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MODEL OF QUANTITATIVE DETERMINATION OF THE EFFICIENCY FACTOR IN KARATE

Nazim KURTOVIC

American University of Europe FON, Skopje 1000, North Macedonia
Correspoding author e-mail: nazim.kurtovic@fon.edu.mk

Abstract

In this paper, we present research to verify whether the continuous individually modeled transformation process with included appropriate content will affect the system for dominant response to a stimulus, as well as the improvement of the overall performance in the sport's fight in karate. We conducted the research through a series of tests on 13 top competitors in laboratory conditions that were close to real, as well as real competition conditions. The obtained results clearly showed the peculiarities of the individuals in terms of technical-tactical preparation and terms of their effectiveness in responding to a stimulus. Based on the data thus obtained, we derived the model of quantitative determination of the efficiency factor. The quotient model is strictly related to the presented materials with an emphasis on defensive responses, but it can be supplemented as necessary with other components that are an integral part of the performance planning for each competitor in the kumite (sports fight) in karate.

Introduction

The system of preparation of the corresponding athlete should be seen as a rounded process of formation and improvement of his movement techniques, as well as his physical and mental properties. In such a case, the main task is to create a system that allows not only a better insight into his state of readiness but also an appropriate influence on the factors on which the achievement of the planned result depends. We based the systematic work presented in this text, above all, on creating a scanning system that provided us with all the necessary and timely information for successful training management. The first step in our experiment was to determine the particularity of the sports fight discipline in karate and to scan the initial situation to determine the weak and strong points of the athletes to improve their training through long-term follow-up and appropriate training intervention. The second step required the creation of a database of model characteristics from champion athletes (indicators of their abilities, traits, knowledge, etc.). For this purpose, we decided to use a set of experiments with a group of elite karate athletes, which was supposed to determine the level of training of the group as a whole, but also of each individual separately. The intention was to compare the achievements of each individual in all variables with the average achievements of the group. Also, based on the obtained indicators, we needed to determine the deviations about the group in each individual separately.

An integral part of the tasks was to ensure that motivated athletes participated in the experiments, in sufficient numbers and for a long period, as well as that they used appropriate equipment (measuring instruments) to ensure quality, precision, and validity in the measurements. At this stage, with the help of experts in the field of sports psychology, each individual was given various tests: a personality strength test, anxiety test, egocentricity test, and an intelligence test, to obtain a clear psychological profile for each athlete, before starting the specific tests in the experimental phase. Their physical and functional abilities were checked with a shuttle running test and Polar training equipment, with the help of experts in the field of sports medicine. The specific laboratory experiments also required proper organization and technical

implementation. The experimental methodology was supposed to follow the logic of increasing the complexity of movement actions from local and regional to global, and all the obtained results of the experiments were to be processed with the help of various statistical analyses. Consequently, in the third step, we had to diagnose the current condition and record it in the personal file of each athlete separately. The fourth step required correlational statistical analysis and making a record of the results of the individual indicators of each athlete separately from the average results of the group. In the next, fifth step, according to the recorded initial state and the determined deviations, a short-term training intervention with goals, tasks, periodization, and conditions adapted for each individual was supposed to be planned. The planning of the training intervention in the sixth step, according to the obtained results, was followed by the programming of the individual transformation process with the selection of means, load, and methods according to their needs. In the seventh step, the implementation of the training intervention according to the established plan and program was included, where the athlete had to move from the current state to the state in which they should be. In the eighth stage, there was a complete control assessment to obtain a new status for each individual, according to which we were going to evaluate the programming and implementation of the transformation process. Then, we set new goals, new planning, and programming, and we started to implement the training intervention until the next testing.

Methods

Through multimodality training, athletes can develop the ability to link internal and external events during the performance. So, they can make more realistic choices instead of being unconsciously dominated by habitual habits. What athletes can be taught is to supplement or change their primary self-awareness. In this way, we can best influence the creation of a more liberating form of consciousness in them, liberated from the limited visualized stereotypes about their capacities (ex. Prentice, 1998). This method of training differs from standard practices in that it respects the development potential of each athlete, encouraging the transformation of problematic motor and psychophysiological patterns in conditions close to reality and in a uniquely appropriate way for the athlete. The action model aimed to provide a way out of the usual patterns of awareness and behavior of athletes during training and competitions, but also to increase self-awareness and focus on the physical sensations of the movement to improve the self-regulation and the outcome of the performance.

Technical-Tactical Training

By far the most important aspect of any motor skill training is the amount of quality training. Therefore, effectively designed and implemented training makes the skill perfect (ex. Schmidt, Lee, 2005). To correct the technical performance, we first identified problematic key movement patterns so that we could then break down each technique into a series of discrete movement patterns and further break it down into "target movement mechanics". In this way, we were able to observe them as key mechanical actions that athletes had to perform, making the overall movement pattern ultimately efficient and economical. (ex. Jeffreys, 2006).

Mental Training

Visualization before, during, and after the training is an effective strategy for mental training. That's why we used it because of the ability of athletes to think efficiently in images and control the flow of images and corrections in a positive direction, to easily transform mental intentions into a motor reaction. Otherwise, the visualization and ideomotor method, which constitutes mental exercise and is manifested in the reproduction of the given technical-tactical knowledge, help the athletes as a principle when they make a mistake. It helps

them to return to their thoughts immediately and correct the mistake by presenting various possible situations in a fight. It is a primary mental ability important for the fight that every athlete must have. The goal of the model, first of all, was to help improve specific motor weaknesses, and then increase reliability, and reduce tension, stress, and psychosomatic obstacles among athletes, thus directly creating conditions for their better efficiency. Before each beginning of the treatments, we familiarized the athletes in detail with the training techniques and procedures, which were supposed to enable them to regulate their psychophysiological state through one of the techniques of: KI meditation (ex. Koichi Tohei, 1976), Jacobson's progressive relaxation (1938), and Schultz's autogenic training (ex. Linden, Wolfgang, 1990).

Object of the research

Athletes in the experiment participated voluntarily and behaved as cooperatively as possible to achieve the best possible results. For this purpose, they had regular 90-minute training, six times a week, properly adapted according to the individual capacities and needs of each individual. Training sessions and experiments were performed in optimal technical conditions with optimal temperature and light.

Table 1. Characteristics of the subjects

Num. 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 good psychophysical conditions. Before each simulation, the purpose and procedures, as well as the measures to protect them from injury, were explained in detail. After that, full consent was obtained to participate in the experiments. If there were additional questions, they were explained and practically demonstrated. All subjects who participated had experience in international competitions and were winners of significant domestic and international results in a sports fight.

Hypothesis:

H0: With this approach, we wanted to check if the continuous individually modeled transformation process with included appropriate content according to the modified concepts will affect the system for a dominant response, as well as the improvement of the overall performance in the sport's fight monitored with the applied parameters in this research. The results obtained with this design would confirm the necessity for determining the most appropriate interventions that affect the development and maintenance of the research expertise;
H1: A recognizable and distinctive individual map will be revealed for each participant;
H2: The participants in the corrective training for "optimal performance" will also increase the frequency of staying in their optimal functioning zone, increasing the percentage of successful responses from the initial to the final trials;
H3: The participants in the corrective training for "optimal performance" will also increase the frequency of staying in their optimal functioning zone, improving their performance with better response times (pre-motor phase T0 and motor phase T1);
H4: The participants will experience a high level of presence during the trials and competition performances.

Experiment 1

With the PC stimulator, we measured the reaction time with local movement during external visual display stimuli in 3 different methods – simple reaction, reaction by choice, and discrimination reaction.

Equipment and Stimuli

Personal computer (DELL Vostro 1720), Java software for reaction speed, external keyboard, the manual error counter.

Procedure

To control the experiment and generate stimuli that we frontally projected onto the screen (19 inches), we used a personal computer. We explained the task to the aforementioned participants and they had enough time to rehearse and 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 with a distance of 2 months each. These tests required the use of a computer-based measurement method with the help of a Java application that performs the testing, 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 "D" or "L" which are on the opposite side of the keyboard ("D" where the left hand is, "L" where the right hand is). If the subject made a mistake, we noted it;

In this case, 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.

Fig1. Image of the atmosphere of the measurement done in laboratory conditions

Experiment 2

With the PLC stimulator, we measured the total simple reaction time with regional external visual stimuli in the process of execution of suitable punching and kicking techniques.

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 catadiopters (6), models: PRK 318; retro–reflective photoelectric sensors with polarization filter; 30 W single output industrial DIN rail power supply; set of stands (tripod) 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); meter; and manual error meter..

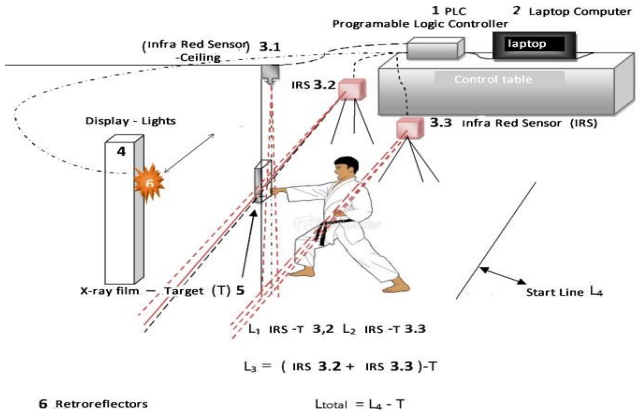

Fig2. Scheme of Programmable Logic Controller measurement

Fig3. Image of the atmosphere of the measurement done in laboratory conditions (PLC -regional movements)

Procedure

We measured the regional movements from the place of standing with the punching and kicking techniques with the dominant side the following strikes: Kizami zuki, Gyaku zuki, Mae geri, Kizami mawashi geri, Mawashi geri, Yoko geri, Ura mawashi geri.
To make a precise measurement of the reaction time, we used specially designed measuring equipment, which consisted of a PLC and a set of laser sensors, catadiopters, and light sources (figure 2-3). We also designed a special program for the controller, which according to the requirements of the experiment, measured the times with a precision of 100 parts of a second. To avoid the possibility of predicting the starting moment, which would have made a better result, 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 subject. 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 intended 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 (left, right side) was 30 strikes per side. Apart from the successful strikes, we also recorded separately the errors of premature reaction or no reaction at all upon turning the light stimulus on. For strikes in which there were circular movements and leg movements, we did the measurements vertically with the laser beam, while we did the measurements of other movements horizontally. We always did the adaptation of the height of the beam and the x-ray film as well as the distance according to the subject's physical characteristics. We experimented with normal conditions: a karate hall with a wooden lacquered surface, optimal ambient temperature, and illumination in which the subject previously had light training for adaptation.

Experiment 3

With the PLC stimulator, we measured the simple reaction time global movements during external visual stimuli in the process of execution of a suitable technique with the help of the hands or legs. The procedure, the equipment, and the stimuli were as in experiment 2, and the athletes performed the strikes from movement with an effective fighting distance for each athlete separately according to their physical characteristics. We measured the same strikes as in experiment 2 with the addition of the Ushiro geri leg strike.

Experiment 4

Measurement of the response time and the efficiency under spatial and temporal constraints with a real opponent

To measure the specific movements, we needed to develop a model with stimuli by karateka in an offensive task. Therefore, instead of a classical stimulator, we recorded the fights from four angles through this model, and then, by using biomechanical analysis software (Dartfish), we measured the reaction times in the pre-motor and motor phase, as well as the number and type of responses and the level of success in a real fight with an opponent.

Equipment and Stimuli:

For the implementation of this experiment, we used 100m² sports mats model: KWON WTF approved 2.4mm; 4 Sony PMW-EX1 cameras; Sony VCT 1170RM tripod; KWON WTF approved head guard; KWON E-protector - chest guard with electronic audio signalization with different sensitivity according to the strength of the strike (M, L, XL); sets of SMAI WKF approved protective gloves and shin and foot guards; and a laptop computer DELL Vostro 1720.

Procedure

We experimented with optimal conditions (figure 4-5) and in front of an audience to "capture" the competitive atmosphere. We placed three cameras on tripods at the corners of the arena, and we also used a mobile camera with an experienced cameraman. In this way, at every moment, we provided a clear picture of what was happening from four angles. The athlete who had a defensive role was protected by a head guard and a protective electronic chest guard with audio signalization, as well as groin protection equipment and a protective mouth guard. Athletes with offensive assignments had a set of protective equipment for hands, shins, and feet. The task for each athlete was to participate in six fights with a defensive assignment against six different opponents in an offensive role. The fights lasted for 3 minutes of effective fighting with an average break (relaxation from the excitement) of 15 minutes between the fights. The task for the athletes who had an offensive role was to attack at full capacity, using fighting techniques of their choice. On the other hand, the task for the athlete who had a defensive role was to defend as many strikes as possible promptly, without the right to counter-strike. We explained the task to the athletes and they had enough time to adapt to it. In each of the measurements, the arrangement of the attacking athletes and each defending athlete was identical. We recorded each set of fights in a synchronized manner and analyzed the materials. For this purpose, we analyzed the recordings with the Dartfish biomechanical program, which enables the analysis of recordings according to the "frame by frame" principle with a sensitivity of 0.20 seconds. Having that in mind, it was possible for us to draw correct conclusions, i.e. to measure the reaction times in the pre-motor and motor phases, the number and type of responses, as well as the level of success. To avoid subjectivity in the analysis of each fight, apart from the fact that we watched it simultaneously from 4 different angles, two experts additionally analyzed the fight and later debated possible disputed scores for the reaction. For an easier indication of the unsuccessful defenses, the special protective equipment helped, since it gave an audible indication when the opponent managed to score.

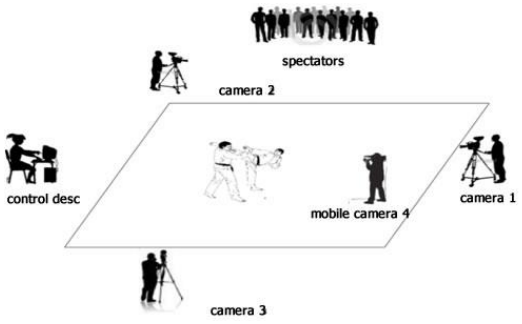

Fig4. Scheme of the measurement

Fig5. the atmosphere during the measurement

The idea of this experiment was to measure the efficiency of the athletes, when they had a defensive role, through the number and time of successful responses with an appropriate blocking technique, as well as the number and time of unsuccessful responses. We divided the unsuccessful responses into responses with an early reaction, with a delayed reaction, and responses without any reaction at all. For the determination of the reaction time in the video analysis for this experiment, the initial moment for the hand strikes was the initial movement of the attacker's hand. While, for the strikes performed with the foot, the initial moment was the moment of separation of the attacker's foot from the ground. We considered the time of the subject's decision-making to be, in fact, from the moment of moving the hand up to the characteristic manifestation of the guard, or rather the manipulative segment - the palm. The palm was identical in all examined athletes and was manifested by its extension from a relaxed position (figure 2). This sudden change in the shape of the manipulative part of the hand, which was previously moved by inertia, in a purposefully extended position ready for an appropriate response was a signal that the "light bulb turned on", i.e. the subject made an appropriate decision.

Experiment 5

To have a clearer connection between the two models, we organized this group of test subjects to participate in internal control competitions in a hall with unknown opponents. The competitions were read with absolute seriousness due to the complete presence of all the officials needed to hold a competition (judges, supervisors, scorekeepers, timekeepers, audience, etc.).

Equipment and Stimuli

100m² sports mats model: KWON WTF approved 2.4mm; 3 DV Canon 1X cameras – rented from Cre8ive8 Production; 1 tripod model – rented from Cre8ive8 Production; WKF approved body protector Parafly – chest guard; face mask from the brand In Lavi – WKF approved protective face mask; SMAI WKF approved sets of protective gloves and shin and foot guards; a laptop computer DELL Vostro 1720 with an installed Dartfish software; five (5) official international licensed judges; scoreboards with officials; and around 50 people as audience.

Procedure

To capture an atmosphere close to that of real competition conditions, we organized control competitions attended by athletes and officially licensed judges properly dressed in uniforms from several clubs. We had the idea that the whole atmosphere in the hall should resemble an official competition, and the temperature and lighting were at an optimal level.

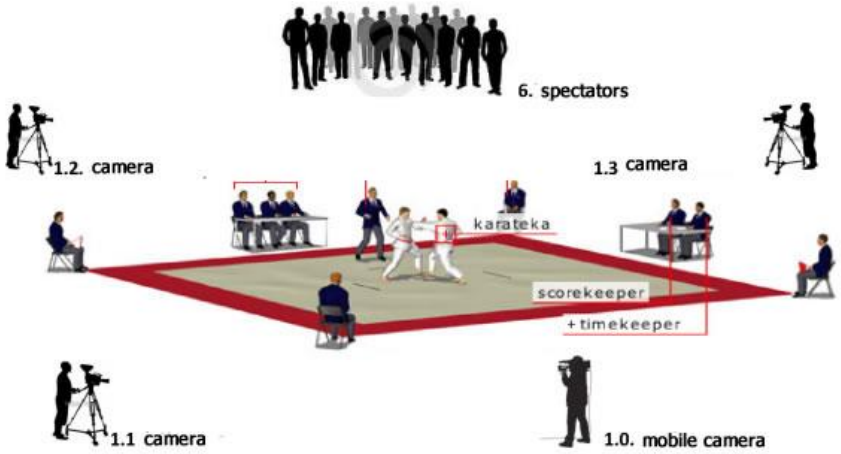

Fig6. A scheme of the atmosphere of the measurement in conditions close to the real ones

Previously, we introduced the experiment to the audience mostly composed of activist members, but also of relatives and friends of the subjects. Their task was to create a competitive cheering atmosphere. The goal of these competitions was to see the degree of efficiency in a competitive fight with different opponents where we measured the ratio between the number of attempts and scoring techniques during offensive actions, as well as the number of successful and unsuccessful defenses during a fight. Due to the speed of the actions and the dynamism of the events, we needed to perform an essential analysis of each fight to determine the number of attempts and defenses of each subject, the type of strikes, defenses, focused regions for the attack, etc. In this case, the presence of the official judges facilitated the subjective evaluation of the scoring action. For this purpose, we analyzed the recordings with the Dartfish program, which enables the analysis of 4 recordings from different angles according to the "frame by frame" principle. This allowed us to draw correct conclusions.

Experiment 6

As an additional method for taking control over the individual progress of the subjects, the group of 13 competitors during the measurement period also took part in regular national and international level competitions according to the WKF calendar. The in-depth analysis of their results in the fights from these competitions gave us additional feedback for further planning and programming of the training intervention. For comparative analysis of all subjects, we recorded their fights and analyzed them in the same way and with the same equipment as in the previous experiment.

Results and Discussion

Experiment 1

In accordance the stated values and the previously presented method of measuring the simple reaction, the reaction by choice, and the discrimination reaction, the results obtained in our first experiment on the PC variables that we analyzed are presented in table 2. This table shows the number of errors, the reaction time, and part of the statistical data for each experiment separately.

Table 2. Average values of the group's reaction time and percentage of errors in Experiment 1

Experiment 1 – Errors No. % / Time sec

Group	ERRORS No./ % PC			TIME/95% CI/SD/P PC Sec			
	SIMPLE	CHOICE	DISCRIMINATION	TEST	SIMPLE	CHOICE	DISCRIMINATION
Initial Test - M1	17 /8.5%	21/10.5 %	24 /12 %	Time	0.264 sec	0.445sec	0.566 sec
Control Test - M2	12 /6 %	17/ 8.5 %	19/9.5%	Time	0.253 sec	0.420 sec	0.516 sec
Final Test - M3	11 / 5.5%	14 / 7 %	15 /7.5%	Time	0.255 sec	0.364 sec	0.469 sec
PC	Experiment 1			95% CI	-0.0979-0.0638	-0.0979-0.0638	-0.0622-0.0324
				SD	0.0417-0.0411	0.1063-0.0666	0.1246 - 0.1145.
				P	P = 0.0436	P = 0.0013	P < 0.0001

Experiment 2

In accordance with the presented method of measuring the simple reaction of different hand and leg techniques, in our second experiment on the PLC variables that we analyzed, the average results of the group in the three measurements for experiment 2 are shown in table 3. This table, just like the previous one, shows the number of errors, the reaction time, and part of the statistical data for each experiment separately.

Table 3. Average values of the group in Experiment 2

Experiment 2 – Errors No. % / Time sec

Group	ERRORS No./ % PLC SRT							TIME PLC SRT Sec.					
Technique	Kiz	Gya	Mae	Mav	KMav	K.Ura	M1-M3	Kiz	Gya	Mae	Mav	KMav	UraM
Initial Test -M1	4	3	3	4	3	5	M1	0.376	0.442	0.671	0.743	0.658	0.697
Control Test -M2	3	3	3	3	3	3	M2	0.374	0.441	0.659	0.743	0.657	0.685
Final Test - M3	3	1	1	3	2	2	M3	0.374	0.459	0.643	0.742	0.655	0.669
PLC regional	Experiment 2						95% CI	-0.0033 -0.0004	-0.0054 -0.0012	-0.0046 -0.0004	-0.0032 -0.0000	-0.0013 -0.0001	-0.0003 -0.0001
							SD	0.0113-0.0047	0.0169-0.0084	0.0174-0.0134	0.0106-0.0082	0.0019-0.008	0.008-0.001
							P=	0.0130	0.0018	0.0009	0.0452	0.0318	0.0300

Experiment 3

In accordance with the presented method of measuring the simple reaction of different hand and leg techniques with the global movement, in our third experiment with the PLC equipment, the variables that we analyzed regarding the average results of the group in the three measurements for experiment 3 are shown in table 4. This table, just like the previous ones, shows the number of errors, the reaction time, and part of the statistical data for each experiment separately.

Table 4. Average values of the group in Experiment 3

Experiment 3 – Errors No. % / Time sec

Group	ERRORS No. / % PLC SRT							TIME PLC SRT Sec						
Technique	Ki	G	M	M	K	K.	Ush	Kiz	Gya	Mae	Mav	KM	Ura	Ushi
Initial Test -M1	3	3	2	3	3	4	4	0.381	0.452	0.681	0.793	0.689	0.717	0.769
Control Test -M2	3	2	2	3	2	3	2	0.364	0.431	0.661	0.757	0.678	0.695	0.732
Final Test - M3	2	1	1	1	2	2	2	0.344	0.4.15	0.647	0.748	0.669	0.679	0.717
PLC global	Experiment 3						95% CI	-0.0033 -0.0004	-0.0054 -0.0012	-0.0046 -0.0004	-0.0032 -0.0000	-0.0013 -0.0001	-0.0003 -0.0001	-0.0034 -0.0028
							SD	0.0381-0.0344	0.0452-0.0415	0.0810-0.0647	0.0491-0.0397	0.0452-0.0423	0.0451-0.0296	0.0454-0.0297
							P=	0.0130	0.0018	0.0009	0.0452	0.0318	0.0300	0.0285

Experiment 4

In accordance with the presented method of measuring the reaction time and the defense efficiency during a predefined fight with a real opponent, in our fourth experiment with video analysis, the variables that we analyzed regarding the average results of the group in the three measurements for experiment 4 are shown in tables 5 and 6. These tables, just like the previous ones, show the reaction time, the number and percentage of successful responses, and the analyzed errors (early reaction, no reaction at all, and late reaction) for each experiment separately.

Table 5. Average values of the group's reaction time in Experiment 4

Experiment 4 – Time sec

Group	Response Time - Kicking attack			Response Time - Punching attack		
	T1	T2	Vt	T1	T2	Vt
Initial measurement	0.114 sec	0.364 sec	0.478 sec	0.097 sec	0.260 sec	0.357 sec
Control measurement	0.112 sec	0.347 sec	0.459 sec	0.078 sec	0.213 sec	0.291 sec
Final measurement	0.097 sec	0.320 sec	0.417 sec	0.075 sec	0.192 sec	0.267 sec

Table 6. Average values of the group's efficiency in Experiment 4

Experiment 4 – Efficacy %

Group	Successful Responses Total%	Unsuccessful Responses Total%	Unsuccessful Response Type%		
			Early Responses	No Responses	Untimely Responses
Final measurement	85 %	15 %	3.5 %	2.7 %	8.6 %
Control measurement	76.2 %	23.8 %	4.0 %	4.6 %	14.9 %
Initial measurement	69.5 %	30.5 %	3.6 %	6 %	21 %

Experiment 5

In accordance with the presented method of measuring the defense efficiency in a free fight with a real opponent in control competitions, in our fifth experiment through video analysis of the recorded fights (2 competitions with 3 matches per measurement), the variables that we analyzed in percentage for the three measurements in experiment 5 are shown in table 7.

Table 7. Average values of the group's efficiency in Experiment 5

Experiment 5 – Efficacy % Control matches

Group	Successful Responses Total%	Unsuccessful Responses Total%	Unsuccessful Response Type%		
			Early Responses	No Responses	Untimely Responses
Final measurement	84.5 %	15 %	3,5 %	2.7 %	8.6 %
Control measurement	76.2 %	23.8 %	4.0 %	4.6 %	14.9 %
Initial measurement	69.5 %	30.5 %	3.6 %	6 %	21 %

In experiment 6 on official competitions we have precisely analyzed the number of successful and unsuccessful defenses three times (6 competitions per person 2+2+2 with mean of 3 individual matches). The obtained results were transformed to percentages and then compared. It was equally interesting to compare the initial measurement to the second and the second to the third, as well as to see the differences between the initial measurement and the last one.

Table 8. Average values of the group's efficiency in Experiment 6

Experiment 6 – Efficacy % Competition

Group	Successful Responses Total%	Unsuccessful Responses Total%	Unsuccessful Response Type%		
			Early Responses	No Responses	Untimely Responses
Final measurement	90.36 %	9.64 %	2 %	2.9 %	3.6 %
Control measurement	84.20 %	11.3 %	3.2 %	3.4 %	4.8 %
Initial measurement	82.15 %	13.45 %	3.7 %	4.7 %	7.9 %

Comparative results Group – Athlete 1

In accordance with the presented methods in all 6 experiments, we compared the achievements of each individual in all variables with the average achievements of the group, and, based on the obtained indicators, we determined the deviations to the group for each individual separately. Tables 9-12 and figures 7-10 visually show the deviations of one athlete to the group for all 6 experiments.

Table 9. Comparison table for athlete 1 and the group in Experiment 1

Table 09. Experiment 1 Initial/Control/Final measurement.

Experiment 1	**SUBJECT 1 PC**			**GROUP PC**		
	SIMPLE	CHOICE	DISCRIMINATION	SIMPLE	CHOICE	DISCRIMINATION
Initial Test -M1	0.256 sec	0.445 sec	0.559 sec	0.264 sec	0.445sec	0.566 sec
Control Test -M2	0.213 sec	0.420 sec	0.447 sec	0.253 sec	0.420 sec	0.516 sec
Final Test - M3	0.233 sec	0.412 sec	0.357 sec	0.255 sec	0.364 sec	0.469 sec

Table 10. Comparison table for athlete 1 and the group in Experiment 2

Table 10. Experiment 2 Initial/Control/Final measurement.

Experiment 2	**SUBJECT 1 PLC SRT Regional sec**						**GROUP PLC SRT Regional**					
	Kiz	Gva	Mae	Mav	KMav	UraM	Kiz	Gva	Mae	Mav	KMav	UraM
Initial Test -M1	0.339	0.377	0.643	0.689	0.686	0.622	0.376	0.442	0.671	0.743	0.658	0.697
Control Test -M2	0.334	0.368	0.558	0.668	0.661	0.600	0.374	0.441	0.659	0.743	0.657	0.685
Final Test - M3	0.312	0.341	0.521	0.625	0.638	0.587	0.374	0.459	0.643	0.742	0.655	0.669

Table 11. Comparison table for athlete 1 and the group in Experiment 2

Table 11. Experiment 3 Initial/Control/Final measurement.

Experiment 3	**SUBJECT 1 PLC SRT Regional sec**						**GROUP PLC SRT Regional**					
	Kiz	Gya	Mae	Mav	KMav	UraM	Kiz	Gya	Mae	Mav	KMav	UraM
Initial Test -M1	0.339	0.377	0.643	0.689	0.686	0.622	0.376	0.442	0.671	0.743	0.658	0.697
Control Test -M2	0.334	0.368	0.558	0.668	0.661	0.600	0.374	0.441	0.659	0.743	0.657	0.685
Final Test - M3	0.312	0.341	0.521	0.625	0.638	0.587	0.374	0.459	0.643	0.742	0.655	0.669

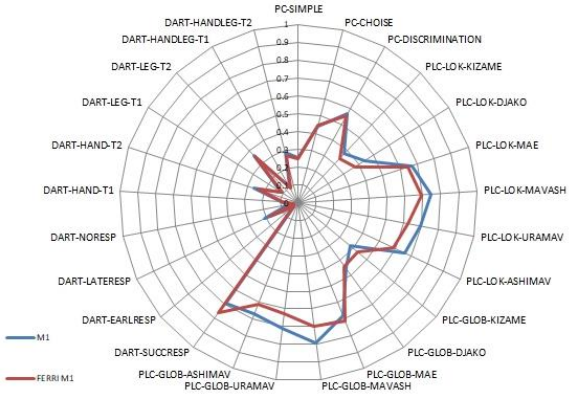

Fig7. Radar Chart 1 Group-Athlete M1

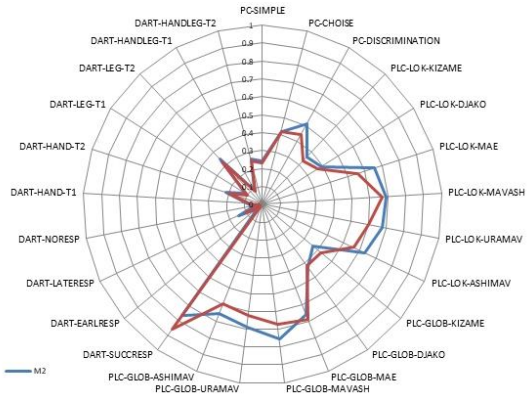

Fig8. Radar Chart 2 Group-Athlete M2

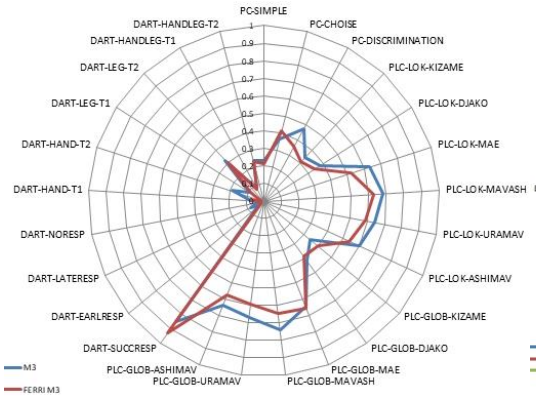

Fig9. Radar Chart 3 Group-Athlete M3

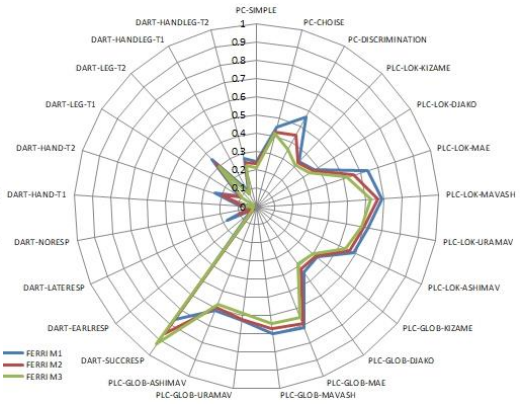

Fig10. Radar Chart 4 Athlete M1-M2-M3

Table 12. Comparative results for experiment 4, 5 and 6 between Athlete 1 - Group

Table 12. Experiment 4 final measurement, experiment 5 and 6 mean results

Subject (X) – Group Experiment 4/5/6	**Successful Response Total%**		**Unsuccessful Response Total%**		**Unsuccessful Response Type%**					
					Early Response		No Response		Late Response	
	Subject	Group	Subject	Group	Subject	Group	Subject	Group	Subject	Group
Ex.4 Laboratory M3	87%	85%	13%	15%	4%	4%	3%	3%	6%	8%
Ex.5 Con. Competition	87%	84.5%	13%	15.5%	4%	4.75%	4%	4.25%	5%	6.5%
Ex.6 Off. Competition	91.5%	90.36%	8.5%	9.64%	3%	3%	2%	2.38%	4.5%	4.26%

After we obtained 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 was performed for each test variable separately in each of the measurements, namely: M1-> M2, M2 -> M3 and M1 -> M3. Obtaining a result of $P \leq 0.05$ in accordance with the standard convention for statistical analyzes with t-tests for each of the mentioned sets shows that we have confirmation of the null hypothesis.

Model of quantitative determination of the efficiency factor (Coefficient of stimuli response efficacy)

After summarizing the results of the performed experiments, we proceeded to derive the reaction efficiency coefficient. In the derived formula, the coefficient K is expressed as a ratio of the successful i.e. the unsuccessful responses.

Since different experiments have different weights and influences, it was necessary to find an appropriate ratio of their influence. Thus, the basic formula for the coefficient is shown below:

$K(x) = КК * \frac{S(x)}{U(x)}$ for the individual X, where $S(x)$ indicates the coefficient of successful responses and $U(x)$ indicates the coefficient of unsuccessful responses in the defensive task.

Each of these coefficients is in fact a functional dependency of the individual and is complexly composed of:

$S(x) = \frac{1*S(lab) + 2*S(cont) + 3*S(comp)}{1*S(group)(lab) + 2*S(group)(cont) + 3*S(group)(comp)}$ where S (lab) stands for the successfulness in experiment 4 in the hall, S (cont.) stands for the successfulness during control competitions, and S (comp) stands for the successfulness during official competitions.

The influence ratio is chosen as 1:2:3 in accordance with the experience for the level of responsibility that each of these activities has (laboratory measurements, control competitions and official competitions).

$$U(x) = 1 * \frac{1 * Ulate(lab) + 2{,}5 * Uearly(lab) + 4 * Unoresp(lab)}{U(group)(lab)}$$
$$: 2 * \frac{1 * Ulate(cont) + 2{,}5 * Uearly(cont) + 4 * Unoresp(cont)}{U(group)(kon)}$$
$$: 3 * \frac{1 * Ulate(comp) + 2{,}5 * Uearly(comp) + 4 * Unoresp(comp)}{U(group)(comp)}$$

The influence ratio is chosen as 1:2:3 in accordance with the experience for the level of effort that each of these activities has (laboratory measurements, control competitions, and official competitions). Additionally, when it comes to this functional dependence, we also took the greater or lesser influence of the specific type of unsuccessful reaction as a ratio of coefficient 1 to the delayed reaction, coefficient 2.5 to the early reaction, and coefficient 4 with no reaction at all. In each functional dependence, the average of the group is taken as an element for correction in the corresponding relationship as the average successfulness or unsuccessfulness of the group.

$S(group)(lab), S(group)(cont), S(group)(comp)$, for successful responses, as well as

$U(group)(lab), U(group)(cont), U(group)(comp)$, for unsuccessful responses.

In the basic formula, there is a correction coefficient KK, which was introduced to leave space for the efficiency coefficient in response to a stimulus. Also, to be influenced by other components that have a corresponding influence, such as efficiency in offensive tasks, functional abilities, adaptive abilities, motor properties, and the like. For our calculations, we considered the value of KK to be 1 (KK=1) because the emphasis was on the response in defensive tasks. In accordance with the aforementioned methodology, table 13 below shows the calculated value for the efficiency in response to a stimulus expressed as a percentage for easier comparison between the 4 top-ranked individuals during the experiments.

Table 13. Calculated values for the 4 top ranked test subjects

Table 13. Coefficient for 4 top ranked individuals in measurements

Subject	Calculated Efficiency	Descriptive (objective)mark
Subject 1 – F.I.	$K(x)$ = 88.45%, for KK = 1;	very well-developed ability for effective response
Subject 2 – M.R.	$K(x)$ = 84.94%, for KK = 1;	well-developed ability for effective response
Subject 3 – G.S.	$K(x)$ = 82.51%, for KK = 1;	well-developed ability for effective response
Subject 4 – S.P.	$K(x)$ = 79.13%, for KK = 1;	well-developed ability for effective response

The obtained coefficient further shows us the level of ability for precise timing of the subject, and through the creation of the descriptive evaluation that sublimes what we obtained above, we have a calculated coefficient of efficiency in response to a stimulus. Table 14 below shows how this descriptive evaluation is set.

Table 14. Evaluation of efficiency in response to a stimulus

Table 14. Evaluation percent for Coefficient for stimuli response efficacy

0-40 %	**insufficiently developed ability for effective response**
41%-65%	partially developed ability for effective response
66%- 85%	well-developed ability for effective response
86%- 95%	very well-developed ability for effective response
>95%	highly developed ability for effective response

Conclusion

The aforementioned research and training methods are individually presented in our previous publications, where all details for each experiment are explained thoroughly. (ex. Kurtovic, Savova. 2012); (ex. Kurtovic, 2014); (ex. Kurtovic, Savova 2016). The purpose of the gathered material was to present the derived reaction efficiency coefficient in a sports fight in karate through a briefing presentation. The presented methods offer an integrated model that will allow each subject to build their own unique set of capabilities for different situational tasks in the fight. In this way, long-term training provides the ability to reactivate neural connections when facing new experiences. By providing real situational challenges, the brain can become more functional, faster, and more successful in real competitive conditions of the sport's fight. Hence, we believe that any competitor who works hard can develop this ability, regardless of age and fighting talent. It is a fact that the good preparedness of an athlete in karate does not depend only on his/her abilities and the abilities of the expert team, but also on external influences i.e. material and technical conditions, sparring partners, opponents, referee rules, subjective referee decisions, etc. Consequently, it is difficult to evaluate the level of combat readiness of the subject in its entirety. In this way, we tried to take the initial step towards determining quantification and evaluation of the degree of combat readiness of the subjects, which will allow the expert teams to perform more accurate planning and implementation of the training activities in the future. We based the concept of "efficiency" in the response to a stimulus in a sports fight in karate on the established research methodology, and according to the obtained results, we could model an additional individual transformation process. We believe that the model defined in this way can be of particular importance for the practice. The experiments unequivocally proved that the elaborated system for individual planning of the training process allowed a qualitative improvement of the basic parameters, to predict the sports-competition result. This statement is particularly important because it refers to competitors who have stabilized their movement structure and their training process developed in plateau conditions in practice. The elaborated laboratory experiments for quantitative assessment of the theoretically derived parameters during regional and global movement actions ensured the basis for individual analysis of the level of sports and technical skills. This helped us to model the training to improve the coordination abilities.

The analysis of the results of the discussed experiments allowed us to ascertain a strong connection between the creation of an "individual map" for the competitor and the appropriate modeling of the transformation process according to it. On the other hand, the suggested specific model of the transformation process through the use of a progressive training model gave us strong support to improve the efficiency of the performance. What remains to be done is to denote the independent significance of the methods for assessment of the spatial and temporal characteristics in attack and defense conditions. The ability to access and choose the appropriate moment to initiate a response is not sufficient by itself and is combined with other strategies such as the kinesthetic sense for effective distance in time and space, tactical thinking, and individual rhythm. In the end, the training process proved the necessity of a complex approach to achieve efficiency and economy of the appropriate motor action. The used realistic situational model describes the logic of the new training approach for kumite - mental training. The applied methods of Ki meditation, progressive relaxation, and autogenic training increase self-regulation, stabilize emotions and provide a proven positive effect on kinesthetic awareness and the ability for tactical thinking. The comparative analysis of the individual results of particular athletes and the average results of the group makes a significant contribution to the individualization of the learning and training process. This describes the image of the future model of the individual approach. It also allows for improving the phases, time, and approach of the training model to individually correct the spatial, temporal, coordinating, and psychological characteristics of the competitors. The efficiency coefficient in response to a stimulus in the sport's fight in karate is derived based on the performed comparative analysis. This is an essential contribution and brings significant information about the level of effective response. By itself, the principle of deriving this coefficient can also be used in many other sports.

Recommendations

It is necessary to think in the direction of creating a simplified system for quick video recording and graphic registration of the karate techniques, which would greatly facilitate the research process by reducing the subjectivity and the competent persons involved. Karate organizations around the world should invest in specialized software products. On the one hand, this will facilitate the research process, but on the other hand, it will also allow the preparation of individual maps for the learning and training process based on easily available precise analyses. This in turn will result in greater interest in this sport, as well as higher sports results. In particular, regarding the research methodology in this work and given the positive results obtained for the training process, as a next step we recommend the analysis of combined techniques – blocking techniques with the subsequent counter strike, simultaneous blocking techniques, and counter strike, as well as interception strike. The time and scope of the current work imposed limitations, but we believe that it is a way to improve the technical mastery of this sport.

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