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REACTION TIME IN KARATE

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Abstract

The purpose of the research presented in this paper was to examine how reaction time can be influenced using a combined training method with technical-tactical and psychological preparation. We conducted the research via two experiments:
- The first experiment was the measurement of the speed of response in top karate competitors using a personal computer and Java software application through the tests for simple reaction, the reaction by choice, and discrimination.
- The second experiment was the measurement of the speed of response using PLC (programmable logic controller) of specific hand and leg karate strikes. The results confirmed that in all cases such a model of training stabilizes the temporal structure of the movement actions and generally optimizes the psychophysical condition during the performance of the fighting techniques.

Keywords: sports fight, karate, timing, reaction time, optimal performance

Introduction

The reaction time is a level of neuromuscular coordination in which visual, auditory or tactile stimulations are decoded through various processes (physical, chemical, and mechanical) that reach the brain as sensory stimulations (ex. Der, Deary, 2006). To put it briefly, reaction time is the time that passes from the moment of stimulation to the execution of an intentional reaction. The execution of intentional reactions, unlike reflex ones, happens through the processing of stimuli at the level of the cerebral cortex, which requires the inclusion of a lot more neurons and complex neurophysiological mechanisms. The realization of the voluntary movement consists of several components. First, we have the time in which the receptor forms an impulse (information about the stimulus), followed by the time that passes by during the transmission of the impulse to the cerebral cortex. Then, the time needed for the processing of the content of the stimulus, the time which includes preparation of a response to the given stimulus, the time for transmission of the impulse to the effector, and the last time needed to achieve a response in the effector (ex.Drenovac, 2010) Also, the reaction time (RT) is closely related to the physical capacity of human performance and can be defined as the time spent between the presentation of the stimulus and the subsequent behavioral response (ex.Godinho et al.,1999). The response time can be affected by numerous factors, such as: continuous training, gender, age, mental maturity, type of stimulus, the intensity of the stimulus, number of stimuli, the complexity of the content of the stimulus, the complexity of the components of the reaction process, preparedness, excitement, test subject's attention span, etc. According to Czajkowski, to achieve the desired result in a sports fight, improving the quality and efficiency of all components of the training is necessary, especially the socio-psychological training. They include perfecting the analyzers' function and some mental characteristics and processes needed for the sport's fight (ex. Czajkowski, 1982). Therefore, the technical-tactical and psychological preparation of athletes should be inseparable, and only together will they enable the building of a relationship between intentions and performance in karateka during the sport's fight.

With the help of this study, we wanted to check to what extent we could develop the intuitive timing of the initiative for response to the stimulus. We conducted the research by examining thirteen subjects with

experience in international competitions. We followed their progress from a motor, cognitive and emotional aspect and later we carried out the research in laboratory conditions. We believed that the development of a specific structure of knowledge would enable the quick making of appropriate decisions and would develop the connection between the perceptual, cognitive, and motor system. We also focused on locating the most common types of psychophysical and technical weaknesses present in the subjects, which further helped us considerably to develop a system of specific transformation methods.

Methodology

For the implementation of the research, we used a set of experiments that was supposed to show us the difference in the progress of the group as a whole, but for each individual separately as well. The idea was then to compare the achievements of each individual in all variables with the average achievements of the group and based on the indicators obtained in such a way to determine the individual peculiarities of each individual separately.

Object of the research

All athletes in the experiment participated willingly and were maximally cooperative. They had a regular 90-minute training session, six times a week, appropriately adapted in accordance with the individual capabilities and needs of each individual.

Table 1. Characteristics of the measuring subjects

Number of subjects	Age (years)	Body weight (kg)	Body height (cm)	Training experience (years)	Karate rank (belt)
13	26.4 ± 6.8	78.5 ± 6.5	179.0 ± 5.2	15.7 ± 5.8	1 kyu - 4 dan

All athletes had the satisfactory psychophysical condition. Before each simulation, we explained in detail the goal and the procedures, as well as the measures for their protection from injuries. If there were any additional questions, we explained and demonstrated them in practice. All subjects who participated were male with experience in international competitions in sports fights.

Experiment 1

With the PC stimulator, we measured the total reaction time during external visual display stimuli, i.e. simple reaction, the reaction by choice, and discrimination reaction.

Equipment and stimuli

A desk, armchair and a laptop computer DELL Vostro 1720, JAVA software for reaction time testing, external keyboard.

Procedure

To implement the experiment and generate stimuli that we frontally projected onto the screen (17 inches), we used a personal computer (DELL Vostro 1720). We explained the task to the aforementioned participants and they had enough time to adapt to it. They had three tests, 200 attempts each, with no time pressure. Apart from the successful reactions, we gave special attention to the mistakes such as premature reactions or not reacting at all to the stimulus. We carried out the tests in three measurements: an initial measurement, followed by a control measurement 2 months later, and in the end final measurement 2 months later. These tests required the use of a computer-based measurement method with the help of a Java application, while the subject was required to react to the following three scenarios in a timely and appropriate manner:
Simple reaction – after the appearance of a screen in a corresponding color, we measured the time until the first pressing of a key on the keyboard.

The reaction by choice – after the appearance of a green or red screen, we measured the time until the pressing of the "C" or "Z" key, respectively. If the subject made a mistake, we noted it.
Discrimination reaction – there were 2 cubes of different sizes on the screen and the subject needed to evaluate which one of them was bigger (the right one or the left one) and press the corresponding keys "R" or "L" which are on the opposite side of the keyboard ("R" where the left hand is, "L" where the right hand is). If the subject made a mistake, we noted it. Additional randomization was not necessary because the software package itself had an estimated heterosis of randomness that completely ensured sufficient randomness in the test cases. For easier usage, we localized the software in the Macedonian language. During the implementation of the testing, we told the test subjects that they have the right to try each test separately 200 times.

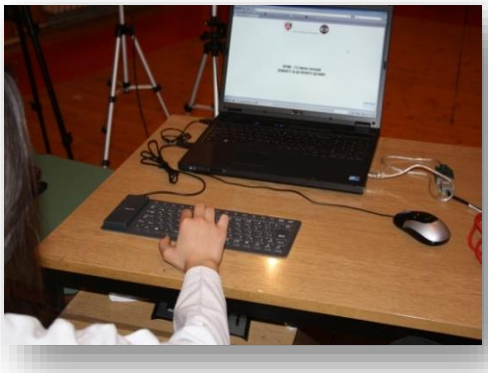

Fig1 and 2. The atmosphere during the measurement done in laboratory conditions with PC – local movements

Experiment 2

With the PLC (programmable logic controller) stimulator that we specifically designed for this research, we measured the simple reaction time with regional external visual stimuli in the process of execution of a suitable technique with the help of the hands or legs.

Equipment and stimuli

Adapted display of a karateka in guard with a visual signaling system built into the arms and legs of the image of the karateka (4); PLC (programmable logic controller) stimulator with appropriate software (1), model Unitronics PLC Jazz JZ10-11–R10; 6 digital inputs; 4 relay outputs. Set of laser sensors (3.1; 3.2; 3.3) with a set of retro-reflectors (6), models: PRK 318; retro–reflective photoelectric sensors with polarization filter; 30 W single output industrial DIN rail power supply set (tripod) stands for laser beams especially made for the occasion (3.1-3.3); X-ray film with elastic compensation system (5); a laptop computer DELL Vostro 1720 (2); and meter.

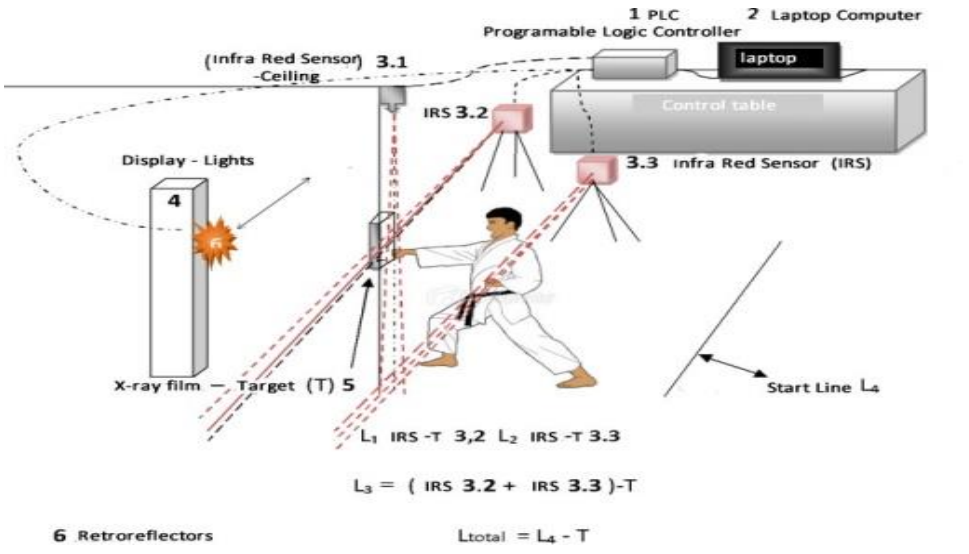

Fig3. Scheme of PLC measurement

Procedure

We measured the reaction time with the dominant side of the following puching and kicking techniques: Kizami zuki, Gyaku zuki, Mae geri, Kizami Mawashi geri, Mawashi geri, Ura Mawashi geri, and Ushiro geri. Specially designed measuring equipment was used for the experiment, which consisted of a PLC and a set of laser sensors, catadiopters and light sources (Figure 3, 4 and 5). We also designed a special software program for the Programmable logic controller, which according to the requirements of the experiment, measured the times with a precision of 100 parts of a second.

Fig4 and 5. The atmosphere during the measurement done in laboratory conditions with PLC

To avoid the possibility of predicting the starting moment, the initial start-up of the system was done manually by a third party at random time intervals. The person was out of the visual and auditory domain of the respondent. In this way, the subject of measurement had to pay full attention to the image of the imaginary opponent and at the time of lighting the red light bulb placed on the imaginary opponent, immediately perform the corresponding blow. The endpoint of the strike was monitored by laser sensors, which precisely determined the time from the moment of stimulation (lighting the light bulb) to the moment of completion of the execution (cutting the laser beam off and turning the light bulb off). To provide enough statistical material, the number of measurements for each strike was 50 strikes. Apart from the successful strikes, we also recorded separately the errors of premature reaction or no reaction at all upon turning on the light stimulus. When measuring the moves, we placed the lasers on tripods in a horizontal or vertical position depending on the technique, whereby we always did the adaptation according to the subject's physical characteristics. We fully recorded the measurement with a video camera for additional video analysis. We experimented with normal conditions: the group had a work task during the time of measurement to perform one technique per day in a karate hall with a wooden lacquered surface (parquet flooring), optimal ambient temperature and illumination in which the subject previously had a light training for adaptation.

Results and discussion

By measuring the reaction time through a personal computer and Programmable Logic Controller stimulators and with additional video analysis, we made a scan for each subject separately. The goal was to determine the initial state, whether and to what extent the performance of the technical elements meets the biomechanical requirements, as well as what the state of the perceptual and cognitive functions is. According to some researchers (ex.Roosen et al, 1999), the measurement of the simple reaction time is irrelevant for the sport's fight in karate. Regardless of what elicited it, we believe that a quick and accurate response is essential when assessing the athlete's condition because it reflects the interaction of all functions during the performance of the respective technique.

Experiment 1: Reaction time – PC

As an illustration, we will mention that the acceptable values for the average reaction time are around 190 msec for light stimulus and about 160 msec for auditory stimulus. In that context, according to Donders' pioneering study for reaction time, simple reaction time is shorter than the recognition time (ex.Donders, 1868). Laming concluded that the average simple reaction time was 220 msec, and the average recognition time was 384 msec (ex.Laming, 1968). Many researchers confirm that the reaction to sound (140-160 msec)

is faster than the reaction to light (180-200 msec) (ex.Galton, 1899, Woodworth and Schlosberg, 1954, Fieandt et al., 1956, Brebner and Welford, 1980). Auditory stimulus takes only 8-10 msec to reach the brain (ex.Kemp et al., 1973), but the visual stimulus needs about 20-40 msec. (ex.Marshall et al., 1943). Tactile reaction time is average, around 155 msec. (ex.Robinson, 1934) the differences between reaction times for these types of stimuli are constant regardless of whether the subject is asked to make a simple or a complex reaction. (ex.Sanders, 1998). Results obtained from our tests shown in this study are presented in table 2 and figure 6-7.

Table 2. Average values of the group in Experiment 1

Experiment 1	ERRORS Number / % PC			TIME Sec PC Sec		
	SIMPLE	CHOICE	DISCRIMINTAION	SIMPLE	CHOICE	DISCRIMINTAION
Initial Test - M1	17 / 8.5%	21/10.5 %	24 /12%	0.251 sec	0.445sec	0.566 sec
Control Test -M2	12 / 6 %	17 / 8.5 %	19 /9.5%	0.253 sec	0.420 sec	0.516 sec
Final Test - M3	11 / 5.5 %	14/ 7 %	15/7.5%	0.246 sec	0.364 sec	0.469 sec

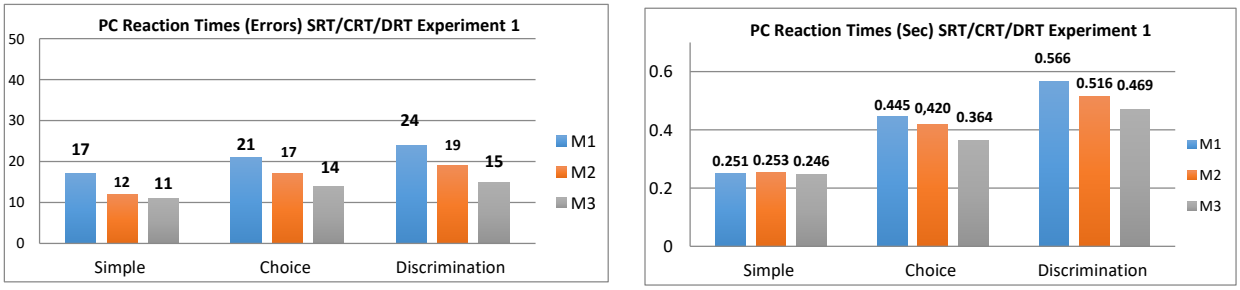

Fig6-7. Statistical values for the obtained results of the three variables in the three measurements for Experiment 1

When analyzing the results for all variables, we obtained a normal distribution in the range of 0.000 - 0.554. In the simple reaction test (Figure 7), we obtained average values that were decreasing from measurement to measurement, i.e. from 0.251 for the first measurement to 0.246 in the third measurement. The test served us to discover the average values of the group in order to compare the results of the individuals and determine the genetic influence in each individual. The standard deviation ranged from 0.417 to 0.411. In this test, the errors reduced from measurement to measurement with average values of 17-12-11 in relation to M1-M2-M3 (figure 6). In the test for reaction by choice (Figure 7), we obtained average values that were also decreasing from 0.445 sec for the first measurement to final 0.364 sec in the third measurement. The standard deviation ranged from 0.1063 to 0.0666, and the errors were significantly reduced 21-17-14 in relation to M1-M2-M3 (figure 7). In the differentiating reaction-discrimination test, we obtained average values that were also decreasing from 0.566 sec to the final 0.469 sec in the third measurement (Figure 7). In this test, as well, the errors significantly reduced from 24 to 15 in relation to M1-M3 (Figure 6). The standard deviation was in the range of 0.1246 to 0.1145.

The obtained results of our research coincide with other similar research on reaction time measurement, e.g. (ex.Vences de Brito and Silva, 2011), where it was determined that the simple reaction time of different groups ranges between 0.288 ± 0.24 sec and 0.295 ± 0.32 sec after the stimulus. Regarding the reaction time by choice, responses occurred between 0.423 ± 0.50 sec and 0.501 ± 0.80 sec after the stimulus. According

to the results, we can see that the obtained average values of the group we analyzed coincide with the mentioned research, i.e. the reaction time to a stimulus from a computer screen is the shortest for a simple reaction in contrast to discrimination or choice stimuli. The simple reaction time to such stimuli is an individual trait of each individual and it is genetically coded which leaves space for very small and insignificant improvements. They need to be nurtured, i.e. constantly trained, but in the time of reaction by choice and discrimination, which are much more significant for sports fight in karate, the results showed that the group achieved progress and better results in relation to the simple reaction. Namely, we obtained times of 0.250 ± 0.15 sec for the simple reaction time, 0.400 ± 0.22 sec for the reaction by choice, and 0.520 ± 0.30 sec for the discrimination reaction.

Experiment 2: Reaction time of punching and kicking techniques – Programmable Logic Controller

The purpose of this assessment was to determine the technical level of punching and kicking techniques commonly used in competitions. It should have given us an image of which direction to direct the training process. Our "check point" details were the orientation of the body in space, the balance of the body and the posture, the quality of the locomotion, then the manipulation controlled by the activity of the muscles of the forearm and palms, as well as the positioning controlled by the lower leg and foot muscle activity.
We focused on those details because they have a significant role in the degree of the economy during the performance of the techniques. The variables of these measurements are shown in table 3. In all variables, we had a normal distribution in the range of 0.000 – 0.982. For the Gyaku zuki strike (Table 3 and Figure 8-9), we had average values of 0.442 sec to the final 0.439 sec in the third measurement.
The number of errors was 3-3-1 in relation to M1-M2-M3 (Figure 9). The standard deviation was in the range of 0.0650 to 0.0666. Table 3, figure 8 and 9 show the average results of the group across the three measurements for Experiment 2..

Table 3. Average values of the group in Experiment 2

Experiment 2	ERRORS Number / % PLC SRT							TIME PLC SRT Sec						
Technique	Kiz	Gya	Mae	Mav	A.Mav	UraM	Ushiro geri	Kiz	Gya	Mae	Mav	A.Mav	UraM	Ushiro geri
Initial Test -M1	4	3	3	4	3	5	6	0.376	0.442	0.671	0.743	0.658	0.697	0,769
Control Test -M2	3	3	3	3	3	3	4	0.374	0.441	0.659	0.733	0.647	0.689	0.732
Final Test - M3	2	1	1	3	2	2	3	0.354	0.439	0.643	0.717	0.635	0.669	0.717

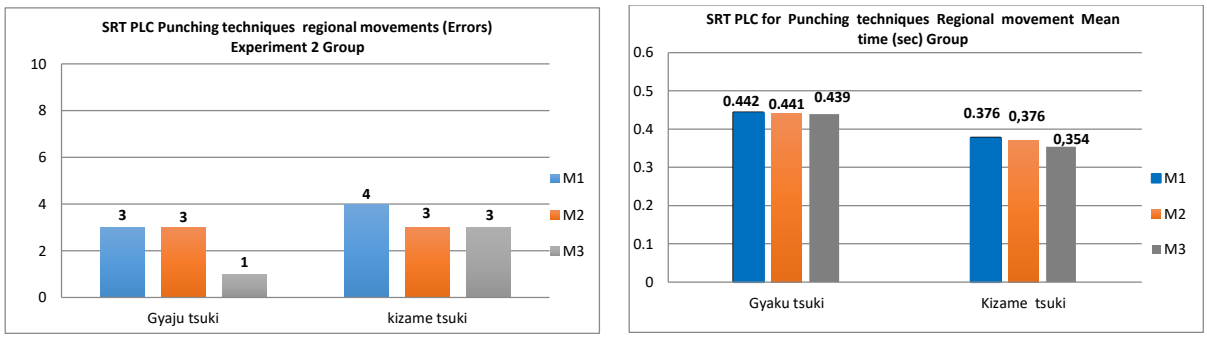

Fig8-9. Statistical values for the obtained results of the three variables in the three measurements for Experiment 2 – Average times and errors of the hand strikes

In the case of the Kizami zuki strike (Table 3 and Figure 8-9), we had average values from 0.376 sec for the first measurement to final 0.354 sec in the third measurement. The standard deviation ranged from 0.0701 to 0.0693. In this test, the number of errors was 4-3-3 in relation to M1-M2-M3.

In the case of the Mae Geri strike (Table 3 and Figure 10-11), we had average values from 0.671 sec for the first measurement to final 0.643 sec in the third measurement. The standard deviation ranged from 0.0836 to 0.0865. In this test, the number of errors was 3-3-1 in relation to M1-M2-M3. In the case of the Mawashi Geri strike (Table 3 and Figure 10-11), we had average values from 0.743 sec for the first measurement to final 0.717 sec in the third measurement. The standard deviation ranged from 0.0697 to 0.0711. In this test, the number of errors was 4-3-3 in relation to M1-M2-M3. In the case of the Ashi Mawashi Geri strike (Table 3 and Figure 10-11), we had average values from 0.658 sec for the first measurement to final 0.635 sec in the third measurement. The standard deviation ranged from 0.1052 to 0.0953. In this test, the number of errors was 3-3-2 in relation to M1-M2-M3.Figure 8-9.

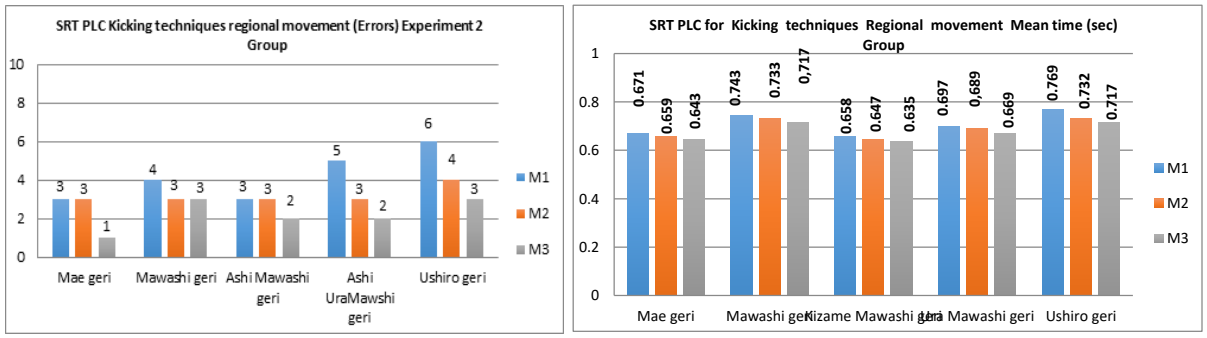

Fig10-11 Statistical values for the obtained results of the three variables in the three measurements for Experiment 2 - Average errors and average times for leg strikes

In the case of the Ura Mawashi Geri strike (Table 3 and Figure 10-11, we had average values from 0.697 sec for the first measurement to the final 0.669 sec for the third measurement. The standard deviation ranged from 0.0951 to 0.0888. In this test, the number of errors was 5-3-2 in relation to M1-M2-M3. In the case of the Ushiro Geri strike (Table 3 and Figure 10-11) we had average values of 0.769 sec during the first measurement to final 0.717 sec during the third measurement. The standard deviation ranged from 0.0454 to 0.0297. In this test, the number of errors was 6-4-3 in relation to M1-M2-M3. After presenting the basic statistical parameters, we proceeded to analyze the significance of the obtained results by performing a paired t-test according to Pearson (Pearson paired samples t-test), which we performed for each test variable separately in each of the measurements, namely: M1->M2, M2->M3 and M1->M3. Obtaining a result of $p \leq 0.05$ according to the standard convention for statistical analyzes with t-tests for each of the mentioned sets proves the existence of a significant statistical situation, i.e. that the obtained results are the result of the

implemented training program. According to the obtained results of this test, we can conclude that the entire group recorded improvements in all variables with significant stabilization of the temporal structure of the motor actions. The obtained individual map of achieved results indicates that the technical level of the more skilled subjects is relatively good and we cannot significantly improve it as in the case of less skilled subjects, but we can significantly reduce their errors. Therefore, we can see that the properly modeled training had an impact on the optimization of the performance, which is supported by the shortening of the reaction time and the reduced number of errors in the whole group, regardless of whether it is a response with a hand or a leg. The average results of the group's final measurements (table 3 and figure 10-11) e.g. for Gyaku zuki hand strikes were 0.439 sec and for Kizami zuki 0.374 sec. While for Ashi Mawashi geri leg strikes the average score was 0.655 sec and for Mawashi geri 0.742 sec. These results coincide with such similar research by other authors, for e.g. (ex. Villani et.al , 2009) , and that for Kizami zuki hand strikes the time was 0.56 sec and Gyaku zuki 0.60 sec while for Ashi Mawashi geri leg strikes it was 0.61 sec and Mawashi geri 0.64 sec.

Conclusion

The research confirmed that the combined training at the individual level significantly improved the reaction time, and thus the optimal performance. The group as a whole but also each individual separately in each new measurement showed better results when measuring the reaction time and the number of errors. With long-term monitoring of the training activity and video analysis, it became clear that we could precisely locate possible weaknesses and more easily implement the corrective process.
The approach, testing methods and training intervention used during the research provided clear and specific information on how to address the individual needs of each individual.
In the indicated stage of preparation, we can conclude that our training methodology, in all cases, stabilizes the temporal structure of the movement actions. We believe that the presented text can be of benefit to professional work in martial arts.

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