as different styles of fighting within one martial art.

There are a number of styles of wushu, united by the common name of xiang xinquan - "style of image and form" or "style of imitation of form." They are based on imitating the movements and habits of animals. In Xinxingquan, the state of naturalness, spontaneous looseness (jizhan) is achieved through complete self-identification with the selected object, not only external, but most importantly, internal. Man, mastering the "form and manner" of the tiger, snake, dragon, reached the natural looseness and natural power of the animal in its "original state" [10, 11].

Imitation of animal movements has been known in China for a long time [1]. In early totem dances, the ancestors of the Chinese imitated the manner of fighting the animal. The doctrine of activity styles and, in particular, of fighting styles, has its roots in antiquity. There are historical facts that indicate the origin of the styles of dueling as an imitation of the manners of movement and survival strategies of different animals. Thus copying was carried out both external movements, and internal states. It is logical to assume that the physiological basis of style formation is relatively constant genetically determined functions, such as neurodynamic processes and psychophysiological capabilities [12, 13], and registration of these indicators in the

training process will help determine the propensity of a boxer to a certain style of fighting.

There are many different methods for measuring psychophysiological functions [14, 15]. At present, methods of studying psychophysiological functions are becoming more widespread, which make it possible to determine not only the reaction rate, the sense of time, but also the typological properties of the nervous system: strength, mobility, resistance to stimuli in time [15, 16 - 18].

Currently, the study of psychophysiological functions [19-22] in connection with the individual characteristics of the technique of movements, according to biomechanical indicators [23-25], is of great importance. This makes it possible to quantitatively determine how and how the peculiarities of brain activity affect the formation of an individual style of human activity. For this purpose, qualified veteran boxers are one of the most suitable contingents for such studies for several reasons [26]: 1 - as a person's age increases, there is an improvement in technical skill while continuing to engage in a certain type of activity, including sports; 2 - as the age increases, the manifestation of individual psychological and psychophysiological traits occurs; 3 - the study of the peculiarities of technical skill of qualified middle-aged and elderly athletes in conjunction with the individual characteristics of psychophysiological functions is important as a tool for cognition of motor and psychophysiological manifestations of various styles of activity. However, there is much less scientific research on veteran athletes today than on younger active athletes.

In our previous studies [26], an attempt was made to determine the individual styles of fighting qualified veteran boxers on the basis of individual factor values of the analysis of psychophysiological and biomechanical indicators. With the help of factor analysis, carried out by the method of principal components, in the structure of complex readiness of qualified veteran boxers, 2 main factors were identified: "Speed" and "Speed and coordination endurance". Further, the individual factor structure of the athletes' readiness was found on the basis of determining the percentage values of the severity of each factor in each boxer. All athletes have different severity of various factors, which indicates the presence of significant individual differences. This should be manifested in different styles of fighting and the need to use individual training programs for qualified veteran boxers [26].

Our previous studies have also shown that for an accurate distribution of veteran boxers according to fighting styles, it is necessary to use modern methods of mathematical statistics, in particular, cluster analysis [26]. Thus, this work is a continuation of our previous research to determine the fighting styles of qualified veteran boxers. In the presented work, it was assumed that a multivariate analysis of psychophysiological and ergonomic indicators would allow the athletes to be divided into groups that would correspond to different styles of fighting qualified veteran boxers.

Purpose: to reveal the styles of fighting veteran boxers on the basis of a multivariate analysis of psychophysiological and biomechanical indicators.

Material and methods

Participants

The study involved 42 qualified veteran boxers (age 45-50 years, body length - 178.67 ± 8.26 cm, body weight - 70.96 ± 9.38 kg). The total experience of boxing for the participants was 20-25 years. Athletes were selected as follows: a prerequisite for participation in the study was the presence of a sports qualification in the past not lower than a candidate for master of sports (the winners of competitions not lower than the level of the city and region) and the regularity of training for the last 10 years 3-4 times a week. The study was carried out on the basis of sports clubs "KhTZ", "Vostok", "Metalist" in Kharkov, Ukraine.

All participants were aware of the objectives of the study and agreed to participate. All participants gave written consent to participate in the study. The research was conducted in compliance with WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, 2013.

Procedure

The study was conducted from April 18 to May 25, 2021. At the beginning, athletes were filmed while performing a direct blow in boxing. Each athlete performed a series of strikes alternately with the right and left hands in the training session against the background of a visible object for subsequent calibration with known dimensions. Video filming was carried out at training sessions from 18-00 after a short warm-up in the boxing gym of the KhTZ sports club. During one training session, 10-12 people were filmed. The next day after the video filming, the athletes underwent psychophysiological testing also from 18-00. When conducting psychophysiological testing, athletes were initially asked to pass the proposed tests in a training mode. Psychophysiological testing was carried out in the classroom for theoretical studies of the sports club "KhTZ".

Biomechanical Analysis of Direct Punch Technique in Boxing

We have chosen the direct punch as the main element for the analysis of the athletic technique of qualified veteran boxers. The choice of the direct hit was due to the fact that it is the main technical element in boxing [26, 27, 28]. This stroke is the most standardized of all boxing elements and provides the least variability in execution. This element is perfectly mastered by all qualified boxers, in particular - veteran boxers. Also, the individual style of movements is most traced precisely in those movements performed most automatically, that is, with minimal control from the side of consciousness. This blow is the most convenient for biomechanical analysis using video filming, since it is performed practically in the same plane.

Biomechanical analysis of the direct kick technique in qualified veteran boxers was carried out using the Kinovea software, version 0.8.15. (Fig. 1). The Kinovea program allows performing video analysis of movements [29, 30]. It is intended for athletes, coaches, healthcare professionals, and sports research. Also, the software can be useful for specialists in the field of ergonomics or animation. The main function of Kinovea is to view and analyze sports videos. The main tools used by users are "Line", "Chronometer", "Tracking", "Angles". The Line and Chronometer functions allow you to measure distance and time, while the Semi-automatic tracking tool can track both the path and time. When working with Kinovea, you can use video from external sources: video cameras, smartphones, and so on.

To analyze the biomechanical parameters of the direct strike technique of qualified veteran boxers, 6 frames were selected at a speed of 26 frames per second. Thus, the time of one frame was 0.03-0.04 s (Fig. 1-3). The duration of the direct impact was 0.13-0.16 s, depending on how many frames were analyzed (5 or 6, respectively). Distance calibration was carried out along the length of a special device, against the background of which video filming was carried out (138 cm). The movement time was determined by the stopwatch indicators in the program. The speed of movement of the fist, shoulder joint, elbow joint, knee joint was determined (V, m • s-1) (Fig. 2). Determination of the angles between the shoulder and the torso (the angle at the shoulder joint), between the shoulder and the forearm (the angle at the elbow joint), between the thigh and the lower leg (angle at the knee joint) (degrees) also worked (Fig. 1).

A total of 10 videos of direct kick were analyzed for each athlete. Averaged data for each athlete was analyzed from 10 videos. The total number of video recordings was 420. The point of the greatest extension of the striking arm in the shoulder joint was chosen as the end of the impact. In each video, 6 frames were selected for analysis (duration of a direct impact). If the impact ended on the fifth frame, then the sixth frame was excluded from the analysis. Earlier in the fifth frame, more than one athlete did not end the direct hit. Thus, the total duration of a direct blow in boxing among qualified veteran boxers was 0.13-0.16 s. The point of the minimum angle between the shoulder and the torso (shoulder joint), from which the movement of the striking arm begins [26, 29, 30], was chosen as the beginning of the impact.

To analyze the angles in the joints, the "Angles" tool was selected on the toolbar of the Kinovea 0.8.15 program. The point of the apex of the angle was selected, then the angle for analysis was determined. The angle chosen for analysis was determined in each frame (Fig. 1).

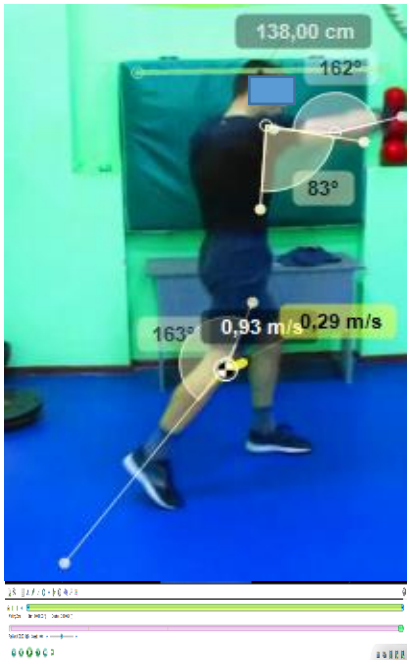

Fig. 1. Determination of the speed of movement of various points of the body and angles in the joints when performing a direct blow in boxing using the Kinovea 08.15 program

We carried out the following trajectory tracking for the subsequent analysis of the distance and speed of movement of each point (Fig. 1): 1 - we chose a point for analysis; 2 - select the "Track Path" option; choose the "End Path Edition" function; 3 - the analyzed point was corrected for each frame; 4 - Select the "Configuration" function and set the "Distance" function. The display showed the distance from the beginning of the movement to the selected segment of the path. To measure the speed of a point, we selected the “Configuration” function, and then we selected the “Speed” function. We chose meters per second as the unit of measurement. The measurement results were exported to the EXCEL program.

Psychophysiological methods

The following parameters characteristic of the psychophysiological state, typological features of the nervous system, indicators of the nervous system efficiency, and attention indicators [12, 14, 15] have been set using the computer program "Psychodiagnostics" (Kharkiv, Ukraine, KhNPU):

– A set of indices for the time of a simple visual-motor reaction (mean of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 element from 3 (mean value of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 elements out of 3 in the feedback mode, i.e. as the response time changes, the signal delivery time changes. The ‘short version’ is carried out in the feedback mode, when the

duration of exposure changes automatically depending on the response of the subject: after a correct answer, the duration of the next signal is reduced by 20 ms, and after a wrong one, it increases by the same amount. The range of the signal exposure change during the test subject's operation is 20–900 ms, with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button while displaying a certain exposure (image), or during a pause after the current exposure. In this test, the time to reach the minimum exposure of the signal and the time of the minimum exposure of the signal reflect the functional mobility (speed) of the nervous processes; the number of errors reflects the strength of the nervous processes (the lower these parameters, the higher the speed endurance of the nervous system). The duration of the initial exposure is 900 ms; the amount of change in the duration of the signals with correct or erroneous responses is 20 ms; pause between the presentation of signals – 200 ms; the number of signals is 50. The indicators are fixed: the average value of the latent period (ms); root mean square deviation (ms); number of mistakes; time of test execution (s); minimum exposure time (ms); time of exposure to the minimum exposure (s).

Statistical analysis

We used the method of cluster analysis to distribute athletes into groups using the SPSS - 17.0 program. Within the groups, the athletes are maximally similar to each other in terms of the analyzed indicators, and between the groups they differ as much as possible [31–33]. The analysis of the groups of athletes obtained with the help of cluster analysis made it possible to identify athletes with the following styles of fighting: tempo, playing, strength styles.

When conducting cluster analysis, we used the following options of the SPSS program: Analyze - Classify - Hierarchical cluster analysis. We first printed the Agglomeration Schedule table without setting the estimated number of clusters. Based on the values of the coefficients in the table "Agglomeration Schedule" during the formation of clusters, we have determined the optimal number of clusters for our study. To do this, we subtracted the step number from the total number of cases (42), after which the increase in the coefficients occurs nonlinearly (39). As a result, we got the optimal number of clusters equal to 3. Next, we performed the cluster analysis again, setting the Cluster Membership - Single solution option. We set the number of clusters to 3. Thus, we got the cluster membership of each athlete. Further, we combined the results of determining individual factor values in absolute and relative terms with the results of the distribution of athletes into clusters (groups). Based on the prevalence of the severity of various factors in each group of athletes, we gave a name to each cluster.

Results

The test for normality of distribution of test indicators showed that all test indicators correspond to the normal distribution (Asymptomatic significance according to the Chi-square test> 0.05; Significance according to the Monte Carlo

test> 0.05) [26]. The distribution of indicators of the analyzed sample does not significantly differ from the Gaussian normal distribution.

To determine the optimal options for combining qualified veteran boxers into groups based on the principle of different styles of fighting, a cluster analysis of testing indicators was carried out. The results of the cluster analysis were compared with the individual factor values, and the profiles of the athletes were drawn up. On the basis of the data obtained, the individual characteristics of qualified veteran boxers were determined by the prevalence of factors in the individual structure of preparedness and the corresponding styles of fighting.

In hierarchical cluster analysis, each individual case first forms its own separate cluster. At each step, two separate clusters that are closest to each other in their structure are combined into one cluster. First, the athletes who are closest in terms of the analyzed indicators are united, then athletes who are similar in the analyzed indicators join the formed pairs. Thus, groups of athletes appear, which can be considered as the groups most similar in their structure to the preparedness of the subjects.

Clusters were determined according to the degree of "similarity" of athletes according to the indicators of complex testing (Tables 1, 2, Fig. 2). In order to find out how many clusters are optimal, one should subtract the step number from the number of analyzed athletes, from which the cluster coefficients begin to grow nonlinearly. In our case, this is step 39 (Table 1). Based on this, 42-39 = 3. That is, the optimal number of clusters is 3 clusters.

The first cluster included athletes No. 2; 5, 8; eleven; fourteen; 17; twenty; 23; 26; 29; 41 (n = 11) (Tables 1, 2, Fig. 2). The second cluster includes athletes No. 1; 4, 7, 10, 13; 16; 19; 22; 25; 28; 31; 32; 34; 37; 38; 40 (n = 16) (Tables 1, 2, Fig. 2). The third cluster included athletes No. 3, No. 6; nine; 12; 15; eighteen; 21; 24; 27; thirty; 33; 35; 36; 39; 42 (n = 15) (Tables 1, 2, Fig. 2). The stages of the combination of athletes into clusters are presented in Table 1. It can be seen from the table that at the first stage athletes No. 39 and No. 42 are united, in the next step athletes No. 38 and No. 41 are united. In the third step, athletes # 37 and # 40 are united. At the fourth step, athlete # 3 joins athletes 39 and 42. At the fifth step, athlete # 2 joins athletes # 38 and 41. At the sixth step, athlete 1 joins athletes 37 and 40. Further, each group of athletes is alternately replenished with the next veteran boxer. In total, 41 steps were taken to unite veteran boxers into clusters, 1 less than the number of athletes (42).

Table 1

Agglomeration Schedule in cluster analysis of biomechanical and psychophysiological indicators of qualified veteran boxers

Stage	Cluster Combined			Stage Cluster Last Appears		Next Stage
	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	
1	39	42	0.153	1	1	4
2	38	41	1.342	1	1	5
3	37	40	2.412	1	1	6

4	3	39	3.141	1	1	10
5	2	38	4.2705	1	2	11
6	1	37	5.2739	1	3	12
7	33	36	6.2773	1	1	10
8	32	35	7.2807	1	1	11
9	31	34	8.2841	1	1	12
10	3	33	9.2875	4	7	16
11	2	32	10.2909	5	8	17
12	1	31	11.2943	6	9	18
13	27	30	12.2977	1	1	16
14	26	29	13.3011	1	1	17
15	25	28	14.3045	1	1	18
16	3	27	15.3079	10	13	22
17	2	26	16.3113	11	14	23
18	1	25	17.3147	12	15	24
19	21	24	18.3181	1	1	22
20	20	23	19.3215	1	1	23
21	19	22	20.3249	1	1	24
22	3	21	21.3283	16	19	28
23	2	20	22.3317	17	20	29
24	1	19	23.3351	18	21	30
25	15	18	24.3385	1	1	28
26	14	17	25.3419	1	1	29
27	13	16	26.3453	1	1	30
28	3	15	27.3487	22	25	34
29	2	14	28.3521	23	26	35
30	1	13	29.3555	24	27	36
31	9	12	30.3589	1	1	34
32	8	11	31.3623	1	1	35
33	7	10	32.3657	1	1	36
34	3	9	33.3691	28	31	37
35	2	8	34.3725	29	32	38
36	1	7	35.3759	30	33	39
37	3	6	36.3793	34	1	41
38	2	5	37.3827	35	1	40
39	1	4	38.3861	36	1	40
40	1	2	267.014	39	38	41
41	1	3	612.816	40	37	0

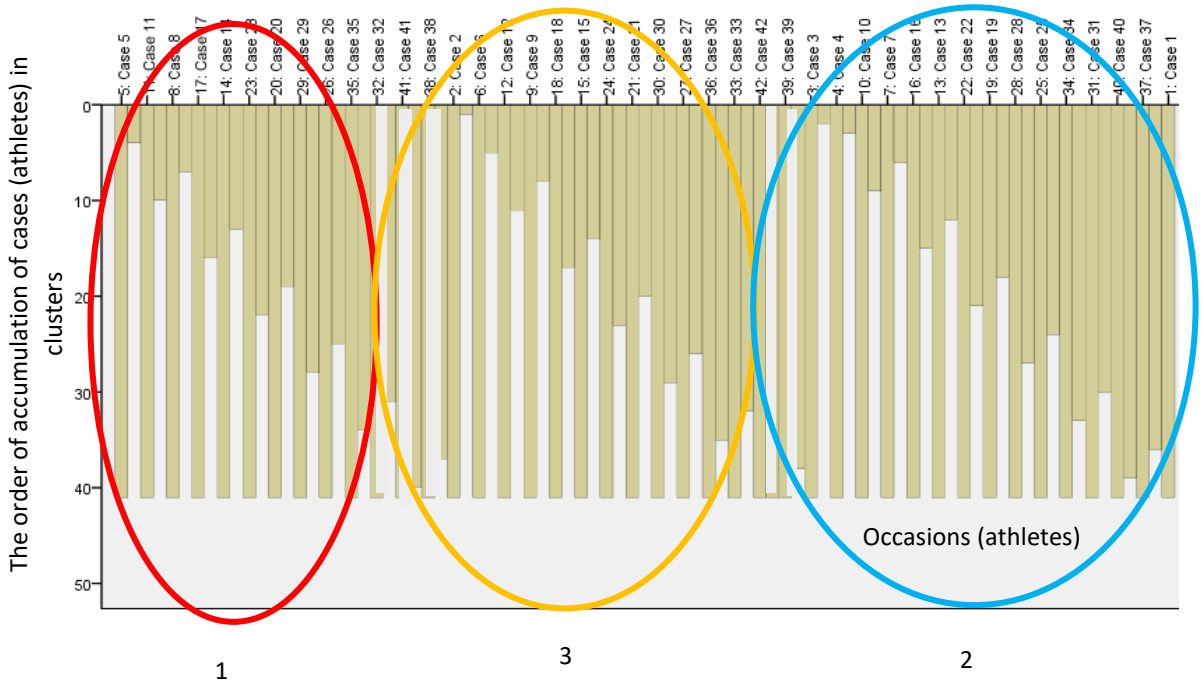

Fig. 2. Distribution of qualified veteran boxers into clusters:
1 - cluster 1; 2 - cluster 2; 3 - cluster 3

Thus, we received 3 clusters (groups) of veteran boxers, differing in their psychophysiological and biomechanical indicators. The athletes of these groups have different severity of factors in the individual structure of preparedness (Table 2). Individual severity of factors in the structure of preparedness of qualified veteran boxers was determined by us in our previous studies [26].

In the presented study, we found that in the athletes of the first cluster, the severity of the factor "Speed and coordination endurance" (more than 80%) and a small level of severity of the factor "Speed" (less than 30%) prevail. In athletes of the second cluster, the severity of the "Speed" factor (more than 80%) and the average severity of the "Speed and coordination endurance" factor (about 50%) prevail. Athletes of the third cluster have an average severity of the "Speed" factor (about 50%) and a small severity of the "Speed and coordination endurance" factor (less than 30%) (Table 2).

If we consider examples of factor models [26], built on the basis of individual values of the factor structure of veteran boxers (Table 2), it can be noted that the athletes of the first cluster have the most pronounced factor “Speed and coordination endurance”. This means that these athletes are distinguished by their ability to maintain high speed and accuracy (coordination) of actions for a long time. That is why we named this cluster “Speed and coordination endurance”. This cluster (group) of athletes in terms of their performance can be attributed to the style of fighting, requiring a high level of endurance with the support of a relatively high speed of movements. This is a style of fighting - tempo. In the athletes of the second cluster, the development of the first factor "Speed" and the average severity of the factor "Speed and coordination endurance" prevail. That is, these athletes are capable of high-speed actions at the beginning of movements and in average expressiveness of speed and coordination endurance. These qualities are most typical for boxers with a style of fighting - playing. Athletes of the third cluster have an average severity of the "Speed" factor and a small

severity of the "Speed and coordination endurance" factor. We did not measure strength in this study because biomechanical analysis does not represent strength capability. We can draw conclusions indirectly about the manifestation of strength abilities. These athletes are characterized by the manifestation of speed with low endurance. Therefore, we named this cluster "Strength and Speed". This most characterizes the style of fighting - power.

Table 2

Cluster Membership and individual severity of the factors of qualified veteran boxers based on the analysis of biomechanical and psychophysiological indicators

Occasions	Clusters	Absolute individual values of factors		Individual values of factors, expressed as a percentage of the maximum values in a sample of athletes	
		Factor 1	Factor 2	Factor 1	Factor 2
1	2	35.50	21.50	84.52	51.19
2	1	7.50	35.50	17.86	84.52
3	3	21.50	7.50	51.19	17.86
4	2	34.68	20.72	83.19	50.26
5	1	7.68	35.79	19.65	85.64
6	3	19.86	6.48	52.28	18.75
7	2	35.50	21.50	84.52	51.19
8	1	7,.50	35.50	17.86	84.52
9	3	21.50	7.50	51.19	17.86
10	2	34.68	20.72	83.19	50.26
11	1	7.68	35.79	19.65	85.64
12	3	19.86	6.48	52.28	18.75
13	2	35.50	2.,50	84.52	51.19
14	1	7.21	38.64	15.59	85.58
15	3	21.50	7.50	51.19	17.86
16	2	34.68	20.72	83.19	50.26
17	1	7.21	38.64	15.59	85.58
18	3	19.86	6.48	52.28	18.75
19	2	34.68	20.72	83.19	50.26
20	1	7.50	35.50	17.86	84.52
21	3	21.50	7.50	51.19	17.86
22	2	35.50	21.50	84.52	51.19
23	1	7.21	38.64	15.59	85.58
24	3	21.67	8.50	56.19	18.86
25	2	34.68	20.72	83.19	50.26
26	1	7.50	35.50	17.86	84.52
27	3	21.50	7.50	51.19	17.86
28	2	34.68	20.72	83.19	50.26
29	1	7.68	35.79	19.65	85.64
30	3	19.86	6.48	52.28	18.75
31	2	35.50	21.50	84.52	51.19
32	2	21.67	8.50	56.19	18.86

33	3	21.67	8.50	56.19	18.86
34	2	35.50	21.50	84.52	51.19
35	3	7.21	38.64	15.59	85.58
36	3	21.50	7.50	51.19	17.86
37	2	35.50	21.50	84.52	51.19
38	2	35.50	21.50	84.52	51.19
39	3	21.50	7.50	51.19	17.86
40	2	34.68	20.72	83.19	50.26
41	1	7.21	38.64	15.59	85.58
42	3	21.67	8.50	56.19	18.86

The revealed regularities of speed in the movement of points of the fist, elbow, knee and angles in the joints are also reflected in the trajectory of movement of the points of the fist, elbow, knee (Fig. 2-4). The athletes of cluster 1 “Speed and coordination endurance” have the most pronounced trajectory of the knee point movement (Fig. 2). Also, the trajectory of movement of the knee point among athletes of cluster 1 "Speed and coordination endurance", which is typical for athletes of the tempo style, is the lowest of all analyzed groups of athletes (Fig. 2).

The obtained facts can be explained by the fact that tempo-style boxers compensate for the lower level of speed of nervous processes by the speed of movement, which requires more flexion of the legs in the knee and hip joints. This causes a low stance during the fight and is displayed in the lower position of the knee point trajectory.

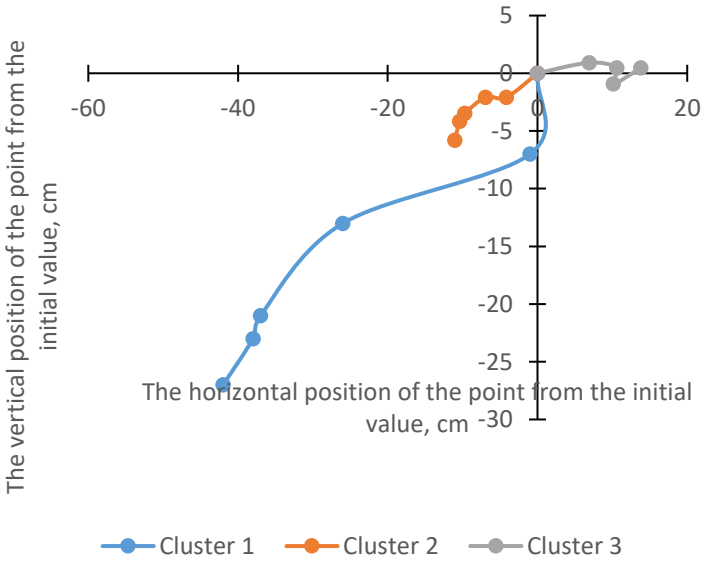

Fig. 3. Values of the trajectory of movement of the knee joint among qualified veteran boxers from different clusters:

Cluster 1 – «Speed and coordination endurance»;

Cluster 2 – «Speed»;

Cluster 3 – «Strength and speed»

The athletes of the “Speed” cluster, which corresponds to the boxers of the playing style, have the highest trajectory of the fist point movement (Fig. 3). This is due to the fact that the high speed of hand movement and the general variability of the boxers' actions in this cluster allows them to act in a high stance and execute strikes along a high trajectory. In addition, for the development of a high speed of movement of the fist point, the most favorable position is a high stance of a boxer, since a high stance requires the least strength and the least manifestations of speed endurance. The lowest trajectory of the fist point movement among boxers of the tempo style, the cluster "Speed and coordination endurance" (Fig. 3). This is due to the lowest stance of the boxers in the tempo style of fighting. The trajectory of the fist movement in power style boxers, the “Strength and Speed” cluster, occupies an intermediate position. In playing style athletes, the point of fist ends the movement earlier than the other two fighting styles. This is due to the higher speed of execution of the blow by the boxers of the playing style, cluster "Speed".

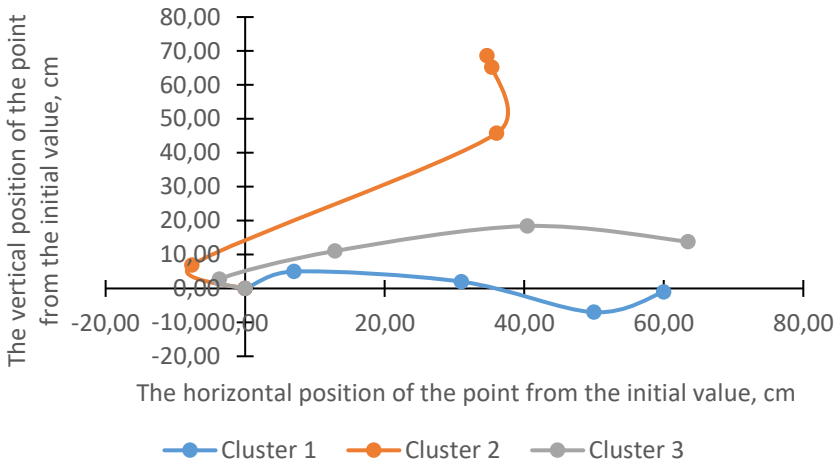

Fig. 4. Values of the trajectory of the fist movement among qualified veteran boxers from different clusters:
Cluster 1 – «Speed and coordination endurance»;
Cluster 2 – «Speed»;
Cluster 3 – «Strength and speed»

The trajectory of movement of the elbow joint is also the lowest in tempo style boxers, the cluster "Speed and coordination endurance" (Fig. 4). This is also due to the lowest stance in the bout of these athletes. Also, the trajectory of the elbow point in tempo style athletes is characterized by an initial movement of the elbow back for a small swing, and then forward. At the end of the strike, the elbow point is practically at the same level for boxers of all analyzed styles. In playing style athletes, the elbow point finishes the movement earlier than boxers of the other two fighting styles (Fig. 4). This is due to the higher speed of execution of the blow by the boxers of the playing style, cluster "Speed".

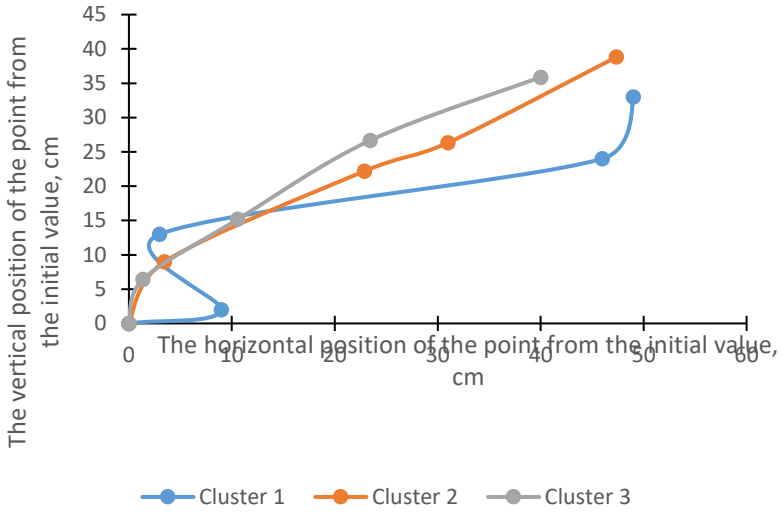

Fig. 5. Values of the trajectory of movement of the elbow joint among qualified veteran boxers from different clusters:
Cluster 1 – «Speed and coordination endurance»;
Cluster 2 – «Speed»;
Cluster 3 – «Strength and speed»

Discussion

As far as we know, this study is one of the first to determine the fighting styles of qualified veteran boxers. In our study, we used cluster analysis to distribute boxers into groups based on biomechanical and psychophysiological indicators. This method was applied for the first time to determine the styles of competitive activity of veteran boxers.

In our study, the hypothesis was confirmed regarding the effectiveness of using the methods of multivariate analysis (in our case, cluster analysis) of biomechanical and psychophysiological indicators to determine the styles of fighting qualified veteran boxers.

Issues related to the style of activity have occupied the attention of psychologists for several decades, both in work and, especially, in sports. The problem of the style of activity is the problem of the highest level of achievement in the activity of each person, the problem of mastery and its formation, the problem of optimal “docking”, balancing the subject with objective requirements [1, 2]. Therefore, the most acceptable way of an individual approach is not to adjust the trainees' characteristics to a certain unified model, but to promote the formation of those techniques and methods of action that are most optimal for students and correspond to pronounced abilities. A person should look for individually unique ways of mastering the required qualities and skills, taking into account his natural inclinations; the insufficiency of some of them will have to be compensated for, while others will turn out to be favorable. Thus, the problem arises of the formation of an individual style of activity [3, 4]. Currently, the most effective in terms of ease of use and information content are psychophysiological indicators to

determine the individual genetically determined factors in the formation of the style of activity [12–15].

Analysis of the research results in the aspect of comparing them with the available literature data showed that this work is one of the first in terms of determining the influence of the athlete's psychophysiological indicators in combination with the biomechanical data of individual technique on the formation of the style of fighting in boxing. The authors dealing with the issues of determining the styles of athletes' activity [3, 5], do not consider the process of training athletes from the point of view of the system, analysis of a wide range of indicators of readiness. The authors dealing with this problem [6] focused on visual observation of the boxer's activity, without offering specific indicators for determining the style of fighting. In our study, the effectiveness of the use of objective indicators has been shown, which makes it possible to determine the propensity of a boxer to a certain style of fighting, which is the data obtained for the first time. At the same time, the possibilities of using congenital psychophysiological characteristics are not considered.

Psychophysiological features are decisive in the formation of an individual style of activity, one of the manifestations of which is the style of fighting in boxing. Our research expands, confirms and supplements the data presented in the works [7–9, 12] regarding the informativeness of psychophysiological indicators for the current and operational control of the functional state of athletes and the determination of their individual characteristics. This is most important for predicting the results of competitive activity.

It should be noted that the problem considered in our work closely intersects with the problem of individualization of the training process considered in works [31–33] and is consistent with the concept of individualization presented in the works of Kozina [32–36]. The concept of individualization of the training process [31, 32] was developed using the deductive method. It lies in the fact that for the adequate construction of individual training programs it is necessary:

1 - to conduct comprehensive testing of athletes, which includes anthropometric, biomechanical, psychophysiological and other indicators;

2 - to carry out a factor analysis of the obtained indicators;

3 - to determine the individual factor structure of the complex fitness of athletes;

4 - to highlight the leading and lagging factors in the individual factor structure of athletes' fitness;

5 - to form groups of athletes according to the degree of similarity among themselves according to the individual factor structure of fitness or using cluster analysis of indicators of complex testing of athletes;

6 - develop and implement training programs for athletes of each group (cluster).

On the basis of the theoretical concept of individualization of the training process in sports, developed by Kozina [32], we determined the groups of boxers according to the indicators of complex testing. The concept assumes the use of an algorithm, which consists of the following stages [32, 33]: testing athletes, including a set of tests of at least 10; determination of the general structure of athletes' fitness by means of factor analysis. Determination of the main factors and drawing up their characteristics; conducting a hierarchical cluster analysis of testing indicators; determination of

individual factor values; based on individual factor values and cluster analysis of compiling individual characteristics. Factor analysis with the determination of the individual severity of factors was carried out in our previous study [26]. In the study presented in the current work, the concept of individualization by Kozina was fully implemented [31–33]. The effectiveness of this concept was confirmed [32, 33] for determining the individual characteristics of athletes. In particular, we have applied this concept to define the fighting styles of qualified veteran boxers.

It should be noted that the methods of psychophysiological and biomechanical testing proposed in our work to determine the individual characteristics of boxers are an effective, informative and sufficiently accessible and convenient tool for identifying the predisposition of boxers to a certain style of fighting.

Prospects for further research

Further research suggests:

- identification of differences between boxers of different styles of fighting according to biomechanical and psychophysiological indicators;
- development and substantiation of recommendations regarding the construction of the training process of qualified veteran boxers of different styles of fighting.

Limitations

The study was conducted on qualified veteran boxers, therefore, the data obtained apply only to the studied contingent. Additional research is needed to disseminate the obtained data to boxers of other age and social groups, as well as to representatives of other sports.

Conclusions

1. Cluster analysis of psychophysiological testing showed the presence of 3 groups of athletes. 3 clusters (groups) of veteran boxers have been identified, which differ in their psychophysiological and biomechanical indicators. Athletes of the first cluster are dominated by the expression of qualities that determine the speed and coordination endurance (over 80%) and a small level of expression of speed qualities (less than 30%). This corresponds to the pace of the fight. The athletes of the second cluster are dominated by the expression of speed qualities (over 80%) and the average level of expression of qualities that determine the speed and coordination endurance (about 50%). This corresponds to the game style of the fight. Athletes of the third cluster have an average expression of speed qualities (about 50%) and a small expression of qualities that determine speed and coordination endurance (less than 30%). Approximation of the obtained results to the expression of different qualities made it possible to determine the greatest manifestation of the speed and strength

qualities of the boxers of the third cluster. This corresponds to the power style of the fight. The clusters were named as follows: Cluster 1 - "Speed and coordination endurance", corresponds to the boxers of the pace of the fight; Cluster 2 - "Speed", corresponds to the boxers of the game style of fighting; Cluster 3 - "Strength and speed", corresponds to the boxers of the pace of the fight.

2. Biomechanical features of boxers of different styles of fighting are reflected in the trajectories of the points of the fist, elbow, knee. The athletes of the “Speed and coordination endurance” cluster (tempo style boxers) have the most pronounced trajectory of knee point movement. The trajectory of movement of the knee point in tempo style athletes is the lowest of all analyzed groups of athletes. The athletes of the “Speed” cluster, which corresponds to the boxers of the playing style, have the highest trajectory of the fist point movement. The lowest trajectory of the fist point movement among boxers of the tempo style, the “Speed and coordination endurance” cluster. The trajectory of movement of the elbow joint is also the lowest in tempo style boxers, cluster "Speed and coordination endurance".

3. It is advisable to use the results of this research when planning the individual training of athletes in boxing and to determine the optimal style of conducting a competitive combat for qualified veteran boxers. The proposed methods of psychophysiological and biomechanical testing to determine the individual characteristics of boxers are an effective, informative and fairly accessible and easy-to-use tool for revealing the predisposition of boxers to a certain style of fighting.

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Biomechanical and psychophysiological features of qualified veteran boxers of various fighting styles

Introduction

Veteran boxers are a special category of people who do not just want to lead an active lifestyle and maintain their physical and psychological condition at an optimal level. These are athletes who continue to take risks [1, 2, 3]. At every training session and every competition, they seem to test themselves for courage, cleverness, courage, and the ability to withstand the dangerous circumstances of life at any moment and to protect themselves and their loved ones. They train almost all their lives, honing their skills [4, 5]. And each of them is more and more formalizing their own style of fighting. With increasing age with constant practice of any type of motor activity come to the fore movements that are most optimal in terms of anthropometric, physiological, psychological characteristics of each person. This is reflected in the clear manifestation of a certain style of movement, which with age becomes more noticeable [6]. That is why determining the characteristics of the style of fighting veteran boxers is relevant as a problem of determining the styles of people in general. In addition, this problem is relevant in terms of identifying the peculiarities of the fight of representatives of not only boxing but also other martial arts [7]. The issue of determining the indicators characteristic of a certain style of fighting is relevant for building the training process of boxers at all stages of the training process, in particular - for veteran boxers.

To date, the nature of the origin of different styles is not fully understood. There are hypotheses that suggest that the styles are the result of separate training of certain groups of people [1, 2, 8]. There are also historical facts that indicate the origin of the styles of dueling as imitation of the manners of movement and survival strategies of different animals [2, 8]. Thus copying was carried out both external movements, and internal states. Martial arts from the "crane style" have come down to our time, as well as different styles of fighting within one martial art - "style of image and form" or "style of imitation of form". They are based on imitating the movements and habits of animals. Man, mastering the "form and manner" of the tiger, snake, dragon, reached the natural freedom and natural potential of the animal in its "original state" [8, 9]. At the present stage, the vast majority of scientists in the field of martial arts, there are three options for tactical styles of fighting: game, power, tempo [1, 2].

What indicators to choose to compare boxers with different styles of fighting? First of all, these are indicators of movement technique, because it is the features of individual technical skills that are reflected in a certain style of movement. There are various research methods for this. Most researchers use observation of boxers during a fight with the fixation of applied technical and tactical elements [8, 9]. There is also a deeper analysis of the technical characteristics of each athlete on the basis of biomechanical indicators of individual movements [10, 11, 12]. But in modern boxing, this method is just beginning to be embodied in the practice of researching the movements of athletes of different styles. Biomechanical analysis allows to objectively determine the peculiarities of the development of the speed of the limbs and torso, changes in the angles in the joints and other indicators of movement of athletes [11,

12]. Therefore, this area of research has scientific prospects for both boxers and people in general to understand the peculiarities of the formation of individual manners and styles of motor activity. In addition, a promising area is also the definition of psychophysiological indicators, in particular - the speed of the pulse in different structures of the central nervous system [13]. The physiological basis of style formation is relatively constant genetically determined functions, such as neurodynamic processes and psychophysiological capabilities, and registration of these indicators in the training process will help determine the propensity of a boxer to a certain style of fighting. It was found that the level of development of psychomotor reactions and specific perception of athletes has certain relationships with typical styles of fighting [13, 14, 15].

For practical work it is necessary to use informative indicators, quite accessible in the definition, which do not require a long period of time for their development and relatively constant in ontogenesis [16, 17, 18]. Psychophysiological indicators can be used for this purpose [19–22]. Also, genetically determined psychophysiological indicators should be supplemented with indicators that are an external reflection of the internal state of man, ie indicators of motor activity [23, 24, 25]. From this point of view, it is advisable to use biomechanical indicators. Thus, the study hypothesized that veteran boxers with different styles of fighting differ in biomechanical and psychophysiological indicators.

Purpose of the work: to give a comparative description of the features of motor activity of boxers-veterans of different styles of fighting based on the analysis of psychophysiological and biomechanical parameters.

Material and methods

Participants

The study involved 42 qualified veteran boxers (age 45-50 years, body length - 178.67±8.26 cm, body weight - 70.96±9.38 kg). The total experience of boxing for the participants was 20-25 years. Athletes were selected as follows: a prerequisite for participation in the study was the presence of a sports qualification in the past not lower than a candidate for master of sports (winners of competitions not lower than the level of the city or region) and the regularity of training for the last 10 years 3-4 times a week. The study was conducted on the basis of sports clubs "KhTZ", "Vostok", "Metalist" in Kharkov, Ukraine.

All participants were aware of the aims of the study and agreed to participate. The study followed the principles of the Declaration of Helsinki and the World Association of Medical Editors.

Fighting styles were determined using a combination of factor and cluster analysis methods, the results of which are presented in our previous studies. [26].As a result of determining the styles of the fight, the boxers were distributed as follows: tempo style (n=11), game style (n=16), power style (n=15).

Procedure

The study was conducted from April 18 to May 25, 2021. At the beginning, video filming of athletes was carried out when performing a direct blow in boxing. Each athlete performed a series of blows alternately with his right and left hands in the mode of a training session against the background of a visible object for subsequent calibration with known dimensions. Video filming was carried out at training sessions from 18:00 after a short warm-up in the boxing gym of the KhTZ sports club. During one training session, 10-12 people were filmed. The next day after the video shooting, the athletes underwent psychophysiological testing also from 18:00. When conducting psychophysiological testing, athletes were first asked to pass the proposed tests in the training mode. Psychophysiological testing was carried out in the classroom for theoretical classes of the sports club "KhTZ".

Biomechanical analysis of direct punch technique in boxing

We have chosen direct hit as the main element for the analysis of sports equipment of qualified veteran boxers. The choice of direct hit was due to the fact that it is the main technical element in boxing. This stroke is the most standardized among all elements of boxing and provides the least variability of performance [26, 27, 28]. This element is perfectly mastered by all qualified boxers, in particular - veteran boxers. Also, the individual style of movement is most traced in those movements that are performed most automatically, ie with minimal control by the mind. This impact is most convenient for biomechanical analysis using video, as it is performed in almost the same plane.

Biomechanical analysis of direct hit technique in qualified veteran boxers was performed using the program "Kinovea", version 0.8.15. (Figs. 1, 2). Kinovea allows you to perform video analysis of movements. It is designed for athletes, coaches, health professionals, for research in the field of sports. Software can also be useful for professionals in the field of ergonomics or animation. The main function of Kinovea is to view and analyze sports videos. The main tools that involve users: "Line", "Chronometer", "Tracking", "Angles". The "Line" and "Chronometer" functions allow you to measure distance and time, and with the help of the tool "Semi-automatic tracking" you can track both the trajectory and time. When working with Kinovea, you can use video from external sources: camcorders, smartphones, and so on [11, 12].

For the analysis of biomechanical parameters of the direct hit technique, qualified veteran boxers were selected 6 frames at a speed of 26 frames per second. Thus, the time of one frame was 0.03-0.04 s (Fig. 1, 2). The total duration of the direct strike was 0.13-0.16 s, depending on the number of frames analyzed (5 or 6, respectively). Distance calibration was performed along the length of a special device, on the background of which video recording was performed (138 cm). The movement time was determined by the stopwatch in the program. The speed of movement of the fist, shoulder joint, elbow joint, knee joint (V, m • s-1) was determined (Fig. 2). The angles between the shoulder and the torso (angle in the shoulder joint), between the

shoulder and the forearm (angle in the elbow joint), between the thigh and the shin (angle in the knee joint) (degrees) were also determined (Figs. 1, 2).

In total, 10 videos of direct hit for each athlete were analyzed. Of the 10 videos, the average data for each athlete was analyzed. The total number of videos was 420. The end of the impact was chosen as the point of greatest extension of the impact arm in the shoulder joint. In each video, 6 frames (duration of direct hit) were selected for analysis. If the stroke ended in the fifth frame, the sixth frame was excluded from the analysis. Before the fifth frame, no athlete had a direct hit. Thus, the total duration of a direct hit in boxing in qualified veteran boxers was 0.13-0.16 s. The point of the minimum angle between the shoulder and the torso (shoulder joint), from which the movement of the striker's arm begins, was chosen as the beginning of the impact [26].

The Angles tool was chosen to analyze the angles in the joints on the Kinovea 0.8.15 toolbar. The point of the vertex of the angle was chosen, then the angle was determined for analysis. The angle selected for analysis was determined in each frame (Figs. 1, 2).

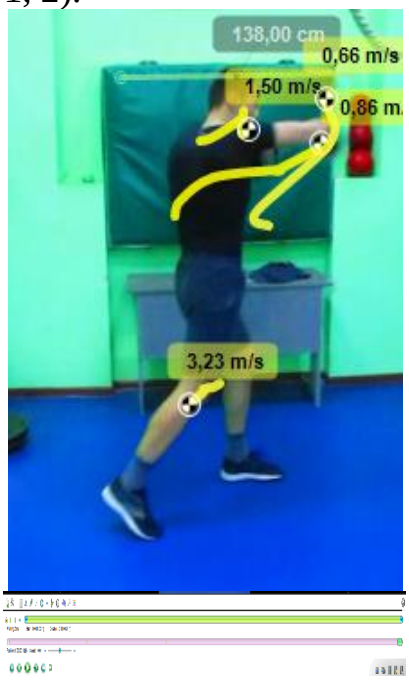

Fig. 1. Determining the speed of movement of various points of the body when performing a direct blow in boxing using the Kinovea 08.15 program

Fig. 2. Determining the angles in the joints when performing a direct blow in boxing using the Kinovea 08.15 program

We carried out the following trajectory tracking for subsequent analysis of the distance and speed of movement of each point (Fig. 1): 1 – we chose a point for analysis; 2 - chose the option "Track Path" ("Record the trajectory"); chose the "End Path Edition" function; 3 – the analyzed point was corrected for each frame; 4 - select the "Configuration" function and set the "Distance" function. The display showed the distance from the start of the movement to the selected section of the path. To measure the speed of the point, we selected the "Configuration" function, and then we selected the "Speed" function. We chose meters per second as the units of measurement. The measurement results were exported to the EXCEL program.

Psychophysiological methods

The following parameters characteristic of the psychophysiological state, typological features of the nervous system, indicators of the nervous system efficiency, and attention indicators [15] have been set using the computer program "Psychodiagnostics" (Kharkiv, Ukraine, KhNPU):

– A set of indices for the time of a simple visual-motor reaction (mean of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 element from 3 (mean value of 30 attempts (ms), standard deviation (ms), number of errors); duration of exposure (signal) – 900 ms.

– A set of indicators of a complex visual-motor reaction of selecting 2 elements out of 3 in the feedback mode, i.e. as the response time changes, the signal delivery time changes. The ‘short version’ is carried out in the feedback mode, when the duration of exposure changes automatically depending on the response of the subject: after a correct answer, the duration of the next signal is reduced by 20 ms, and after a

wrong one, it increases by the same amount. The range of the signal exposure change during the test subject's operation is 20–900 ms, with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button while displaying a certain exposure (image), or during a pause after the current exposure. In this test, the time to reach the minimum exposure of the signal and the time of the minimum exposure of the signal reflect the functional mobility (speed) of the nervous processes; the number of errors reflects the strength of the nervous processes (the lower these parameters, the higher the speed endurance of the nervous system). The duration of the initial exposure is 900 ms; the amount of change in the duration of the signals with correct or erroneous responses is 20 ms; pause between the presentation of signals – 200 ms; the number of signals is 50. The indicators are fixed: the average value of the latent period (ms); root mean square deviation (ms); number of mistakes; time of test execution (s); minimum exposure time (ms); time of exposure to the minimum exposure (s).

Statistical analysis

We used the following methods of statistical analysis using the SPSS-23.0 program.

1. Descriptive statistics (Analyze - Descriptive Statistics). We used this method to obtain a general idea of the analyzed sample of qualified veteran boxers. We calculated the following indicators: Minimum, Maximum, Mean value $\overline{(x)}$, standard deviation (S). In total, 52 indicators were analyzed, including 42 indicators of the biomechanics of the technique of a direct blow in boxing and 10 indicators of the psychophysiological capabilities of athletes.

2. Determining the reliability of differences between groups of different fighting styles. To do this, a Chi-square test was first carried out to determine the normality of distribution for each group of athletes for each indicator. Since for all three groups of athletes the significance of the Chi-square test was greater than 0.05, it was concluded that there was a normal distribution for all analyzed indicators for all groups of athletes. Therefore, to determine the significance of differences between groups, we applied the Student's method. Differences were considered significant at a significance level of $p<0.05$.

Results

We determined the significance of differences between clusters (groups) of athletes. To do this, a Chi-square test was first carried out to determine the normality of distribution for each group of athletes for each indicator. Since for all three groups of athletes the significance of the Chi-square test was more than 0.05 (Tables 1–3), it was concluded that there was a normal distribution for all analyzed indicators for all groups of athletes. Therefore, to determine the significance of differences between groups, we applied the Student's method.

Table 1

The results of the Chi-square test of biomechanical and psychophysiological parameters of qualified boxers-veterans of the tempo style of fighting (n=11)

Indicators	Chi-Square	df	Asymp. Sig.	Monte Carlo Sig.	95% Confidence Interval	
					Lower bound	Upper bound
Simple visual-motor reaction time (ms)	4.28	10	0.5	0.49	0.48	0.5
Selection response time (ms)	2.57	10	0.46	0.27	0.27	0.28
Selection response time in feedback mode (ms)	5.14	10	0.27	0.99	0.99	0.99
Errors in the selection reaction test in the feedback mode (number)	0	10	0.99	0.27	0.27	0.28
The minimum exposure time of the signal to the test for the selection reaction in the feedback mode (ms)	5.14	10	0.27	0.9	0.97	0.99
Time to reach the minimum exposure of the signal in the test for the selection reaction in the feedback mode (s)	0	10	0.99	0.52	0.51	0.53
Total time to complete the test for the selection reaction in the feedback mode (s)	4.28	10	0.5	0.52	0.51	0.53
Shoulder angle at position 3 (degrees)	4.28	10	0.5	0.99	0.97	0.99
Shoulder angle at position 5 (degrees)	4.28	10	0.99	0.99	0.97	0.99
Elbow angle at position 3 (degrees)	4.28	10	0.99	0.99	0.97	0.99
Elbow angle at position 5 (degrees)	0.07	10	0.99	0.99	0.97	0.99
Knee angle in position 2 (degrees)	0.08	10	0.99	0.99	0.97	0.99
Knee angle at position 5 (degrees)	0.04	10	0.99	0.99	0.97	0.99
Fist movement speed in position 3 ($m \cdot s^{-1}$)	0.07	10	0.99	0.52	0.51	0.53
Fist movement speed in position 5 ($m \cdot s^{-1}$)	4.28	10	0.5	0.48	0.47	0.49
Shoulder speed in position 3 ($m \cdot s^{-1}$)	1.71	10	0.42	0	0	0.01
Shoulder speed in position 5 ($m \cdot s^{-1}$)	7.71	10	0	0.99	0.97	0.99
Elbow speed in position 3 ($m \cdot s^{-1}$)	0	10	0.99	0.52	0.51	0.53
Elbow speed in position 5 ($m \cdot s^{-1}$)	4.28	10	0.5	0.52	0.51	0.53
Knee speed in position 2 ($m \cdot s^{-1}$)	4.28	10	0.5	0.99	0.97	0.99
Knee speed in position 5 ($m \cdot s^{-1}$)	4.28	10	0.99	0.99	0.97	0.99

Table 2

The results of the Chi-square test of biomechanical and psycho-physiological parameters of qualified boxers-veterans of the game fighting style (n=16)

Indicators	Chi-Square	df	Asymp. Sig.	Monte Carlo Sig.	95% Confidence Interval	
					Lower bound	Upper bound
Simple visual-motor reaction time (ms)	4.28	15	0.99	0.52	0.51	0.53
Selection response time (ms)	2.57	15	0.5	0.52	0.51	0.53
Selection response time in feedback mode (ms)	5.14	15	0.5	0.99	0.97	0.99
Errors in the selection reaction test in the feedback mode (number)	5.14	15	0.99	0.99	0.97	0.99
The minimum exposure time of the signal to the test for the selection reaction in the	0	15	0.99	0.99	0.97	0.99
Time to reach the minimum exposure of the signal in the test for the selection	4.28	15	0.99	0.52	0.51	0.53
Total time to complete the test for the selection reaction in the feedback mode (s)	4.28	15	0.5	0.48	0.47	0.49
Shoulder angle at position 3 (degrees)	0.07	15	0.42	0	0	0.01
Shoulder angle at position 5 (degrees)	0.08	15	0	0.99	0.97	0.99
Elbow angle at position 3 (degrees)	0.04	15	0.99	0.52	0.51	0.53
Elbow angle at position 5 (degrees)	0.07	15	0.5	0.52	0.51	0.53
Knee angle in position 2 (degrees)	0.05	15	0.5	0.99	0.97	0.99
Knee angle at position 5 (degrees)	0.03	15	0.99	0.99	0.97	0.99
Fist movement speed in position 3 ($m \cdot s^{-1}$)	4.28	15	0.99	0.99	0.97	0.99
Fist movement speed in position 5 ($m \cdot s^{-1}$)	1.71	15	0.99	0.99	0.97	0.99
Shoulder speed in position 3 ($m \cdot s^{-1}$)	7.71	15	0.99	0.99	0.97	0.99
Shoulder speed in position 5 ($m \cdot s^{-1}$)	0.09	15	0.99	0.52	0.51	0.53
Elbow speed in position 3 ($m \cdot s^{-1}$)	4.28	15	0.5	0.52	0.51	0.53
Elbow speed in position 5 ($m \cdot s^{-1}$)	4.28	15	0.5	0.99	0.97	0.99
Knee speed in position 2 ($m \cdot s^{-1}$)	0.08	15	0.99	0.99	0.97	0.99
Knee speed in position 5 ($m \cdot s^{-1}$)	0.04	15	0.99	0.99	0.97	0.99

Table 3

The results of the Chi-square test of biomechanical and psychophysiological parameters of qualified boxers-veterans of the tempo fighting style (n=15)

Indicators	Chi-Square	df	Asymp. Sig.	Monte Carlo Sig.	95% Confidence Interval	
					Lower bound	Upper bound
Simple visual-motor reaction time (ms)	1.71	14	0.42	0	0	0.01

Selection response time (ms)	7.71	14	0	0.99	0.97	0.99
Selection response time in feedback mode (ms)	0	14	0.99	0.52	0.51	0.53
Errors in the selection reaction test in the feedback mode (number)	4.28	14	0.5	0.99	0.97	0.99
The minimum exposure time of the signal to the test for the selection reaction in the	0	14	0.99	0.48	0.47	0.49
Time to reach the minimum exposure of the signal in the test for the selection	1.71	14	0.42	0	0	0.01
Total time to complete the test for the selection reaction in the feedback mode (s)	7.71	14	0	0.99	0.97	0.99
Shoulder angle at position 3 (degrees)	0	14	0.99	0.52	0.51	0.53
Shoulder angle at position 5 (degrees)	4.28	14	0.5	0.52	0.51	0.53
Elbow angle at position 3 (degrees)	4.28	14	0.5	0.99	0.97	0.99
Elbow angle at position 5 (degrees)	0	14	0.99	0.99	0.97	0.99
Knee angle in position 2 (degrees)	0	14	0.99	0.99	0.97	0.99
Knee angle at position 5 (degrees)	0	14	0.99	0.99	0.97	0.99
Fist movement speed in position 3 ($m \cdot s^{-1}$)	0	14	0.99	0.48	0.47	0.49
Fist movement speed in position 5 ($m \cdot s^{-1}$)	1.71	14	0.42	0	0	0.01
Shoulder speed in position 3 ($m \cdot s^{-1}$)	7.71	14	0	0.99	0.97	0.99
Shoulder speed in position 5 ($m \cdot s^{-1}$)	0	14	0.99	0.52	0.51	0.53
Elbow speed in position 3 ($m \cdot s^{-1}$)	4.28	14	0.5	0.52	0.51	0.53
Elbow speed in position 5 ($m \cdot s^{-1}$)	4.28	14	0.5	0.99	0.97	0.99
Knee speed in position 2 ($m \cdot s^{-1}$)	0	14	0.99	0.99	0.97	0.99
Knee speed in position 5 ($m \cdot s^{-1}$)	0	14	0.99	0.99	0.97	0.99

The analysis of differences between groups of boxers of different fighting styles showed significant differences between the time of simple visual-motor reaction in tempo style boxers and boxers of playing style ($p<0.01$), between the choice reaction time in tempo style boxers and boxers of other fighting styles ($p<0.05$; $p<0.001$), between the reaction time of choice in the test with feedback for tempo style boxers and boxers of the playing style ($p<0.001$), between the number of errors in the choice reaction test with feedback for tempo style boxers and boxers of the playing style ($p<0.001$), between the time of the minimum signal exposure in the choice reaction test with feedback for boxers of the tempo style and boxers of other fighting styles ($p<0.001$), between the time of reaching the minimum signal exposure in the reaction test selection with feedback among boxers of tempo style and boxers of other styles of fighting ($p<0.001$), between the total time of the reaction test choice with feedback among boxers of tempo style and boxers of playing style ($p<0.05$) (Table 4).

Таблица 4

Biomechanical and psychophysiological parameters of qualified boxers-veterans of different fighting styles

Indicators	Names of groups of athletes by fighting style						Reliability indicators of differences between groups of athletes					
	1 – tempo style, "Speed and coordination endurance" (n=11)		2 - play style, "Speed" (n-16)		3 - power style, "Strength and speed" (n=15)		t-1-2	p-1-2	t-1-3	p-1-3	t-2-3	p-2-3
	$\bar{x}$	S	$\bar{x}$	S	$\bar{x}$	S						
Simple visual-motor reaction time (ms)	314	17.82	292	12.45	300	17.8	3.54	<0.01	1.98	>0.05	-1.44	>0.05
Selection response time (ms)	590.00	24.63	525.00	21.65	568.00	22.34	7.07	<0.001	2.34	<0.05	-5.44	<0.001
Selection response time in feedback mode (ms)	513.00	21.32	453.00	19.34	449.00	17.89	7.46	<0.001	8.09	<0.001	0.60	>0.05
Errors in the selection reaction test in the feedback mode (number)	17.00	2.03	20.00	2.13	19.00	2.11	-3.70	<0.01	-2.44	<0.05	1.31	>0.05
The minimum exposure time of the signal to the test for the selection reaction in the feedback mode (ms)	540.00	26.08	440.00	22.07	400.00	21.09	10.41	<0.001	14.64	<0.001	5.16	<0.001
Time to reach the minimum exposure of the signal in the test for the selection reaction in the feedback mode (s)связи (с)	73.00	8.09	43.00	5.68	50.00	4.62	10.63	<0.001	8.47	<0.001	-3.77	<0.01
Total time to complete the test for the selection reaction in the feedback mode (s)	107.00	14.82	94.00	12.67	97.00	12.48	2.37	<0.05	1.82	>0.05	-0.66	>0.05

Shoulder angle at position 3 (degrees)	77	9.12	55	6.71	69	4.76	6.83	<0.001	2.66	<0.05	-6.73	<0.001
Shoulder angle at position 5 (degrees)	86	9.67	83	9.25	78	7.56	0.81	>0.05	2.28	<0.05	1.65	>0.05
Elbow angle at position 3 (degrees)	58	5.14	91	9.63	63	6.72	-11.53	<0.001	-2.15	<0.05	9.44	<0.001
Elbow angle at position 5 (degrees)	177	14.16	151	14.46	122	12.43	4.65	<0.001	10.30	<0.001	6.00	<0.001
Knee angle in position 2 (degrees)	125	11.26	140	12.79	140	11.57	-3.22	<0.01	-3.32	<0.01	0.00	>0.05
Knee angle at position 5 (degrees)	143	15.72	163	14.65	149	14.57	-3.34	<0.01	-0.99	>0.05	2.67	<0.05
Fist movement speed in position 3 ($m \cdot s^{-1}$)	7.2	0.21	17.52	2.12	4.63	0.39	-19.33	<0.001	21.61	<0.001	23.89	<0.001
Fist movement speed in position 5 ($m \cdot s^{-1}$)	2.07	0.15	8.74	1.39	5.86	1.45	-19.03	<0.001	-10.05	<0.001	5.64	<0.001
Shoulder speed in position 3 ($m \cdot s^{-1}$)	2.56	0.18	5.71	0.92	1.74	0.08	-13.33	<0.001	14.12	<0.001	17.19	<0.001
Shoulder speed in position 5 ($m \cdot s^{-1}$)	2.41	0.17	1.06	0.01	1.9	19	26.31	<0.001	0.10	>0.05	-0.17	>0.05
Elbow speed in position 3 ($m \cdot s^{-1}$)	7.04	0.29	7.03	0.61	3.17	0.43	0.06	>0.05	27.38	<0.001	20.46	<0.001
Elbow speed in position 5 ($m \cdot s^{-1}$)	1.51	0.14	3.56	0.28	4.74	0.27	-25.08	<0.001	-39.63	<0.001	-11.94	<0.001
Knee speed in position 2 ($m \cdot s^{-1}$)	3.81	0.19	1.39	0.03	1.74	0.13	41.89	<0.001	31.18	<0.001	-10.18	<0.001
Knee speed in position 5 ($m \cdot s^{-1}$)	3.81	0.49	0.93	0.16	0.36	0.15	18.82	<0.001	22.59	<0.001	10.24	<0.001

All indicators reflecting the time are the highest among boxers of the tempo style ($p<0.05$; $p<0.01$; $p<0.001$), the indicator reflecting the number of errors when performing the choice reaction test in the feedback test, on the contrary, is the lowest among tempo style boxers ($p<0.05$; $p<0.01$). The greatest differences were revealed between these indicators in tempo style boxers and playing style boxers.

It follows from the obtained data that tempo-style boxers differ from representatives of other fighting styles in their lower mobility of the nervous system and greater endurance to speedy and precise actions. Accuracy is a manifestation of coordination abilities. In this regard, we can conclude that the boxers of the tempo style differ from the boxers of other fighting styles in greater coordination endurance, speed endurance and endurance in performing precise actions over time.

We also revealed that the psychophysiological features of boxers-veterans of different fighting styles determine the features of the direct punch technique. So, playing-style boxers, when performing a direct blow, sometimes first move their arm backwards, performing a small swing, then at high speed at the very beginning of the movement they perform a blow. This is reflected in the largest angle in the shoulder joint at the very beginning of the movement ($p<0.05$, $p<0.001$) (Table 4, Fig. 3), the greatest speed of movement of the fist and shoulder at the very beginning of the movement ($p<0.001$) (0 06 s from the start of movement) (Fig. 4, 5).

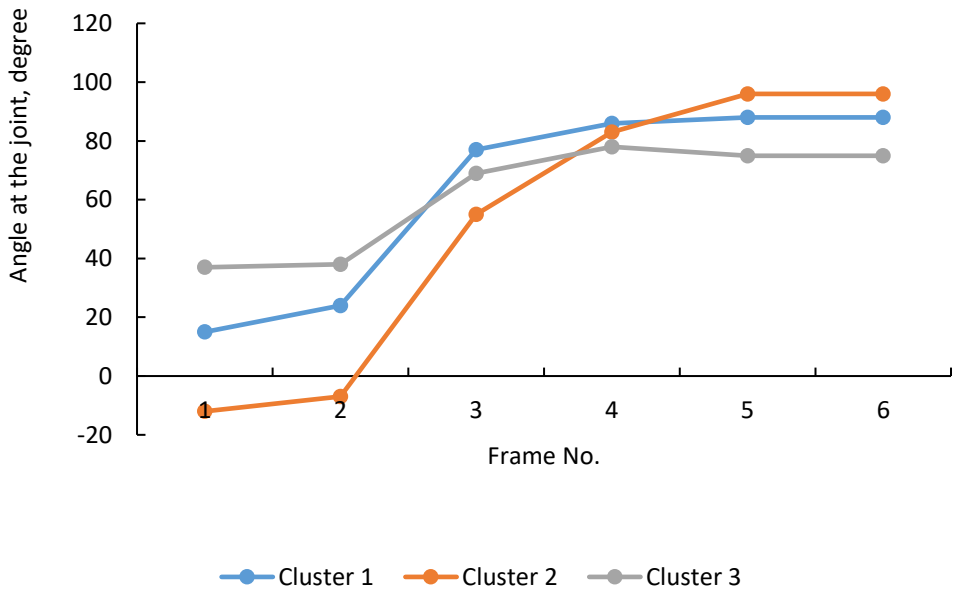

Fig. 3. The values of the angles between the shoulder and the torso of qualified veteran boxers of different fighting styles:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

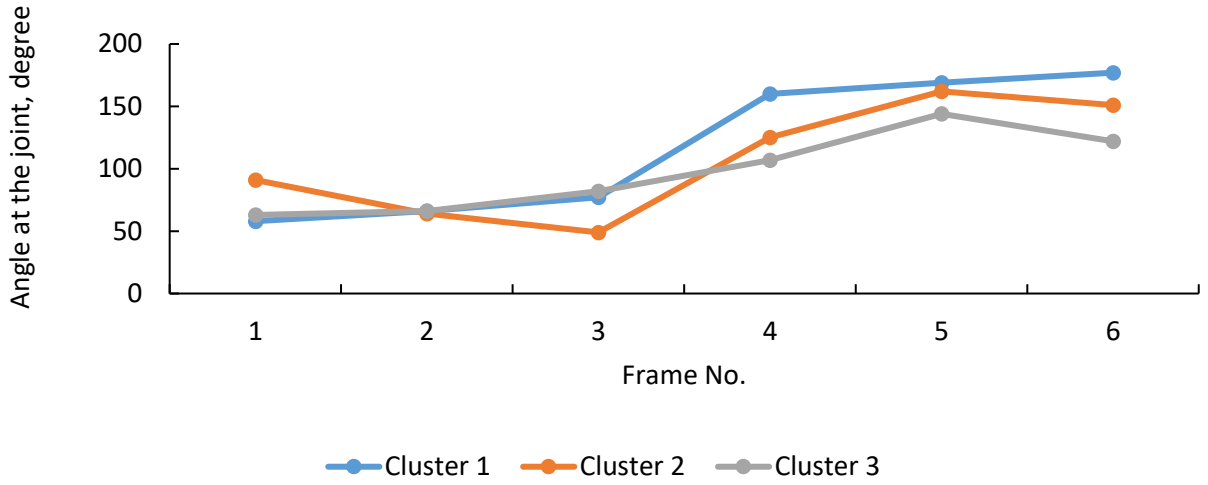

Fig. 4. Values of the angles between the shoulder and forearm of qualified boxers-veterans of different fighting styles:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

Such a quick start serves as a compensatory mechanism for the lack of speed and coordination endurance compared to tempo style boxers. To quickly achieve the result, boxers of the playing style develop maximum speed already in the first milliseconds of the execution of a direct blow. In addition, boxers of the playing style have the highest stance with the least bending of the knees (Table 4, Fig. 6). This is due to the fact that a high stance gives more opportunities for review and analysis of the situation and makes it possible to quickly vary actions. Boxers of the playing style also have the smallest angle in the elbow joint at the very beginning of the movement (0.06 s from the beginning of the movement) (Table 4, Fig. 6) and the lowest speed of movement of the knee joint (Table 4, Fig. 7) as at the beginning and at the end of the movement.

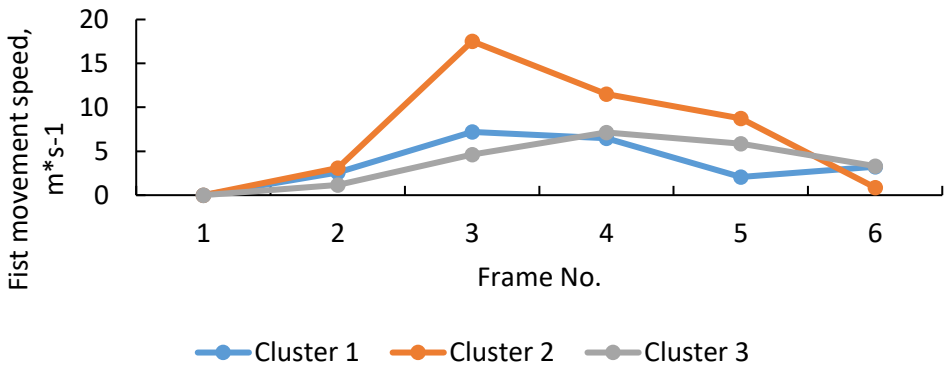

Fig. 5. Values of fist movement speed of qualified boxers-veterans of different fighting styles:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

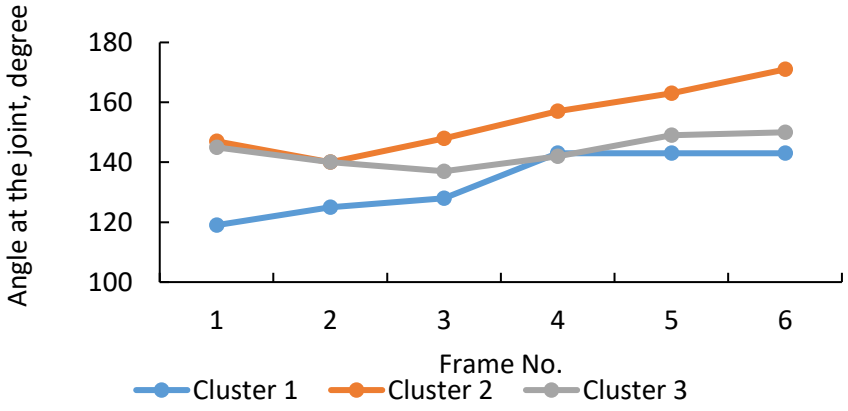

Fig. 6. The values of the angles between the thigh and lower leg in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

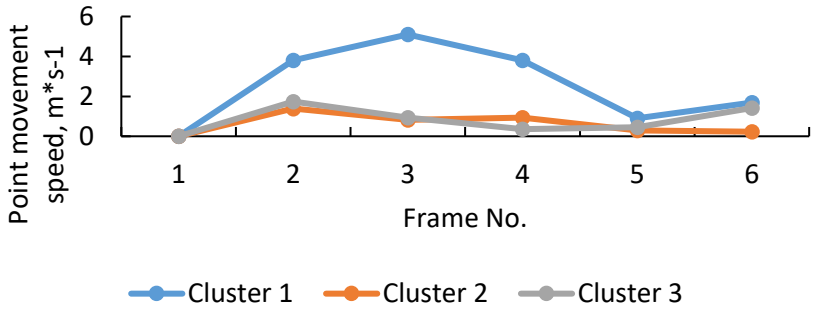

Fig. 7. Values of the speed of movement of the knee joint in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

We also revealed that the psychophysiological features of boxers-veterans of different fighting styles determine the features of the direct punch technique.

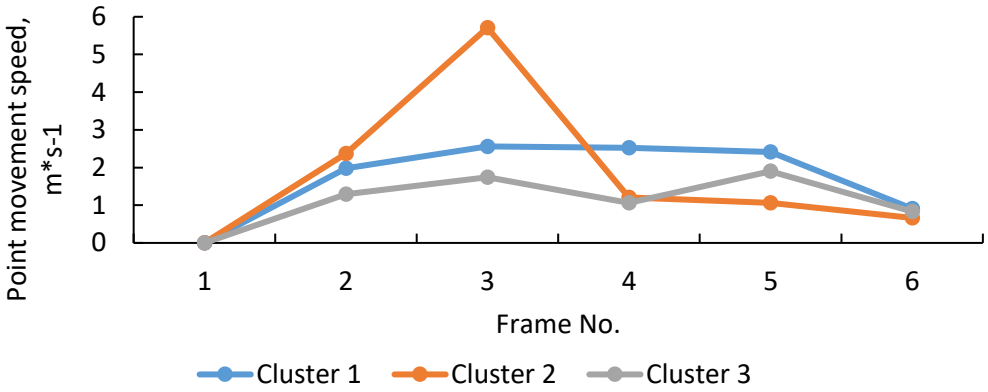

Fig. 8. Values of the speed of movement of the shoulder joint in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

Power-style boxers develop the maximum movement speed at the end of a direct punch compared to the beginning (Table 4, Fig. 5, 7, 8, 9), which is due to the gradual activation of myofilaments and motor units to achieve maximum strength. Also, power-style boxers are distinguished by the smallest values of the angle in the elbow joint, which is especially noticeable at the end of the movement (0.13-0.16 s from the beginning of the movement) ($p<0.001$) (Table 4, Fig. 3, 4).

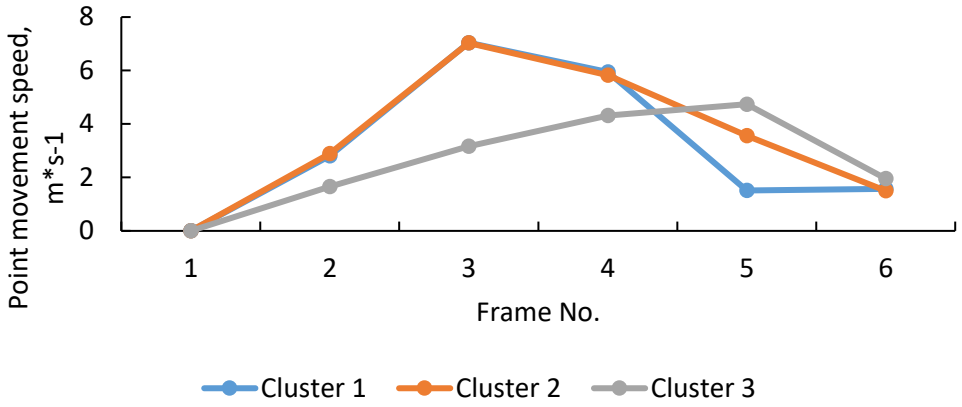

Fig. 9. Values of the speed of movement of the elbow joint in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style;
1 – initial value of movement, 0.00 s;
2 - the second frame from the beginning of the movement, 0.03 s;
3 - the third frame from the beginning of the movement, 0.06 s;
4 - the fourth frame from the beginning of the movement, 0.10 s;
5 - the fifth frame from the beginning of the movement, 0.13 s;
6 - the sixth frame from the beginning of the movement, 0.16 s.

Tempo style boxers have the highest angle in the elbow joint at the end of the movement (0.13-0.16 s from the beginning of the movement) ($p<0.001$) (Table 4, Fig. 9), the smallest angle in the knee joint throughout the movement ($p<0.05$, $p<0.01$) (Table 4, Fig. 6) and the highest speed of movement, which is reflected in the highest speed of movement of the point of the knee joint throughout the movement ($p<0.001$) (Table 4, Fig. 7). This feature of the technique of tempo style boxers can be regarded as a compensatory mechanism for the lack of reaction speed and speed of inclusion in the movement at the very beginning of the action. The speed of movement of the points of the fist, elbow and shoulder in tempo style boxers is evenly distributed throughout the execution of a direct blow (Fig. 5, 8, 9). This fact characterizes the speed endurance of tempo style boxers. The revealed patterns of speed in the movement of the points of the fist, elbow, shoulder, knee and angles in the joints are also reflected in the trajectory of the movement of the points of the fist, elbow, shoulder, knee (Fig. 10–13).

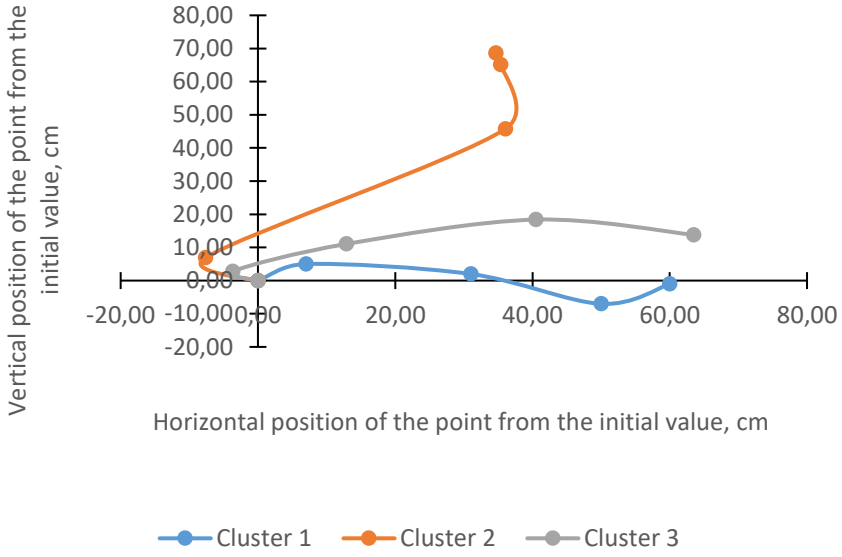

Fig. 10. Values of the trajectory of the movement of the fist in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style.

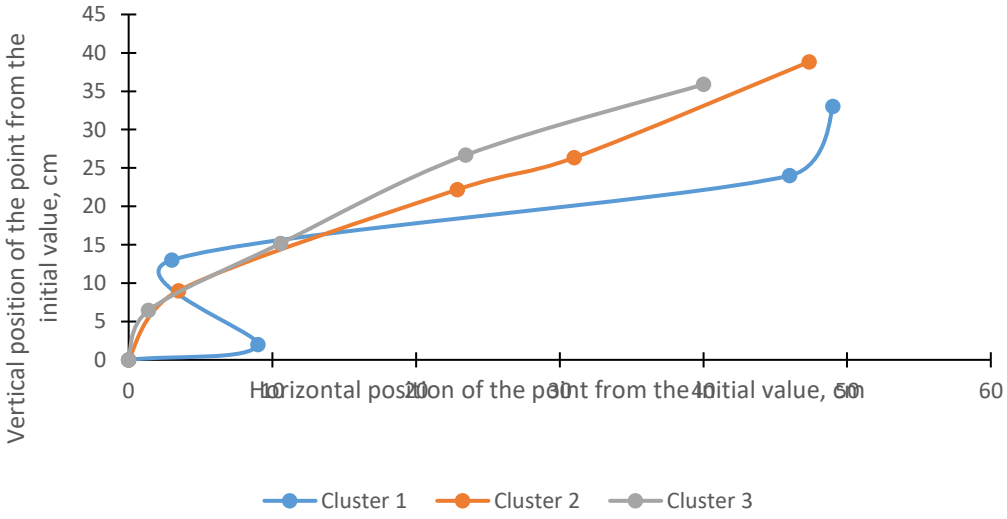

Fig. 11. Values of the trajectory of the elbow joint in qualified veteran boxers of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Power and speed", power style.

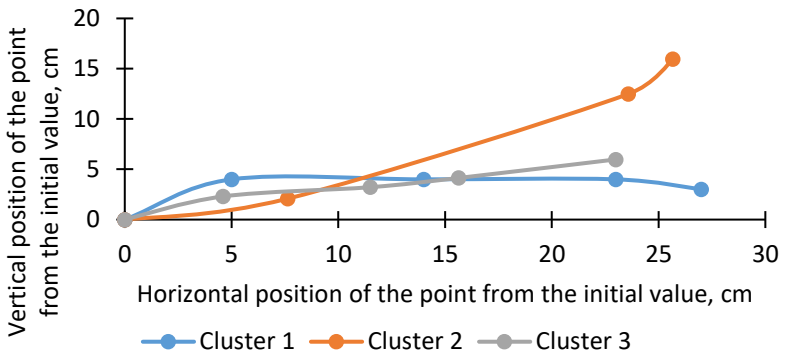

Fig. 12. Values of the trajectory of the shoulder joint movement in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style:
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style.

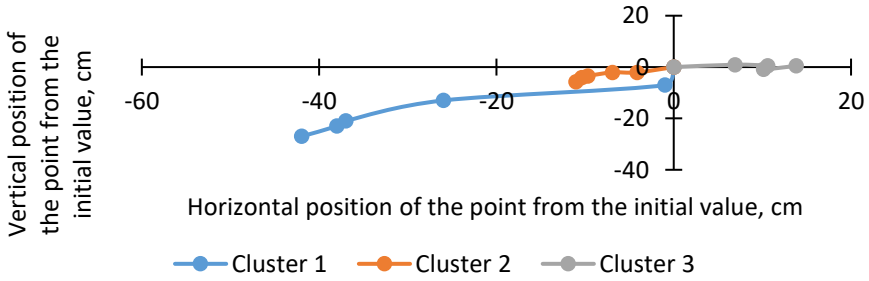

Fig. 13. The values of the trajectory of the knee joint movement in qualified boxers-veterans of different styles of fighting:
Cluster 1 - "Speed and coordination endurance", tempo style;
Cluster 2 - "Speed", game style;
Cluster 3 - "Strength and speed", power style.

Thus, the psychophysiological features of boxers of different styles of fighting are reflected in the features of the direct punch technique. The lack of speed when tempo-style boxers are engaged in movement is supplemented and compensated by the high speed of movement. This ensures that speed is maintained throughout the fight and creates the conditions for victory by the fact that boxers of other fighting styles cannot maintain high endurance for accurate and fast actions for a long time, realizing their potential at the very beginning of the movement. Play style boxers are characterized by high speed of movement at the very beginning of punching. This provides the possibility of small rest breaks and thus creates the conditions for the variability of actions. Power style boxers are distinguished by the gradual development of movement speed, which creates conditions for the implementation of the impact force.

Discussion

In our study, the hypothesis was confirmed. It was found that veteran boxers with different fighting styles (tempo, game, power) significantly differ from each other in terms of psychophysiological and biomechanical indicators. The goal of the work was also achieved: a comparative description of veteran boxers of various styles of fighting was given. It was found that the psycho-physiological features of boxers of different styles of fighting are reflected in the features of the direct punch technique. The lack of speed when tempo-style boxers are engaged in movement is supplemented and compensated by the high speed of movement. This ensures that speed is maintained throughout the fight and creates the conditions for victory by the fact that boxers of other fighting styles cannot maintain high endurance for accurate and fast actions for a long time, realizing their potential at the very beginning of the movement. Play style boxers are characterized by high speed of movement at the very beginning of punching. This provides the possibility of small rest breaks and thus creates the conditions for the variability of actions. Power style boxers are distinguished by the gradual development of movement speed, which creates conditions for the implementation of the impact force.

Analysis of the results of the study in terms of comparing them with the available literature data showed that this work is one of the first in terms of determining the influence of the athlete's psychophysiological indicators on the formation of the style of fighting in boxing. The authors who dealt with the problems of activity styles [1, 8, 9] do not consider the process of training athletes from the point of view of the system, the analysis of a wide range of readiness indicators, and also do not consider the possibility of using innate psychophysiological characteristics that are decisive in the formation of an individual style of activity. , one of the manifestations of which is the style of waging a fight in boxing.

Our study expands, confirms and supplements the data presented in [1, 7, 8] regarding the information content of psychophysiological indicators for the current and operational control of the functional state of athletes and determining their individual characteristics, which is most relevant for predicting the results of competitive activity.

It should be noted that the problem considered in our work closely intersects with the problem of individualization of the training process and is consistent with the concept of individualization presented in [29–32]. The concept of individualization of the training process developed using the deductive method lies in the fact that for an adequate construction of individual training programs, it is necessary, on the basis of an analysis of a wide range of indicators, including anthropometric, physiological, psychophysiological, psychological data, to identify the leading factors in the individual structure of the preparedness of athletes based on the complex related indicators.

In the theory and methodology of training boxers, attempts have already been made to link the type of temperament, which is based on the properties of the nervous system, and the style of activity, in particular, the style of fighting. The authors [1, 7, 8], dealing with this problem, focused on visual observation of the boxer's activity, without offering specific indicators for determining the style of the fight. In our study,

the most informative psycho-physiological indicators have been identified that allow us to determine the boxer's inclination to a certain style of fighting, which is the data obtained for the first time.

This study confirmed the results of our previous studies [26, 33] on the informativeness of psychophysiological and biomechanical indicators to determine the propensity to a certain style of fighting in boxing. Confirmation of this position is due to the results of a comparative analysis of groups of athletes tested for psychophysiological and biomechanical indicators. The informativeness of biomechanical and psychophysiological indicators is also confirmed by the presence of significant differences between boxers with different styles of fighting on these indicators. From this point of view, our results complement the results of research presented in [1, 8]. It should be noted that differences in psychophysiological capabilities of boxers with different styles of fighting are the physiological basis for the formation and manifestation of individual style of activity. Thus, higher indicators of reaction speed determine the formation of the style of the fight, which requires a quick response to changing circumstances, quick decision-making. This is exactly what is observed in game style boxers. In addition, the game style involves performing precise actions in a rapidly changing environment. Physiological prerequisites for the formation and manifestation of this style of action are psychophysiological indicators such as speed, ie the number of correctly performed tasks per unit time in an unforeseen nature and time of the signal.

It should be noted that power style boxers compensate for the lack of reaction speed, speed and accuracy with higher stability with fewer errors, ie they are better than others in terms of identical actions. It follows that for such athletes the best option for the realization of their physiological talents is to achieve mastery in actions that do not require high variability of actions and which consist in the manifestation of a high level of strength in relatively similar actions. This is realized in boxers of power style of fighting. Thus, physiological talents are realized in specific abilities, which are manifested in the formation of a certain style of activity, in our case - the style of fighting in boxing. Similar provisions explain the higher mental and physical capacity of boxers of tempo style. From this point of view, the results are new.

It is known that each person has different "sets" of abilities. An individual combination of abilities is formed throughout life and determines the uniqueness of the individual. Success is also ensured by the presence of a combination of abilities that work for the result. In activity, some abilities can be replaced by others - similar in manifestations, but differ in their origin. The success of the same activity can be ensured by different abilities, so the lack of one ability can be compensated by the presence of another or even a whole complex. Therefore, the individual uniqueness of a set of individual abilities that ensure the successful implementation of activities, it is common to call "individual style of activity". Psychophysiological differences of boxers with different styles of fighting are the basis for differences in the special performance of boxers.

Prospects for further research

Further research suggests development and substantiation of recommendations regarding the construction of the training process of qualified veteran boxers of different styles of fighting.

Limitations

The study was conducted on qualified veteran boxers, therefore, the data obtained apply only to the studied contingent. Additional research is needed to disseminate the obtained data to boxers of other age and social groups, as well as to representatives of other sports.

Conclusions

1. Boxers of the tempo style of fighting differ from representatives of other styles of fighting by less mobility of the nervous system and greater endurance to speedy and precise actions. Tempo style boxers differ from boxers of other fighting styles in greater coordination endurance, speed endurance and endurance in performing precise actions over time.

2. Psychophysiological features of boxers of different styles of fighting are reflected in the features of the technique of a direct blow. The lack of speed when tempo-style boxers are engaged in movement is supplemented and compensated by the high speed of movement. This ensures that speed is maintained throughout the fight and creates the conditions for victory by the fact that boxers of other fighting styles cannot maintain high endurance for accurate and fast actions for a long time, realizing their potential at the very beginning of the movement.

3. Play style boxers are characterized by high speed of movement at the very beginning of punches. This provides the possibility of small rest breaks and thus creates the conditions for the variability of actions. Power style boxers are distinguished by the gradual development of movement speed, which creates conditions for the implementation of the impact force.

Acknowledgments

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Conclusions

1. In the structure of the complex readiness of qualified veteran boxers, 2 main factors have been identified. The first factor (55.063% of the total variance) according to the indicators included in it, was named "Speed". The second factor (44.937% of the total variance) according to the indicators included in it, was named "Speed endurance". The styles of fighting qualified veteran boxers were revealed on the basis of the analysis of the general and individual factor structure of biomechanical and psychophysiological indicators. It is shown that the individual factor structure, which is characterized by the expressiveness of the factor "Speed and coordination endurance" by more than 80%, and the severity of the factor "Speed" by less than 30%, is typical for boxers of the tempo style. The individual factor structure, which is characterized by the expressiveness of the factor "Speed" by more than 80%, and by the severity of the factor "Speed and coordination endurance" by less than 30%, is typical for boxers of the playing style. Individual factorial structure, which is characterized by the expressiveness of the factor "Speed" by more than 50%, and by the severity of the factor "Speed and coordination endurance" by less than 30%, is typical for boxers of the strength style.

2. Qualified veteran boxers with a high level of speed and coordination endurance manifestation (tempo style of fighting), are characterized by the least number of errors when performing the test for the choice reaction in the feedback mode and the average development of the reaction speed, work in a low stance with a high speed of movement and development of maximum speed at the end of the movement or evenly throughout the movement. Qualified veteran boxers with a high level of manifestation of speed capabilities and an average level of manifestation of speed and coordination endurance (playing style of fighting) are characterized by a high level of development of reaction speed, a relatively large number of errors in the test for the choice reaction in the feedback mode, work in a high stance and development of maximum speed at the beginning of the movement. Qualified veteran boxers with an average level of speed abilities and a low level of speed and coordination endurance manifestation (strength style of fighting) are characterized by a high number of errors when performing the test for the choice reaction in the feedback mode and a high level of development of reaction speed, work in a high stance and development of maximum speed at the end of the movement.

3. It is shown that the psychophysiological characteristics of boxers of different styles of fighting are reflected in the characteristics of the technique of direct blow. The lack of speed at the beginning of the movement in tempo style boxers is supplemented and compensated by the high speed of movement. Playing style boxers are characterized by a high speed of movement at the very beginning of the strike. Power style boxers are characterized by the gradual development of movement speed.

4. Cluster analysis of psychophysiological testing showed the presence of 3 groups of athletes. 3 clusters (groups) of veteran boxers have been identified, which differ in their psychophysiological and biomechanical indicators. Athletes of the first cluster are dominated by the expression of qualities that determine the speed and coordination endurance (over 80%) and a small level of expression of speed qualities (less than 30%). This corresponds to the pace of the fight. The athletes of the second cluster are dominated by the expression of speed qualities (over 80%) and the average level of expression of qualities that determine the speed and coordination endurance

(about 50%). This corresponds to the game style of the fight. Athletes of the third cluster have an average expression of speed qualities (about 50%) and a small expression of qualities that determine speed and coordination endurance (less than 30%). Approximation of the obtained results to the expression of different qualities made it possible to determine the greatest manifestation of the speed and strength qualities of the boxers of the third cluster. This corresponds to the power style of the fight. The clusters were named as follows: Cluster 1 - "Speed and coordination endurance", corresponds to the boxers of the pace of the fight; Cluster 2 - "Speed", corresponds to the boxers of the game style of fighting; Cluster 3 - "Strength and speed", corresponds to the boxers of the pace of the fight.

5. Biomechanical features of boxers of different styles of fighting are reflected in the trajectories of the points of the fist, elbow, knee. The athletes of the “Speed and coordination endurance” cluster (tempo style boxers) have the most pronounced trajectory of knee point movement. The trajectory of movement of the knee point in tempo style athletes is the lowest of all analyzed groups of athletes. The athletes of the “Speed” cluster, which corresponds to the boxers of the playing style, have the highest trajectory of the fist point movement. The lowest trajectory of the fist point movement among boxers of the tempo style, the “Speed and coordination endurance” cluster. The trajectory of movement of the elbow joint is also the lowest in tempo style boxers, cluster "Speed and coordination endurance".

6. It is advisable to use the results of this research when planning the individual training of athletes in boxing and to determine the optimal style of conducting a competitive combat for qualified veteran boxers. The proposed methods of psychophysiological and biomechanical testing to determine the individual characteristics of boxers are an effective, informative and fairly accessible and easy-to-use tool for revealing the predisposition of boxers to a certain style of fighting.

7. Boxers of the tempo style of fighting differ from representatives of other styles of fighting by less mobility of the nervous system and greater endurance to speedy and precise actions. Tempo style boxers differ from boxers of other fighting styles in greater coordination endurance, speed endurance and endurance in performing precise actions over time.

8. Psychophysiological features of boxers of different styles of fighting are reflected in the features of the technique of a direct blow. The lack of speed when tempo-style boxers are engaged in movement is supplemented and compensated by the high speed of movement. This ensures that speed is maintained throughout the fight and creates the conditions for victory by the fact that boxers of other fighting styles cannot maintain high endurance for accurate and fast actions for a long time, realizing their potential at the very beginning of the movement. Play style boxers are characterized by high speed of movement at the very beginning of punches. This provides the possibility of small rest breaks and thus creates the conditions for the variability of actions. Power style boxers are distinguished by the gradual development of movement speed, which creates conditions for the implementation of the impact force.

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