Journal of Sports Science 4 (2016) 132-149
doi: 10.17265/2332-7839/2016.03.003

Optimization of Performance in Top-Level Athletes during the Kumite in Sport Karate

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Abstract: This text represents a research that by individual treatment explores the influence and effect of the so-called advanced karate training (combined training program for development of physical and mental skills) in strengthening the person's tolerance to difficult and stressful situations. The aim of the research was to achieve optimal performance by the athletes during the kumite[1] in karate. The research involved initial, control and final experiment, where the karate practitioners were focused on the training model given (group; n = 13) and working in a group with additional individual intensive sessions provided for each participant. All athletes were male contestants aged 26.4 ± 6.8. The aim of the research was to explore how their performance can be influenced using psychological techniques during karate trainings, or how not to fall into one of the four undesirable states of mind called Shikai[2]. Results confirmed that the model of combined physical and mental training for athletes improves their physical skills and optimizes performance during competitions.

Key words: Kumite, karate, timing, mental training, optimal performance.

1. Introduction

The idea behind this text is to attract the attention of the professional karate community towards the necessity of systematic approach to the training process, underpinned with the experience from sports and other ancillary sciences. Sports combat in karate is an open skills technique and does not depend solely on the current physical and mental condition of the athlete, but also on the opponent, the task, as well as the circumstances under which the task should be done. Thus, most karate instructors use their own strategy. Often, they are not aware that the strategy needs to be justified, so they restrain themselves from using scholarly experience which makes them avoid the opportunity for a qualitative change.

To achieve the desired result, one has to work with evidence based on methods, study the features of the discipline (kumite[1] or kata[3]) and the structure of the adequate moves. We believe that establishing a duly substantiated theory is extremely important for practical karate and would contribute more instructors and athletes to perceive specific activities on rational and functional level [1].

However, the kumite in karate, as a sports discipline, goes through competitive expansion globally. During one season, there are many official competitions organized that are being scored for the world karate federation ranking. To be able to follow this trend, athletes are put under extreme pressure,

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[1] Kumite literally translated means "grappling hands" and is one of the three main sections of karate training, along with kata and kihon. Kumite is the part of karate in which a person trains against an adversary, using the techniques learned from the kihon and kata. Kumite can be used to develop a particular technique or a skill (e.g. effectively judging and adjusting one's distance from one's opponent) or it can be done in competition. *Reference: Wikipedia*

[2] Shikai In traditional martial art terminology the word Shikai represents the four states of the mind which the competitor can't afford him/herself. Kyo (surprise), Ku (fear, anxiety), Gi (suspect, dilemma) and Waku (confusion). *Reference:Kendo-Guide.Com*

[3] Kata (Closed skills activity) the detailed choreographed patterns of movements. *Reference: Wikipedia*

mostly by improvisation. We think that a substantiated reaction to this challenge is undoubtedly focusing on the need of additional training by emphasizing the individual needs of the athlete. In this regard, Bompa argues that instructors and their assistant expert teams should treat each subject individually, following his skills, potential, method of learning and sports features. Thus, this approach should be seen as a tool to objectively assess each athlete and follow his development [2].

Cybernetic approach via closed circuit management [3] is a good method of identifying the necessary prerequisites for planning, programming and realization of the training process. According to this approach, phase one defines the particularity of the competitive activity that shapes the success of the activities in the following phases.

In order to achieve the desired result in karate, efforts need to be made to increase the quality and efficiency of all training components (general training for physical capabilities or functional-motor training; specific training of motor skills or technical-tactical training; training of motor completeness specific in kumite and theoretical-methodic preparation) in their mutual interdependencies. This also involves socio-psychological trainings that need to be given serious attention, because they include refining of the analyzer's functions and some psychological characteristics and processes necessary for kumite. Such trainings play extremely important role in the selection of athletes, the application of individualization, the development of personal combat style and the anticipation of sports development, at the same time closely relating to building technically-tactical skills and tactical knowledge [1]. Thus, technical-tactical and psychological preparation for athletes should be inseparable, because, only combined, they allow building a relationship between the intention and the performance of the karate practitioner during kumite.

In the interest of this research and to determine the competitive focus, we analyzed the efficiency of the point techniques in kumite, recorded at the official European and World Championships [4]. It was concluded that the contestants do not use many technical elements, but they know them perfectly. The focus in the kumite is not aimed at changing the type of movement activity, but the approach of using that activity. Generally, they do not experiment and use techniques that they are most familiar with. The emphasis is often put on the preparatory movements in order to put themselves in favorable, and the opponents in unfavorable position. It has to be noted that this is the only approach that guarantees minimum negative consequences when transforming ideas into acts. According to Czajkowski, these situations are closely related to the functions of attention and quality of tactical thinking valued as highly specialized form of operational thinking [1]. The best ones are characterized with good self-regulation, expressed through control of the situation during kumite, which testifies for their highly developed tactical thinking skills. This is manifested through emphasized skill of recognizing the opponent's features, preparation of general kumite plans, imposing their personal kumite style, changing the tactics according to the situation during kumite, using the opponent's weaknesses, adequate initiative timing, predicting the opponent's intentions, etc.

One of the key components for efficient realization of tactical plans is the timely and exact realization of the movements. According to our analysis, it is actually the best indicator of the athletes' kumite skills. In order to have these skills, it is necessary to develop them continuously and simultaneously in several directions: skills to open the opponent or force him to make a mistake (Suki[4]), adequate initiative timing

[4] Suki meaning a gap, commonly in attention, but also in stance, guard, etc.
Reference:
https://martialtraveler.wordpress.com/2010/02/14/feeling-maai-and-suki/

(Sen[5]) and sense of effective kumite distance (Maai[6]); meeting the biomechanical requirements, i.e. efficient and economical execution while performing specific technical elements; development of perceptive, metacognitive, attentive and anticipatory functions, as well as increasing the emotional stability during kumite.

The activities in this research were going exactly in that direction, and the aim was to examine whether the discussed approach and the methods used significantly influence the improvement of the optimal performance in athletes, presented through their capabilities of fast and accurate reaction in kumite.

2. Theoretical Analysis

In the preparatory stage, through theoretical analysis, we decided to conduct the research with the above mentioned cybernetic approach via closed circuit management. In the first phase, we were supposed to define the originality (specialty) of the competitive activity that, according to us, lays in the athletes' efficiency to defend against the opponents' attacks. Since the quality of such performance is significantly influenced by the level of training and expertise, it was certain that it is adequate for defining this criterion. However, the defense is a recognizable, and consequently, a flexible model of action, where during the training the whole structure needs to be well defined by both biomechanical requirements and perceptive, cognitive and anticipatory functions. The better the defense techniques are, the higher the level of self-confidence, and the easier it is to enter the state of Fudo-shin[7]. It is the main precondition for athletes not to "fall" in some of the unwanted Shikai states of mind during the kumite.

Having defined the originality (specialty) of the discipline, first it was necessary to scan the initial condition to identify strengths and weaknesses in athletes in order to improve their preparedness by long-term monitoring and adequate coaching. The second phase required creating a database of model features of champion athletes (indicators of their features, skills, knowledge, etc.). Thus, it was decided to use a set of experiments with a male group of top athletes—karate practitioners that needed to identify the level of preparedness of the group as a whole, but also of each individual separately. The purpose was to compare the achievements of each individual in all variables with the average achievements of the group and based on the results to define the discrepancies of each individual in relation to the group. According to some, this type of research cannot be treated as valid for generalization. Nevertheless, due to the fact that it is a research that explores the individual features of the athlete, this is considered to be an adequate and innovative approach. Actually, it is observed that a different approach would not contribute to a significant general change.

Given that the kumite in karate is an activity where the individual's efficiency is often a result of arbitrary assessment (that often is imprecise and subjective), it

[5] Sen (Initiative) is "the decisive moment when a killing action is initiated." There are three types of initiative in Japanese martial arts, early initiative (sen no sen an initiative launched in anticipation of an attack where the opponent is fully committed to their attack and thus psychologically beyond the point of no return.), tui no sen meaning a defensive initiative launched simultaneously with the attack of the opponent and late initiative (go no sen meaning "late attack" involves a defensive or counter movement in response to an attack).

[6] Maai (Timing) is a complex concept, incorporating not just the distance between opponents, but also the time it will take to cross the distance, and angle and rhythm of attack. It is specifically the exact "position" from which one opponent can strike the other, after factoring in the above elements. *Reference: Scientific Karatedo (1976) by Masayuki Kukan Hisataka/Heijoshin/ ISBN: 978-1-4629-0417-4 (ebook) Published by the Charles E. Tuttle Company, Inc. Of Rutland, Vermont & Tokyo, Japan with editorial offices at Osaki Shinagawa-ku, Tokyo 141-0032*

[7] Fudo-shin is a state of equanimity or imperturbability (literally and metaphorically, "immovable mind", "immovable heart" or "unmoving heart"). It is a philosophical or mental dimension to Japanese martial arts which contributes to the effectiveness of the advanced practitioner. Mind and body are deeply connected to each other with full concentration. Fudo-shin means that you let go of clinging and firmly believe that you won't be beaten by anything. *Reference: Mind power: secret strategies for the martial arts (2010) by Kazumi Tabata /Fudoshin/; foreword by Kaiichi Hasumi. cm. ISBN 978-1-4629-0106-7.*

cannot be compared to the skills of closed management (where the measures and assessments are far easier and precise). It is considered that in such area, where many psychophysical components are treated, the knowledge of neurophysiology, psychology and biomechanics is used. For each ambitious researcher, this unique model is useful and it can show the effect of the performance.

An integral part of the tasks was to get the athletes motivated to participate in the experiments for a long-term period, as well as to use appropriate equipment, in order to provide quality, precision and validity of the measurements. In this phase, with the help of experts in the field of sports psychology, each individual went through different tests: personality strength test, anxiety test, egocentricity test and intelligence test, in order to provide clear psychological profile of each athlete. Physical and functional skills were tested with a shuttle running test and polar trainer equipment with the help of experts in the field of sports medicine. The specific laboratory experiments also required adequate organization and technical realization. Experimental methodology should have followed the logic of complicating the moving actions from regional to global, and all results gained from the experiments to be processed by a variable statistical analysis. Consequently, in the third phase, the current situation was supposed to be defined and registered in the personal data base of each athlete. The fourth phase required correlational statistical analysis and registering of the results of the individual indicators for each athlete with regard to the average group results.

In the next, fifth phase, according to the registered initial condition and the defined discrepancies, a short-term training involving goals, tasks, periodization and conditions customized for each individual separately should have been planned.

The planning of the training in the sixth phase, according to the results received, was followed by a process of programming the individual transformation process by selecting the means, intensity and methods according to their needs.

After the programming, in the seventh phase, there was a realization of the training according to the established plan and program, where the athlete had to transfer from the current condition to the desired condition.

In the next, eighth phase, there was a complete control testing in order to define the new condition of each individual, according to which the programming and realization of the transformation process would be evaluated. Then, new goals were set, as well as new planning, programming and we started the training realization until the next testing.

3. Methods

Regardless of the level of preparedness of the contestants, the reasons for the problems related to the quality of the performance in kumite, most often are of emotional or motivational origin and are result of a lack of mental control. To cut this deficit, in the traditional Japanese methodology, martial arts training cannot be successful if the athlete has not achieved the Heijo-shin[8] state of mind. On the other hand, mental control, as argued by some authors, can be improved by psychological training procedures, through attention control development, stress optimization, anxiety control, etc. Since the structure of the movement and its execution is mostly defined by the level of the mental representations that must be perfectly clear, the training procedures (designed to optimize the regulation process) should be distributed

[8] The term Heijoshin is comprised of three words that combine this state of being. First: “Hei” meaning peaceful, calm or steady. “Jo” meaning always, constant or continually and “Shin” being understood as more than just the “heart”, defining the mind, the spirit, the emotion, the character, the whole inner essence of the individual or briefly stated as: consistently peaceful mind or a state of readiness for action appropriate for the moment.(complete control of himself, allowing him to keep this placid state of mind called “heijoshin” when others were overcome by fear and hysteria)
Reference: Scientific Karatedo (1976) by Masayuki Kukan Hisataka/ Heijoshin / ISBN: 978-1-4629-0417-4 (ebook) Published by the Charles E. Tuttle Company, Inc. Of Rutland, Vermont & Tokyo, Japan with editorial offices at Osaki Shinagawa-ku, Tokyo 141-0032

at the level of mental representations. The acquisition of presentation structures, in these circumstances, can contribute a lot to the training optimization in both technical-tactical and psychological terms [5]. In order to optimize the training process, during the implementation of the research, the method of advanced karate training was used, believing that this approach would most adequately link all functions of the athlete. Those athletes that are underprepared often experience difficulty focusing on specific thoughts and feelings due to the subjectivity related to the particular task. Thus, the development of the skills to solve various combat tasks by using this model, can improve the awareness of the bodily sensations and create more objective self-image. Mental training plays an important role in the development of these skills. Although this mental training is already an integral part of many training programs, some karate experts fail to understand its significance in increasing the potential of the athletes. Although most professional authors emphasize that "victory is ten percent physical, ninety percent mental", many athletes are not aware of the importance of practicing mental skills and the efficiency of this type of training [6]. The truthfulness of this thesis is confirmed by the athletes themselves who have practiced these skills with the fact that they win only when they are both physically and mentally fit [7]. Accordingly, with the help of multimodal training, athletes can develop the ability to link the internal and external events during the performance. Thus, they can make more realistic choices instead of being unconsciously dominated by their common habits. Prentice argues that what the athletes can actually learn is to complement or change the primary opinion of themselves. In this way, the creation of more liberating form of consciousness, which is also free from limited visualized stereotypes for their own capabilities, can be best influenced [8]. This training method differs from the rest of the standardized practices because it respects the developing potential of each athlete, encouraging the transformation of the problematic motor and psychophysiological tendencies in circumstances close to reality and only in a way that is adequate for each athlete. The model of intervention aims to provide an outlet from the usual models of consciousness and behavior of the athletes during training and competition, but also increase the self-consciousness and focus on physical senses of the movement [8]. It significantly influences the improvement of the performance that contributes to improved self-regulation.

3.1 Technical-tactical Training

The most essential aspect of any motor skills training is the quantity of quality training. Thus, efficiently designed and implemented training makes the skill perfect [9]. According to Jeffreys, the first step in improving the technical performance is to identify the problematic key motion patterns; then divide each technique in several discreet motion patterns and disperse it to "targeted mechanics of motion" [10]. This way, the key mechanic actions that the athlete needs to perform can be observed, which will finally make the overall motion pattern efficient and economical.

Since the target mechanics of such movements is based on mechanical principles (such as optimization of the underpinning surface, control of the center of the body mass, keeping the vertical axis of the body and optimal foot position for maximum generation of surface force of reaction), the errors could be clearly observed. The execution of each individual movement, according to its function and for easier observation of errors, is classified in three phases: Initial phase, i.e. preparation to initialize or change the movement, consisting of extremely short and fast movements that enable start or change of the current movement (Fig. 1); Transitional phase in which the only concern for the athlete is to stay in favorable position where he can efficiently react on stimulus. In this phase, the goal is not the maximum speed of the movement, but the maintenance of optimal body posture during

transition (Fig. 2). And the third actualization phase, where the ultimate decision is made for the success of the motion sequence, most often involves adequate sparring technique (Fig. 3).

In the first step, according to Knudson and Morrison, there is a developed system of target mechanics identification for each motion pattern that is being corrected in order to increase the training efficiency. To illustrate it, during the analysis of the sparring position called the "check-point", the list covered observation of different areas (overall posture, but also each segment separately—shoulders, feet, legs, arms, hands) and target mechanics for each segment separately. For example, the control of the feet served for analyzing the contact with the surface and the position of the feet in relation to the knees, etc [11].

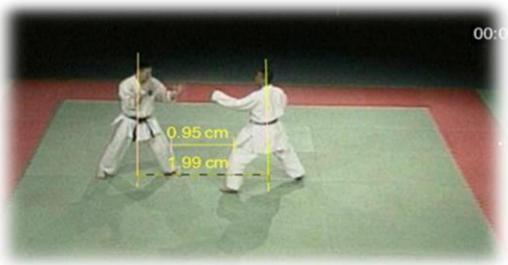


Fig. 1 Preparation to initialize the movement.

Fig. 2 Favorable position for efficient reaction.

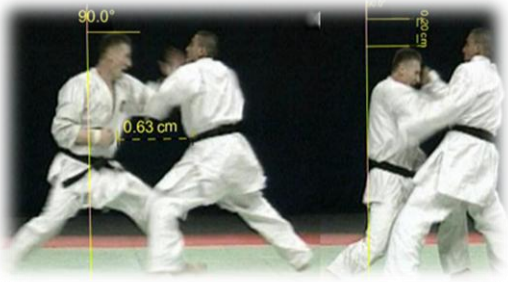


Fig. 3 Execution of adequate sparing technique.

According to this example, a list was compiled for each targeted motion pattern. This analysis represented a powerful tool which provided a model to be used for comparison against the athlete's performance. Once the motion patterns were acquired, the next second step was to identify and integrate these discreet motion patterns in sequences that appear in kumite. The key item was maintaining the optimal body posture, without maximum speed of the movement, focusing on the quality of the movement and the position that enables start and realization of the next move or technique.

The third step was to identify the key stimuli and the reaction to them, by using "open exercises", in an environment that is constantly changing. There were tasks introduces, such as copying the opponents' movements in distant sparring position. This was aimed at the athletes, so that they can get used to the key signals appearing during the kumite and to be capable to better transmit their previously developed skill for efficient movement in a real combat situation.

After this phase, the training was focused on practicing tactical combinations. Actually, the point was to make it integrative in terms of timing the initiative, the effective distance and the specific motor tendencies as a whole, but also the deconstructed overall mechanics of the motion patterns that can still be subject to correction. The assimilation was strictly performed by the principle of gradualism. In the first phase of the development, the elementary timing of the initiative in 1-0 situation was practiced, by a process of solving and realization of certain situations without an opponent. In the second phase of the development, the situational timing of the initiative was improved, that involved practicing in 1-1 circumstances, i.e. prompt and accurate resolution and realization of certain situations with passive, semi-active and active opponents. The final third phase of the development was the temporal and spatial coordination of the action with included stamina for high success in competitions.

3.2 Mental Training

Visualization before, during and after the training is an efficient strategy of mental training. It was used because the athletes are able to think efficiently using images and positively control the flow of the images and corrections, aiming to easily transform the mental intentions into motor reactions. However, visualization and the ideo-motoric method, comprised of mind exercise and reflected in the reproduction of the given technical-tactical knowledge, helps the athletes in a form of principle when they make a mistake, to immediately return to their thoughts and fix it by assuming different possible sparring situations. It is a primary mental ability important for kumite that each athlete must have. In this sense, the Blumenstein model [12] served as a pattern to incorporate our experiences and create an adequate model for kumite in karate. The model was intended, above all, to assist in improving the specific motor weaknesses, then to enhance the safety, to decrease the tension, the stress and certain psychosomatic obstacles among athletes, thus directly creating conditions for better efficiency. In the first phase, the athletes were introduced to the techniques and training procedures, which were supposed to enable the regulation of their psychophysiological condition through some of the following techniques: KI meditation [13], progressive relaxation [14, 15] and autogenic training [16].

Using purposefully prepared video material (offensive attack sparring), the athletes learned different sparring situations and exercises to learn how to control their reaction and excitement. After introducing them to the techniques and training procedures, they began with virtual work for three minutes, when they were supposed to respond to different attacks timely and consistently in their minds. This was followed by 15 minutes of relaxation with breathing exercises and Ki Meditation. Thus, the purpose of the opening phase was to achieve a steady process in which the athlete would try to be completely focused (excitement phase) for 3 minutes, immediately followed by relaxation that would last nearly 15 minutes, and then he would switch to the excitement phase for 3 minutes, etc. (An official karate match lasts for 3 minutes, and to go from one to another round it takes an average of 15-25 minutes).

The next phase was working on identification and strengthening of the most efficient reaction procedure (dominant initiative timing), through stimuli from a partner positioned at a great distance (three to four meters). In ideal conditions, the athlete should harmoniously perform several successful reactions in a sequence, thus using procedures that involve individually built self-control system targeted to increase the activation (for example: that's good, go ahead, you're doing great, I'm the best, etc.) or tranquilization (for example: now faster, be careful, don't worry, it will be fine, I'll catch the moment, etc.) in order to achieve a high level of self-confidence.

In the third phase, through stimulation of attack, they practiced an adequate reaction. At first, using a video wall, and then with a partner, following and giving adequate motor reaction to different attack actions within three minutes. Here, they used excitement and relaxation techniques, learned in the previous phases. During the work, depending on the efficiency, they got verbal correction (you're late, faster) or praise (excellent, great, keep up the good work) from the instructor and the other participants to give them additional motivation. In each round, the correct attempts were counted and recorded.

The fourth phase involved implementation of self-regulation techniques. It was a phase where athletes prepared for the specific reaction in a given situation. The techniques acquired from the first and third phase, were then applied in a particular training session including three minute attack against a random partner.

They were forced to use the established predominant initiative timing, implementing specific self-regulation techniques in order to reach the area of

greatest safety. Here, besides the suggestive effect in every successful action, there was also audio material with ovations, applause or whistles from a taped audience. In order to evaluate the efficiency, the athletes were tested in 6 different matches with 6 different opponents, each match being three minutes long, and the opponents should perform up to 10 attacks. The athletes are supposed to respond successfully to as many attacks as possible.

The fifth and last phase included realization through situational training, in circumstances characteristic for a competition that should contribute to increased intensity. The athletes applied previously learned techniques in an environment of free style sparring (Jiyu kumite). There was verbal support from the opponent's surroundings, ignoring them and sometimes criticizing or praising their kumite performance. The presented behavior and realization was a reflection of everything that was practiced during the trainings in the fourth phase. Ensuring that even in such circumstances "they are doing good", they were left alone to use these techniques during training sessions and later at the control competitions. The idea was that by this type of training, athletes should become more confident, but also resistant to difficult and stress-full situations; to be self-contained and to be able to follow their psychophysiological condition within trainings and competitions.

4. Experimental Analysis

4.1 Objective of the Research

The 13 top athletes male contestants aged 26.4 ± 6.8 (Table 1) has participated in the experiment on voluntary basis with maximum cooperation to achieve the best possible results. Thus, they had regular 90-minute training sessions, six times a week, tailored according to their personal capacities and needs of each individual. Trainings and experiments were implemented in an environment with optimal temperature and lighting.

All athletes were in good psychophysical condition. Before each of the stimulations, the goal and the procedures were explained in details, as well as the measures to protect them from injuries. After that, full agreement to participate in the research was assured. All additional questions were explained and practically demonstrated. All entities participating had international experience in competitions and have won major national and international results in kumite.

To measure the specific movements, it was necessary to develop a stimuli model from karateka with offensive role to attack. Thus, instead of classical stimulator, this model helped in recording the combat from four angles and then with the help of software for biomechanical analysis (Dartfish), the measuring of the reaction time in pre-motor and motor phases was completed, as well as the number and type of reactions and the level of success in real sparring with an opponent.

5. Equipment and Stimulators

To achieve the goal, 100 m^2 mats were used of the model: KWON WTF approved 2.4 mm thickness; 4 Sony PMW-EX1 cameras; Sony VCT 1170RM Tripod; KWON WTF approved Head Guard; KWON E-protector – chest protector with electronic and audio signalization with different punch strength sensibility (M, L, XL); SMAI Sets of protective gloves and shin and instep protectors; Laptop computer DELL Vostro 1720.

6. Procedure

The experiment was carried out in optimal conditions (Figs. 4 -6), as well as before an audience in

Table 1 Characteristics of the respondents.

Number of subjects (male)	Age (years)	Body weight (kg)	Body height (cm)	Training background (years)	Karate title (belt)
13	26.4 ± 6.8	78.5 ± 6.5	179.0 ± 5.2	15.7 ± 5.8	1 Kyu-4 Dan

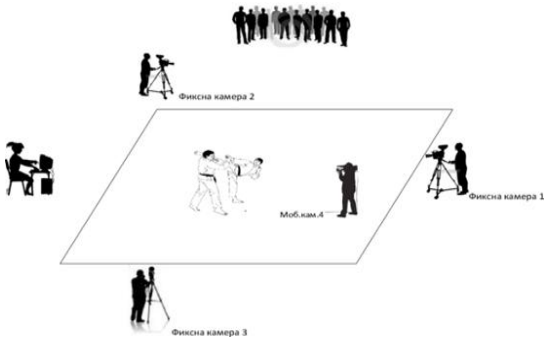


Fig. 4 Atmosphere during the measuring.

Fig. 5 Atmosphere during the measuring.

Fig. 6 Atmosphere during the measuring.

order to "capture" the competitive atmosphere. Three camera tripods were placed in the corners of the arena, and the fourth one was a mobile camera operated by a professional cameraman. In this way, there was clear image from all four angles at every moment of the experimental competition. The athlete who defended himself was protected with head guard and electronic chest protector with audio signalization, as well as groin guard and mouth guard. The athletes in attack positions had a set of protective equipment for arms, shin and instep protectors.

Each athlete was assigned six defensive sparring sessions against six different offensive opponents. The sparring lasted for three minutes which is effective sparring with an average break (relaxation after excitement) of 15 minutes between the rounds. The athletes that had an offensive role were given the task to attack in their full capacity, using kumite techniques of their own choice. On the other hand, the athletes who had defensive roles were given the task to defend as many attacks as possible in a timely manner, without being entitled to a counter-attack. The athletes were previously introduced with the assignment and had enough time for adaptation.

In each measurement, the organization of the athletes' attack and defense were identical. Each set of sparring, simultaneously, was recorded and the material was analyzed using the previously mentioned biomechanical program "Dartfish", which allows analysis of recordings based on the "frame by frame" principle with sensitivity in intervals of 0.020 seconds. This method clearly led to the correct conclusions, i.e. to measure the reaction time in pre-motor and motor phase, the number and the type of reactions, as well as the level of success. In order to avoid subjectivity in analyzing each sparring, besides the fact that it was observed simultaneously from all four angles, it was additionally analyzed by two experts who discussed the possible controversial assessments of the athlete's reaction. For easier indication of the unsuccessful defense, there was special protective equipment that provided audio indication when the opponent received a point.

The idea of this experiment was to measure the efficiency through the number and timing of successful reactions with adequate blocking techniques of each athlete, as well as the number of unsuccessful reactions. The unsuccessful reactions were dissected into reactions with premature response, untimely response and non-response. To identify the reaction time during the video analysis within this experiment, an initial moment of the hand techniques (straight reverse and jab punch attacks—striking blow with the closed fist), was the initial movement of the attacker's arm. For the kicking techniques (straight, roundhouse, side and back kicks), the initial moment

was the moment of separation of the foot of the attacker from the surface. The time of making the decision by the subject, was actually counted from the moment of moving the arm until the characteristic guard manifestation, particularly the manipulation segment—the palm, which was identical in all athletes and was manifested by extension from the relaxed position (Fig. 5).

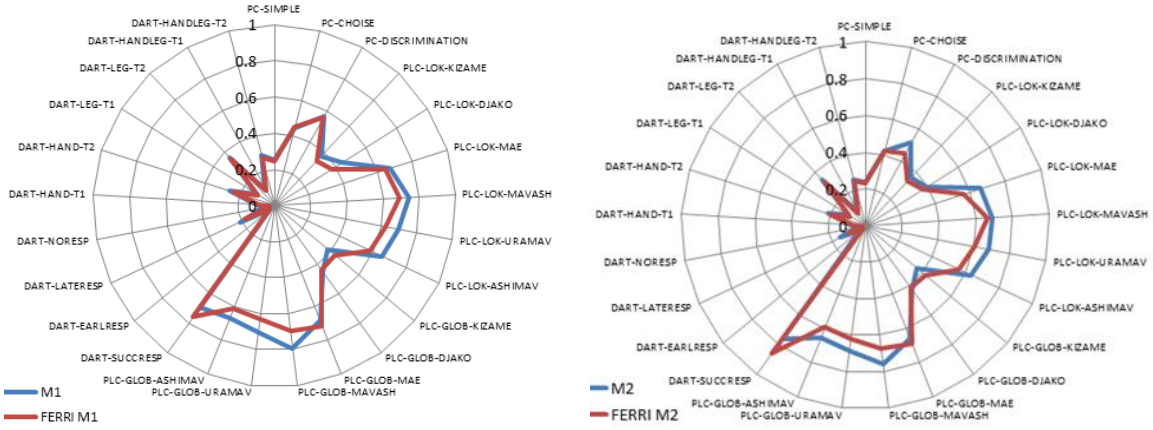
This sudden change of form of the manipulative part of the arm, previously moved by inertia, in purposefully extended position ready for adequate response, was a signal that "it got to him", i.e. the subject made the right decision.

7. Results and Discussion

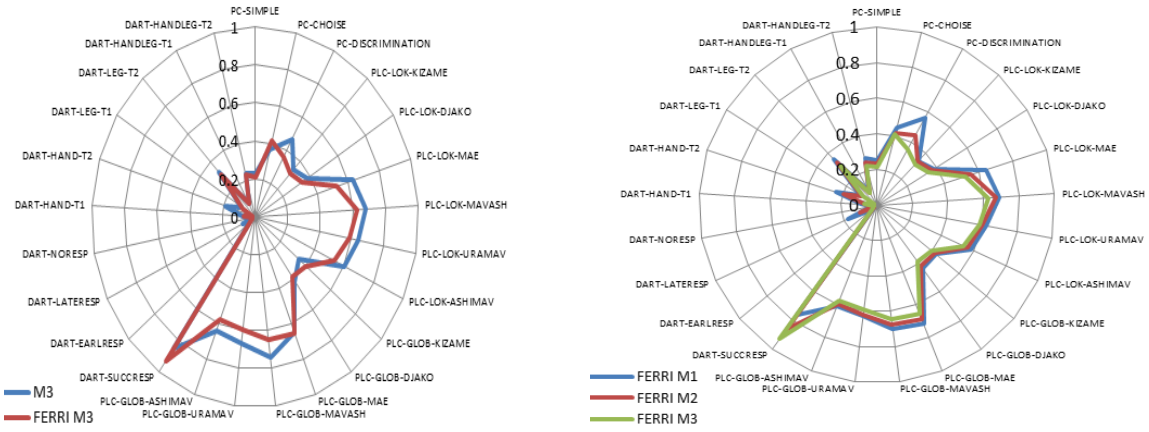
According to some researchers [17], time measurement of a simple reaction is not as important in kumite. For the purposes of this research, in three additional experiments (time measurement of a reaction through PC (Personal Computer) and PLC (Programmable Logic Controller) in the form of local movement stimuli, as well as specific karate movements, we scanned each individual athlete, in order to identify the initial state of perceptive and cognitive functions, but also to check if and how much the performance of the technical elements fulfills the biomechanical requirements. Besides, since the kumite in karate faces strict spatial and temporal limitations, the research was mainly focused on testing with real opponent in an environment close to reality. It was done due to the athletes' ability to notice the important information quickly and accurately, which significantly facilitates the decision making and gives them more time to prepare and organize the motor movements [18], but also due to the conclusion that the fast and accurate reaction to unexpected stimuli is a constantly needed requirement by the athletes [17].

The fast and accurate reaction is essential in kumite. It reflects the interaction of all functions that contribute the athletes, in kumite, to spend less or more time on decision making or to make less mistakes, which leads to creating more or less conditions for efficient implementation of motor movements. Thus, in this paper, the fourth experiment is emphasized, i.e. the efficiency and the reaction time in conditions of spatial and temporal limitations with opponent in an environment close to reality. Thanks to the implemented research and the results obtained, it was established that through the described methods of the transformation process, we have significantly influenced the improvement of these skills among the participants. In Radar charts (1-4), we can observe the level of preparedness within a group as a whole, but also compared to one of the athletes from the group for all three measurements separately.

The compared achievements within the group and the compared individual in all variables for all four experiments, considering the average results, show the progress in these measurements.



Radar charts 1/2 The average results between group (M1; M2) and compared athlete (F. M1; M2) in measurement 1 and 2.



Radar charts 3/4 The average results between group (M3) and compared athlete (F. M3) in measurement 3 and Individual progress of compared athlete (M1, M2, and M3) in all variables of the three measurements.

Also, radar diagrams 1, 2 and 3 show the deviations of the athlete compared to the group, while radar diagram 4 shows the individual progress of the compared athlete in all variables for all three measurements.

To support the results, we decided to make a statistical analysis using Md Calc 2013 software. First, the normal distribution that appeared to be normal in all cases was checked, using the paired Student *T*-test to check the probability. In all comparisons, the *P* values were ≤ 0.05 which, in turn, proved the hypothesis that the continuous, individually modeled, training intervention had an impact on the capability for optimal performance and would substantially decrease the unsuccessful reactions as well as the time of reaction.

Precisely, the number of successful and unsuccessful defenses was measured three times (6 matches per person on each measurement had a total of 224-273 punches and kick attacks). 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. Firstly, it was interesting to measure the unsuccessful defenses and thus it was decided to divide them in three sections: pre-responses, non responses and untimely responses. The rest of the reactions were the successful ones that are interchangeably called timely responses.

The results of the entire group and the compared athlete in initial tests between successful and unsuccessful responses is an average of 69.538% ± SD 10.8291 (Compared athlete 63% ± SD 5.991) against 30.462% ± SD 10.8291 (Compared athlete 37% ± SD 5.991). From unsuccessful responses, the percentage of untimely responses is 21.078% ± SD 7.1744 (Compared athlete 25%), pre-responses 3.627% ± SD 1.7037 (Compared athlete 5%) and non-responses about 5.991% ± SD 3.9659 (Compared athlete 7%). In the controlling measurement (CM), the percentage of successful responses is enlarged from 69.538 to 76.154% ± SD 7.3807 (Compared athlete from 63% to 80% ± SD 4.0621) against unsuccessful responses, which are decreased from 30.462% to 23.846% ± SD 7.3807 (Compared athlete from 37% to 20%).

The progress of successful responses is due to untimely responses which are reduced from 21.078 to 14.914% ± SD 4.5048 (Compared athlete from 25% to 12%) and non-responses which are reduced from 5.991% to 4.647% ± SD 2.0913 (Athlete from 7% to 5%). In the final measurement (FM), there is additional progress, the successful responses are enlarged from 76.154% to 85% ± SD 6.5192 (Compared athlete from 80% to 87% ± SD 2.7044), while the unsuccessful responses are reduced from 23.846% to 15 % ± SD 6.5192 (Compared athlete

from 20% to 13% ± SD 2.7044).

The final progress of successful responses is due to untimely responses which are reduced from 14.9% to 8.632% ± SD 4.3681(Compared athlete from 12% to 7%), pre-responses reduced from 4.166% to 3.554% ± SD 1.7806 (Compared athlete same 3%-3%) and non-responses that are reduced from 4.647% to 2.738% ± SD 1.3985 (Compared athlete from 5% to 3%). The final analysis that was done was the existence of an opportunity to confirm the hypothesis by paired t-tests to prove the statistical significance of the results obtained.

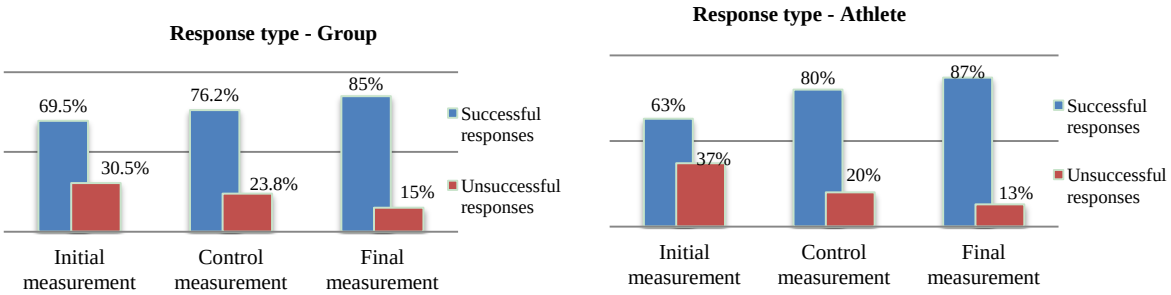
The progress in the percentage of successful defenses and the depth analysis of the failed reactions is represented visually in Table 2 and Bar Graphs 1-4.

In terms of the stimulus responses, Bar Graphs 5/6 below show an illustration of the response times of the hand attacks of the whole group with one chosen athlete after the IM (initial measurement) i.e. their response time composed of the pre-motor time t_1 and the execution time t_2 whose average values were 0.097sec ± SD 0.0508 (Compared athlete 0.079 sec ± SD 0.0232 where 95% CI was between 0.067-0.090 sec) for t_1 and 0.260 sec ± SD 0.0578 (Compared athlete 0.208 sec ± SD 0.0300 where 95% CI was between 0.188-0.240 sec) for t_2 attack responses with manual techniques.

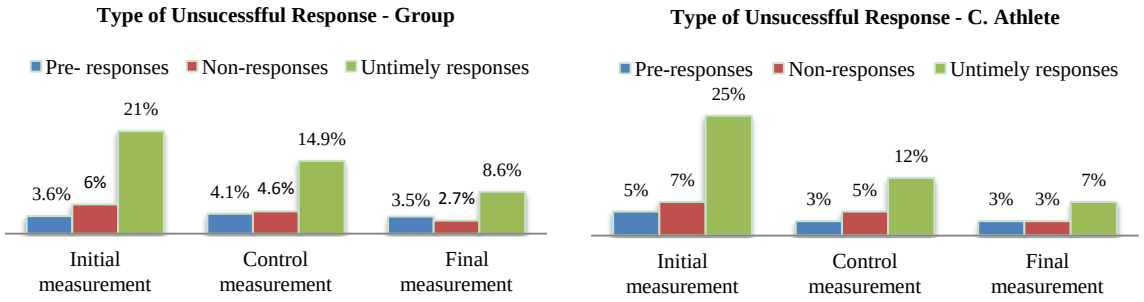
In the controlled measurements (CM), the response time decreased to 0.078 sec ± SD 0.0513 (Compared athlete 0.61 sec ± SD 0.0160 where 95% CI was between 0.053-0.069 sec) for t_1 and 0.213 ± SD 0.0544 (Compared athlete 0.158 sec ± SD 0.0166 where 95%

Table 2 Mean ± SD percent of Personal Efficiency of C. Athlete compared with efficiency of the Group.

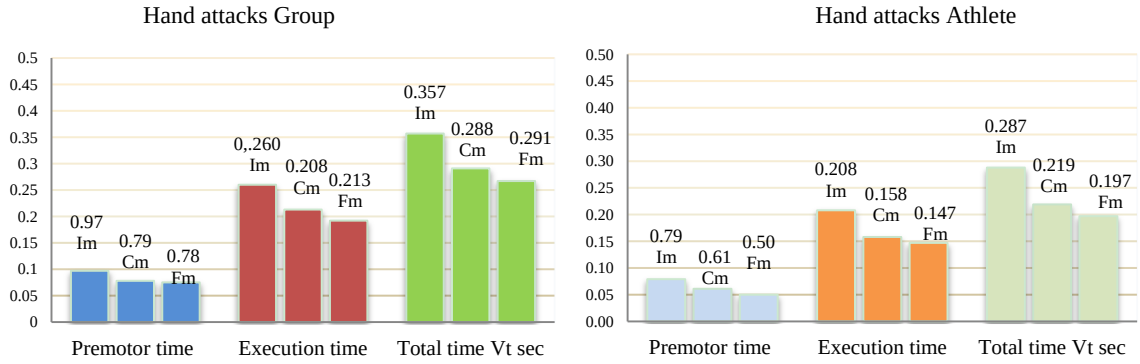
Comparative results Athlete Group	Successful responses total		Unsuccessful responses total		Type of the Unsuccessful Responses					
					Pre-responses		Non responses		Untimely responses	
	Athlete	Group	Athlete	Group	Athlete	Group	Athlete	Group	Athlete	Group
Final measurement	87%	85%	13%	15%	3%	3.5%	3%	2.7%	7%	8.6%
Control measurement	80%	76.2%	20%	23.8%	3%	4.1%	5%	4.6%	12%	14.9%
Initial measurement	63%	69.5%	37%	30.5%	5%	3.6%	7%	6%	25%	21%



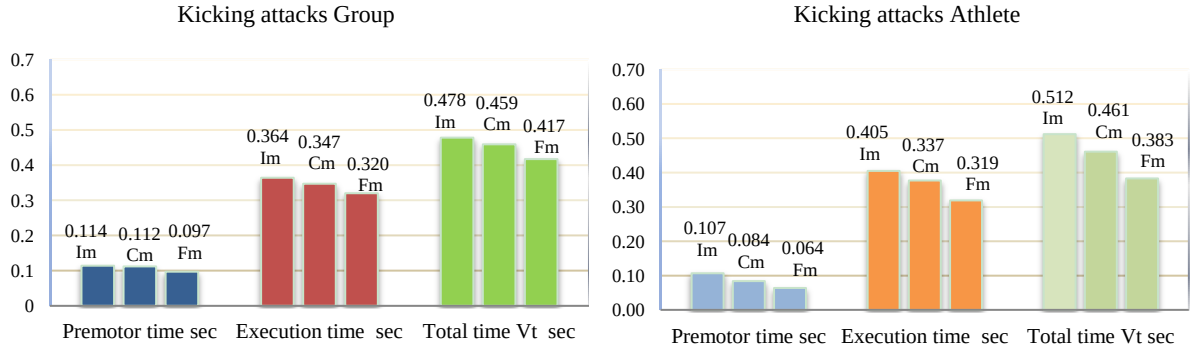
Bar Graphs 1/2 Average ± SD percentage of successful/unsuccessful responses Group C. Athlete.



Bar Graphs 3/4 Average ± SD unsuccessful responses: pre-responses, no responses and untimely responses group/athlete.



Bar Graphs 5/6 Average ± SD reactions time (sec) in defense from straight reverse and jab punch attacks (striking blow with the closed fist), Initial measurement (Im) Control measurement (Cm) Final measurement (Fm). Group/Athlete.



Bar Graphs 7/8 Average ± SD Reactions time (sec) in defense from kicking attacks, (straight, roundhouse, side and back kicks) Initial measurement (Im) Control measurement (Cm) Final measurement (Fm). Group/Athlete.

CI was between 0.149-0.166 sec) for t_2. In the final measurement (FM), there was an additional improvement of the response time for both t_1 and t_2 which were decreased to 0.075 sec ± SD 0.0400 (Compared athlete 0.050 sec ± SD 0.0103 where 95% CI was between 0.045-0.055 sec) for t_1 and 0.192 sec ± SD 0.0478 (Compared athlete 0.147 sec ± SD 0.0119 where 95% CI was between 0.141-0.153 sec) for t_2.

Bar Graphs 7/8 show the response times of the kicking attacks after the initial measurement (IM) t_1 and t_2 which add up to 0.114 sec ± SD 0.0585 (Compared athlete 0.107 sec ± SD 0.0255) where 95% Ci was in the range of 0.096-0.117 sec for t_1 and 0.364 sec ± SD 0.0724 (Compared athlete 0.405 ± SD 0.0335 where 95% Ci was in the range of 0.391-0.419 sec) for t_2. After the control measurement (CM), we had a continuous improvement of the results of the group but not in the compared athlete where t_1 decreased to 0.112 sec ± SD 0.0875 (Compared athlete 0.084 sec ± SD 0.0195) where 95% Ci was in the range of 0.076-0.092 sec, and t_2 of 0.347 sec ± SD 0.0859 (Compared athlete 0.377 sec ± SD 0.0275) where 95% Ci was in the range of 0.365-0.388 sec. In the final measurement (FM), even though there was an additional improvement of the response time in the group, t_1 decreased to 0.097 sec ± SD 0.0552 and t_2 decreased to 0.320 sec ± SD 0.0703. The compared athlete improved his time from 0.084 to 0.064 sec ± SD 0.0144 where 95% Ci was in the range of 0.058-0.070 sec for t_1 and 0.377 to 0.319 sec ± SD 0.0200 where 95% Ci was in the range of 0.311-0.327 sec for t_2.

From the results, it is clear that thanks to the continuous training and methodology used, the athletes progressed in all areas and became faster and more efficient from one measurement to another. The average response time was from 0.478 to 0.417

seconds in kicking attacks and 0.357-0.267 seconds in hand attacks. These results coincide with a similar experiment done by Williams & Elliott [19], where video stimulator was used instead of a live model. The results of that experiment have shown that in top karate practitioners, the average response time was 0.552 seconds. It was concluded that the opponent's attack is completed by 0.430-0.660 seconds from the beginning of the movement that also coincides with this research, where the results are from 0.397-0.657 seconds. If the unnecessary latency is deducted, which is approximately 0.200 seconds for neurotransmission and response implementation [20], then the average response time among athletes indicates that the decisions were made before the completion of the opponent's attacks. In this experiment, there were often cases of interception during initialization of the opponent's movement. The low values in the latent phase among the participants of 0.114-0.097 seconds for responses of the kicking attacks and 0.097-0.075 seconds for responses of hand attack, suggest that these are a result of significantly improved level of perceptive skills, i.e. efficient survey of important, informative parts of the opponent's body and his environment [21], as well as the ability to predict the opponent's action due to prompt recognition of the previously given information [22]. It is considered that the improved ability to predict based on partial or previous information sources (also called perceptive prognoses) [23], had a significant contribution to the athlete's increased efficiency (15.5% in the group and 24% in the compared athlete). Otherwise, the underdeveloped predicting skills would usually result in late decisions for giving effective reaction and ability to plan the movement [24]. In this situation, the competitors under temporal restrictions during kumite would not usually be able to make decisions to simply avoid the obstacles caused by the opponent and the responses would be untimely and confusing.

Also, the significantly improved emotional stability in athletes coming as a result of the implemented training method directed towards crucial understanding of the work should be mentioned and emphasized. One of the main components for quality improvement in sports is particularly the understanding or clear perception of the activity and accurate prediction of the outcome [25]. During the research, the athletes were regularly surveyed. One of the questions was related to the anxiety. Their testimonies showed that as their performance improved during the trainings, their self-confidence grew, the anxiety decreased during competitions and they easily handled their opponents. Actually, by reducing the possibility of being less resistant to stimulation during kumite (condition of Kyo), they managed to decrease the potential possibilities of injuries that influenced their self-esteem and the decrease of fear against failure before and during kumite. This condition is the most commonly explored emotional component due to the known effects of stress that appear in both cognitive functioning and physical activity [26].

Although, according to some researchers who measured the competitor's anxiety during kumite and kata, considering the age, sex and experience in athletes practicing taekwondo, the results showed no significant differences and influence over the efficiency in competitions, except among the youngest competitors [27]. The conclusion is that each athlete deals with anxiety in kumite with unknown opponent, opponent who does not suit him, or opponent with whom he had a negative score. Such anxiety influences the efficiency in competitions and it coincides with the conclusion that the subjects with lower anxiety level, before and during kumite, have grater possibility to win their match [28]. Regardless of the anxiety, from competitor's perspective, there are contradictory results. Testimonies from the participants confirm that long-term training significantly influences the reduction of anxiety not only before and during kumite, but also in everyday life [29]. It is a fact that the offensive approach is most

widely used in tactical preparation, and it characterizes the athletes with efficient attention processes, thus providing fast and accurate reactions to spatial and visual stimuli [19, 30-33] and with extraordinary sensory and motor performance in relation to the speed and power during kumite [34-37].

However, the level of efficiency gained from the analysis of major competitions (EC 25.23% and WC 29.10%) [4], draws to a conclusion that forcing such approach, without defense training, leads to losing the sense of kumite. Namely, in the competitions mentioned above, the lack of any registered action with frequent exchange of punches and blocks before the pointing techniques [4, 38] is an evidence of the possibility for the karate to lose its specialty if this trend continues. Actually, the analyzed combats look a lot like tennis matches where each competitor wins a point only on his serve and mostly by serving an ACE. With this approach, the kumite cannot develop into spontaneous movements and does not allow the richness of these ideas and techniques to be presented in its fullness.

Through this research, the additional aim was to emphasize the importance of the defense skills necessary to create completeness within the training process. The correct approach, the feeling of opening the opponent, effective distance, along with adequate timing of the initiative and a performance that fulfills the biomechanical requirements, are indicators that the athlete can control the kumite match. Thus, acquiring the necessary safety in kumite and complete penetration in the secrets of the kumite is unimaginable without perfecting the defense skills. It allowed the athletes to easily foil the opponents' intentions and to be "at their reach" in realization of their counter-attacks. During competition kumite matches, controlling the center of their own gravity and that of the opponent, along with the center of the arena, they demonstrated routine in keeping the effective distance. They performed their defense and counter-attacks under the right angle, timely and accurately incorporating everything in the rhythm of the opponent's movement. It can certainly be stated that the athletes were able to get enough conclusions from very little information and with their rational movements to always execute before the opponent, since the accuracy of the execution depends on the speed of the technique, the routine distancing and prompt reactions that were witnessing the variable automated technique in athletes [39-41]. On the other hand, the increased efficiency and stable time structure of the movements in athletes were a clear evidence that they understood very well what they were doing, confirming the fact that speed and other components of the moving execution go by the shortest possible way to the finish only through a clear mental image [42]. Also, the resistance to pressure and difficult situations during kumite, and the highly developed kinesthetic awareness to be able to feel the opponent [43], bear witness to the increased emotional stability of the athletes. Therefore, it can be noted that the activities in this research had a significant influence in all areas and generally over the improvement of the optimal performance.

8. Conclusion

It is especially important to be noted that in the individual treatment, the cybernetic approach (via the closed circle management) allows us to objectively evaluate our work and to effectively plan and implement the transformation process focused on the removal of the perceived deficiencies in athletes. The experience gained from this study confirmed us that thanks to the advanced training we can significantly influence the improvement of optimal performance in athletes. Namely, the awareness of the significant improvement of the defense skills contributed to increased self-confidence during kumite and was a basic prerequisite of good general efficiency during the training and competitions. Through longitudinal monitoring of the training and competition activities, via video analysis, it became clear that the eventual

shortcomings could be located very accurately and the correction process could be easily implemented.

The used approach, the testing methods and the training intervention during the research, gave clear and specific information about the method of addressing the individual needs of each athlete. Especially, the model of analyzing the unsuccessful responses and their inter-relation with the analyzed reaction times made it easier to locate the cause for them and gave the direction how to act with further interventions. Although the individual results of the athletes show better results in absolute values as against the group (as a result of few participants), the standard deviations have relatively big values. Thus, the statistical significance of these differences does not bring any hope in all the cases. As the working hypothesis was related to the significance of the individual training process with top athletes, after the implemented comparative analysis of the multiple performances by each participant separately, and within the given preparation stage, it can be concluded that the used training methodology stabilizes the temporal structure of the motion activities in all cases. Extremely important finding is the fact that the widely accepted methods of variation analysis based on control group, are a raw measurement in top athletes. It appeared that much more sensitive was the method where a specific competitor, statistically, is analyzed on individual basis.

It is believed that the text presented here can be helpful for professional teams in combat sports striving to optimize their everyday work and willing to open new perspectives of serious application of the combined method of mental and technical-tactical preparation in the individual training process. Next, besides the defense, it is recommended to include counter-attacks when measuring the efficiency and time of reaction in these types of researches.

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