FEATURES OF EVALUATION OF THE KINEMATIC STRUCTURE OF THE TECHNIQUE OF THE STRAIGHT RIGHT-HAND BLOW FROM THE LEFT GUARD OF HIGH QUALIFIED ATHLETES SPECIALIZING IN HAND-TO-HAND COMBAT

ОЦІНКА КІНЕМАТИЧНОЇ СТРУКТУРИ ТЕХНІКИ ПРЯМОГО УДАРУ ПРАВОЮ РУКОЮ З ЛІВОСТОРОННЬОЇ СТІЙКИ ВИСОКОКВАЛІФІКОВАНИХ СПОРТСМЕНІВ, ЯКІ СПЕЦІАЛІЗУЮТЬСЯ У РУКОПАШНОМУ БОЮ

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Abstracts

The purpose is to develop the evaluation scales for the technique of the right straight blow from the left guard based on the analysis of the kinematic structure of the movements of high qualified athletes specializing in the hand-to-hand combat.

Methods. Theoretical – to determine the relevance of the problem of forming the technique of motor actions in the hand-to-hand bought; empirical: pedagogical observation as a method of empirical level of research – for familiarization with the process of organizing training sessions; registration of the kinematic characteristics of the technique of the right-hand straight blow from the left guard was carried out using the marker system of registration and analysis of motions Qualysis, which allowed to record the data in three-dimensional space. The shooting frequency was 100 frames per second. The measurement error in determining spatial indicators was 1 millimeter per 1 meter of cubic space, the measurement error in time indicators was 0.01 seconds, ensuring high accuracy of registration of kinematic characteristics of athletes' motor actions. Methods of mathematical statistics were used. The technique of performing the studied motor action of twelve high qualified athletes was registered within the research. **Results.** We used the following algorithm to evaluate the kinematic structure of basic impact motions techniques in hand-to-hand combat. First, we chose a biomechanical indicator that can be used as a criterion for performance of the impact motion. As in has been known from the scientific and methodical literature, impact force is used as a criterion for the effectiveness of impact actions in most cases. However, our research did not use dynamometric devices that can register impact force. Therefore, we used the maximum velocity of the impact biolink as a criterion for impact effectiveness, which, according to literature sources, has a close correlation with impact force. Secondly, with the help of correlation analysis, informative parameters of the impact motions technique were identified. The strongest correlations between the efficiency criterion and various kinematic characteristics of impact motions were identified. Thirdly, the scales for evaluating the kinematic structure of the technique of basic impact motions were developed on the basis of the identified informative parameters. Since the evaluation scales were based on the indicator of the action performance by high qualified athletes, we chose a regression scale. Based on the above algorithm, we have developed scales for evaluating the basic technique of motor actions of athletes, specializing in hand-to-hand combat.

Conclusions. Evaluation scales are developed on the basis of the identified informative parameters of the kinematic structure of the technique of the blow and quantitative indicators of these parameters, based on the analysis of the technique of high qualified athletes specializing in hand-to-hand combat.

Key words: combat, hand-to-hand combat, sport training, comparative analysis, technique, kinematic structure, evaluation scales, high qualified athletes.

Мета – розробити оціночні шкали техніки правого прямого удару з лівосторонньої стійки на основі аналізу кінематичної структури рухів висококваліфікованих спортсменів, які спеціалізуються у рукопашному бою.

Методи. Теоретичні: для визначення актуальності проблеми формування техніки рухових дій у рукопашному бою; емпіричні: педагогічне спостереження як метод емпіричного рівня дослі-

джень – для ознайомлення із процесом організації навчально-тренувальних занять; реєстрація кінематичних характеристик техніки бокового удару правою рукою з фронтальної стійки відбувалася за допомогою маркерної системи реєстрації та аналізу рухів Qualisis, що дозволило зафіксувати дані в тримірному просторі. Частота зйомки становила 100 кадрів за секунду. Похибка під час визначення просторових показників становила 1 міліметр на 1 метр кубічного простору, похибка за часовими показниками становила 0,01 секунди, що забезпечує високу точність реєстрації кінематичних характеристик рухових дій спортсменів. Методи математичної статистики. Нами було зареєстровано техніку виконання досліджуваної рухової дії у 12 спортсменів високої кваліфікації. **Результати.** Нами для оцінки кінематичної структури техніки базових ударних дій у рукопашному бою було використано такий алгоритм. По-перше, ми вибрали біомеханічний показник, який може бути використано як критерій ефективності виконання ударної дії. В науково-методичній літературі як критерій ефективності ударних дій здебільшого використовують силу удару. Проте в наших дослідженнях не використовувалися динамометричні пристрої, що можуть зареєструвати силу удару. Тому нами як критерій ефективності ударної дії було використано максимальну швидкість ударної біоланки, що за даними літературних джерел має щільний взаємозв'язок із силою удару. По-друге, за допомогою кореляційного аналізу було виявлено інформативні параметри техніки ударних дій. Було виявлено найщільніші кореляційні взаємозв'язки між критерієм ефективності та різними кінематичними характеристиками ударних дій. По-третє, на основі виявлених інформативних параметрів розроблено шкали оцінки кінематичної структури техніки базових ударних дій. Оскільки шкали оцінки базувалися на показниках виконання прийомів спортсменами високої кваліфікації, то нами було вибрано регресійну шкалу. На основі вищевикладеного алгоритму нами розроблено шкали оцінки базової техніки рухових дій спортсменів, які спеціалізуються в рукопашному бою.

Висновки. Оціночні шкали побудовані на основі виявлених інформативних параметрів кінематичної структури техніки удару та кількісних показників цих параметрів, на основі аналізу техніки спортсменів високої кваліфікації, які спеціалізуються у рукопашному бою.

*Ключові слова***:** єдиноборства, рукопашний бій, спортивна підготовка, порівняльний аналіз, техніка, кінематична структура, оціночні шкали, висококваліфіковані спортсмени.

Introduction. The process of long-term sports training in any sports requires the solution of many tasks [2; 8]. One of which is effective technical preparedness of athletes, what includes training, mistakes correction and adjustment, as well as constant improvement of the technique of motor actions. At each stage of long-term training, both general and specific tasks of improving the technical skills of athletes are being solved [1; 3].

Technical training has its own features in the hand-to-hand combat [4; 12; 14]. Important indicators are the variability of the technique and the low tactical informativeness of the technique for opponents. Also, the athlete has to master the technique of many motor actions performing. However, the basic elements of motor technique are being performed at all stages of long-term training. Therefore, at each stage, it is necessary to have a "reference" sample of the basic action of the whole technique [5]. The "reference" sample of motor action is the most effective method of performing it, the effectiveness of which has been proven and scientifically substantiated [15; 16]. One of the most widespread ways to eliminate such samples is to study the motor actions of high qualified athletes, which is used as a

guideline for less qualified athletes [13]. Direct equalization of indicators technique actions among athletes of different qualifications is not correct, as there is a different level of evolution of motor quality and other components of sports mastery. Therefore, it is necessary to look at the demonstrations of the technique of motor actions of high qualified athletes as the primary data for modeling the technique [14].

The purpose is to develop the evaluation scales for the technique of the right straight blow from the left guard based on the analysis of the kinematic structure of the movements of high qualified athletes specializing in the hand-to-hand combat.

Material & methods. Twelve high qualified athletes specializing in hand-to-hand combat took part in the study. Seven Masters of Sports of Ukraine and five Masters of Sports of Ukraine of International Class were among them. The study was fulfilled in compliance with the requirements of the World Medical Association Declaration of Helsinki as a statement of ethical principles for medical research involving human subjects. Such *methods of research* as analysis of methodological literature, biomechanical

analysis of actions kinematic structure were used in the research. Registration of the kinematic characteristics of the technique was carried out using the marker system of registration and analysis of motions Qualysis, which allowed to record the data in three-dimensional space. The shooting frequency was 100 frames per second. The measurement error in determining spatial indicators was 1 millimeter per 1 meter of cubic space, the measurement error in time indicators was 0.01 seconds, ensuring high accuracy of registration of kinematic characteristics of motor actions of athletes. *Study organization.* Twelve high qualified athletes specializing in hand-to-hand combat performed straight right- and left-hand blows from the left-side guard. All athletes who participated in the research are right-handed and fight in the left-hand guard. *Statistical analysis.* Since the sample size is only 12, we used Pearson's chi-squared (χ^2) test to check of the hypothesis that the input data obey the normal distribution law. All indicators of the kinematic structure of motion technique were subject to normal distribution. Therefore, the following statistical characteristics were determined: the average $(\bar{x})$ standard deviation (S). Correlation analysis was used to determine informative parameters of the kinematic structure of sportsmen's movement actions. The first stage of the correlation analysis was the construction of correlation fields to determine the form of the correlation. Since all constructed correlation fields indicated that the correlation is linear, we used Pearson's pairwise correlation coefficient to determine the closeness of correlations (r) [7].

Statistical reliability of P = 95% was assumed (probability of error 5%, i.e. significance level *p = 0.05*). However, only indicators with levels of the correlation p =0.01 or higher, were included in the evaluation scales when determining the informative parameters of the kinematic structure of the technique.

Statistical processing of the research results was carried out using the Statistica 21 software.

Research results. The indicator of the kinematic structure of the technique of a right-hand straight blow from the left guard by highly qualified athletes was determined, namely: characteristics of the time and phase-rhythmic structure of motor actions, indicators of angular displacements and amplitude of movements in the joints, indicators of linear displacements of various biolinks of the athletes' body, and velocity indicators of motor actions of athletes, both the average velocity indicators in different phases of movement, and the velocity dynamics of individual biolinks of the athletes' body.

The following algorithm was used to evaluate the kinematic structure of the technique of basic impact actions in hand-to-hand combat and to construct evaluation scales.

First, we chose a biomechanical indicator that can be used as a criterion for impact performance. In the scientific and methodical literature, impact force is used as a criterion for the effectiveness of striking actions in most cases. However, our research did not use dynamometric devices that can register impact force. Therefore, we used the maximum velocity of the impact biolink as a criterion for impact effectiveness, which, according to literature sources, has a close correlation with impact force.

Secondly with the help of correlation analysis, informative parameters of the impact motions technique were identified. The strongest correlations between the efficiency criterion and various kinematic characteristics of impact motions were identified.

Thirdly, the scales for evaluating the kinematic structure of the technique of basic impact motions were developed on the basis of the identified informative parameters. Since the evaluation scales were based on the indicator of the action performance by high qualified athletes, we chose a regression scale.

Based on the above algorithm, we have developed scales for evaluating the basic technique of motor actions of athletes, specializing in hand-to-hand combat.

We identified the correlation relationships between 198 indicators of the kinematic structure and the criterion of informativeness by the maximum velocity of the impact biolink (right wrist joint) in order to determine the informative parameters of the kinematic structure of the technique of a right-hand blow from the left guard. Table 1 presents those parameters that have a statistically significant correlation with the informativeness criterion at the p<0.001 and p<0.01 significance levels.

On the basis of the informative parameters of the kinematic structure of the technique of the

right-hand straight blow from the left guard, a regressive evaluating scale was constructed, which included the following indicators: the maximum velocity of the right wrist joint (criterion of impact efficiency) and the average velocity of the right shoulder joint during the impact movement phase, the average velocity of the right hip joint during the impact movement phase, the duration of the impact movement phase, the amplitude of movement in the right knee joint during the impact movement phase, the displacement of the right wrist joint during the impact movement phase, the angle in the right knee joint at the end of the impact movement phase, the average velocity of the right ankle joint during the impact movement phase, the duration of the impact preparation phase.

The scale for evaluating the indicators of the kinematic structure of a right-hand blow from the left guard is presented in the Table 2.

Table 1

The Value of the Correlation Coefficients between the Maximum Velocity of the Right Wrist Joint and Indicators of the Kinematic Structure of the Right-Hand Straight Blow from the Left Guard (n=12)

№	The Indicator	The Value of the Correlation Coefficient	Significance Level
1	The average velocity of the right shoulder joint during the impact movement phase	0.97	p<0.001
2	The average velocity of the right hip joint during the impact movement phase	0.91	p<0.001
3	The duration of the impact movement phase	0.89	p<0.001
4	The amplitude of movement in the right knee joint during the impact movement phase	0.87	p<0.01
5	The displacement of the right wrist joint during the impact movement phase	0.85	p<0.01
6	The angle in the right knee joint at the end of the impact movement phase	0.84	p<0.01
7	The average velocity of the right ankle joint during the impact movement phase	0.82	p<0.01
8	The duration of the impact preparation phase	0.79	p<0.01

Table 2

The Scale for Evaluating the Indicators of The Kinematic Structure of the Right-hand Blow from the Left Guard

№	The Indicator	High	Medium	Satisfactory
1	The maximum velocity of the right wrist joint, m·s⁻¹	9.36–8.47	8.47–7.58	7.58–6.69
2	The average velocity of the right shoulder joint during the impact movement phase, m·s⁻¹	2.62–2.33	2.33–2.04	2.04–1.75
3	The average velocity of the right hip joint during the impact movement phase, m·s⁻¹	1.21–1.06	1.06–0.91	0.91–0.76
4	The duration of the impact movement phase, s	0.17–0.19	0.19–0.21	0.21–0.23
5	The amplitude of movement in the right knee joint during the impact movement phase, °	21.6–19.6	19.6–17.6	17.6–15.6
6	The displacement of the right wrist joint during the impact movement phase, m	0.78–0.72	0.72–0.66	0.66–0.60
7	The angle in the right knee joint at the end of the impact movement phase, °	158.1–138.2	138.2–118.3	118.3–98.4
8	The average velocity of the right ankle joint during the impact movement phase, m·s⁻¹	0.52–0.46	0.46–040	0,40–0.34
9	The duration of the impact preparation phase, s	0.13–0.145	0.145–0.16	0.16–0.175

The presented scales for evaluating the kinematic characteristics of the technique of the right-hand straight blow from the left guard can be used to optimize and improve the efficiency of the technical training of skilled and low-skilled athletes specializing in hand-to-hand combat.

Discussion. During the study of the scientific literature, it was found that the formation of the technique of motor actions is an integral and important component of the system of sports training, since the possession of the correct technique is one of the decisive factors in the realization of the motor potential of an athlete [5; 11].

In order to form the basic technique of hand-to-hand combat at various stages of learning the motor actions and their further improvement, it is necessary to fulfill a number of requirements: first, to determine the criteria for the effectiveness of motor actions; secondly, to have a scientific and methodical justification of the correctness of the athlete's technique of performing the movement actions being studied. To fulfill these requirements, it is necessary to have a reference model of the technique of such motor actions [2; 3]. One of the most widespread methods of obtaining a reference sample of the technique of motor actions in any sport is the biomechanical analysis of the technique of performing motor actions by highly qualified athletes and further statistical processing of the obtained quantitative biomechanical characteristics. In general, the obtained results complement the data of the special literature on issues of athlete movement management [8; 10].

In order to develop a reference sample of the equipment, it is desirable to use the most accurate methods of recording the motor actions of athletes and to apply adequate methods of mathematical and statistical processing of the received data.

Conclusions. Scales for evaluating the kinematic structure of the technique of a right-hand straight blow from a left guard in hand-to-hand combat of highly qualified athletes have been developed. Evaluating scales are built on the basis of the identified informative parameters of the kinematic structure of the blow technique

and quantitative indicators of these parameters, based on the analysis of the technique of highly qualified athletes specializing in hand-to-hand combat.

The evaluating scale of an action is regressive and has three evaluation levels: "high", "medium", and "satisfactory", each of which has its own evaluation interval, and can be used to improve and correct the technique of low-skilled athletes.

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