

The efficiency of the process of forming the skill of performing *kin geri* kick

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Abstract

Background and Study Aim:

The technique *kin geri* is prohibited in competitions, but it is a basic and leading technique for teaching more complex kick techniques. The dynamics and biomechanics of the *kin geri* kick are very similar to those of the front kick *mae geri chusoku* and the roundhouse kicks *mawashi geri* at different levels of body parts: *gedan* (from the waist down, *chudan* (torso), *jodan* (head and neck). For example, to perform roundhouse kicks to the inner thigh *mawashi geri gedan*, it is only necessary to change a little but the trajectory of the kick toward the rival's leg. The aim of this study is model (based on experimental findings) of optimal conditions for improving the process of forming the skill of *kin geri* performance.

Materials and Methods:

The study involved 32 boys aged 8 years. The children and their parents were informed about all peculiarities of the research and gave consent to participate in the experiment. The modes of alternation of exercises and rest on the efficiency of the formation of motor skill *kin geri* kick in young karate athletes were studied. The following specific research methods were used to solve the tasks: study and analysis of scientific and methodological literature, pedagogical observation, and timing of educational tasks, pedagogical experiment, mathematical statistics, and mathematical planning of the experiment. The algorithmic order method was used in the learning process.

Results:

The obtained values of Fisher criterion (F) indicate the adequacy of the obtained mathematical models ($F_{diff} \leq F_{tabl}$): the first series (4 sets, rest interval 60–120 s); the second series (4 sets, rest interval 60 s); the third series (4 sets, rest interval 60 s); the fourth series (4 sets, rest interval 60–120 s); the fifth series (4 sets, rest interval 60–120 s); and the sixth series (4 sets, rest interval 60–120 s). The result of training depends on the number of sets by 87.8% in the first series, 52.8% in the second, 84.1% in the fourth, 83.8% in the fifth, 75.59% in the sixth. In the third series of exercises, the rest interval influenced the training outcome (56.4%).

Conclusion:

The use of a full factorial experiment allowed us to obtain mathematical models of the process of training the *kin geri* kick and to reveal the optimal modes of loading during mastering the technique. The developed methodology makes it possible to distribute the means of training and determine the target indicators that athletes need to achieve in the training process. This will reduce the period of mastering techniques in karate.

Keywords:

boys • karate • motor • physical exercises • skill • technique • training

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Motor – adjective relating to muscle activity, especially voluntary muscle activity, and the consequent body movements [39].

Self-defence – noun fighting techniques used for defending oneself against physical attack, especially unarmed combat techniques such as those used in many of the martial arts [39].

Skill – noun an ability to do perform an action well, acquired by training [39].

Motor skills – plural noun the ability of a person to make movements to achieve a goal, with stages including processing the information in the brain, transmitting neural signals and coordinating the relevant muscles to achieve the desired effect [39].

Performance – noun the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [39].

Technique – noun a way of performing an action [39].

Dan noun 1. One of the numbered black-belt levels of proficiency in martial arts such judo and taekwondo. Also called **dan grade 2.** Somebody who has achieved a dan [39].

Sambo – is a Russian martial art and combat sport. The word "SAMBO" is an acronym for **SAMozashchita Bez Oruzhiya**, which literally translates as "self-defence without weapons". Sambo is relatively modern since its development began in the early 1920s by the **Soviet Red Army** to improve their hand-to-hand combat abilities. It was intended to be a merger of the most effective techniques of other martial arts. The pioneers of Sambo were **Viktor Spiridonov** and **Vasili Oshchepkov**. Oshchepkov died in prison as a result of the **Great Purge** after being accused of being a Japanese

INTRODUCTION

The process of motor skills developing has been widely studied by scientists [1-3]. General patterns have been identified and the structure of motor skills training has been defined [4-6]. However, many issues require attention. For example, it is necessary to distinguish between the skills required at different stages of sports training. Higher-order skills at the stage of initial training and at the stage of sports improvement will be different [7-9]. This is especially important in the methodology of teaching martial arts, so to move to each next step, the young athletes demonstrate not only the new elements learned, but also all the previously trained techniques [10-12]. Simultaneously, the performance of the same element by a beginner or a more trained (senior belt) is evaluated differently. Accordingly, the task of the trainer is to determine when the young athlete has mastered the technical elements at the level of higher order skills for his degree of mastery (belt colour) and is ready to take the exam for a higher degree [13].

Insufficient attention is paid by some trainers to teach techniques that are considered easy to perform. For example, the *king geri* and *hiza geri* kicks. These techniques are included in many training programs in various martial arts and are recommended for mastery by leading experts in these fields: *gojuryu karate* [14], 'combat sambo' [15], 'hand-to-hand combat' [16], *kyokushinkai karate* [17], 'Combat Self-Defense ISO' [18].

The technique *king geri* is prohibited in competitions, but it is a basic and leading technique for teaching more complex kick techniques [20, 21]. The dynamics and biomechanics of the *kin geri* kick are very similar to those of the front kick *mae geri chusoku* and the *roundhouse* kicks *mawashi geri* at different levels of body parts *gedan* (from the waist down, *chudan* (torso), *jodan* (head and neck)). For example, to perform *roundhouse* kicks to the inner thigh *mawashi geri gedan*, it is only necessary to change a little but the trajectory of the kick toward the rival's leg.

Meanwhile, we have not found any scientifically based methodological developments on teaching *king geri*, this issue is of little interest to the research audience. Therefore, it is important and relevant for this study.

The aim of this study is model (based on experimental findings) of optimal conditions for improving the process of forming the skill of *kin geri* performance.

MATERIAL AND METHODS

Participants in the study

The study involved 32 boys aged 8 years. The children and their parents were informed about the features of the study and agreed to participate in the experiment.

Study design

The following research methods were used to solve the tasks: study and analysis of scientific and methodological literature, pedagogical observation, timing of educational tasks, pedagogical experiment, mathematical statistics, and mathematical planning of the experiment. The algorithmic instructions method was used in the training process.

The theoretical basis of the research was formed by the main provisions of the theory and methods of physical education [21, 2], sports training [7]. The methodological basis of the research was based on concepts and provisions on different aspects of training in *kyokushinkai karate*. Methodical approaches to teaching kicking technique in karate [22, 13, 23], scientific and methodological experience of teaching technique in other types of martial arts [24-26], and biomechanical analysis of kicking technique [27, 28] were studied.

Description and general principles of the kick technique. *King geri* is one of the first kicking techniques taught at the initial level. It can be

applied from the frontal stances of *yoi dachi*, *musubi dachi*, and *heisoku dachi*. It can also be performed from the left or right side stances *zenkutsu dachi*, *kumite dachi* and others with both the front and back legs.

The kick with leg extension is performed as follows: lifting the thigh of the right leg forward and upwards (the foot with the heel rises up to the buttock), bending the leg in the knee joint with a sudden movement, and kicking the target with the toe (foot lift). At the moment of impact, the supporting leg is slightly bent, the foot rests firmly on the floor, and the elbows are bent. During the final phase of the kick, tense the abdominal muscles and the front surface of the thigh as much as possible. After the kick is executed, the muscles immediately relax and the leg is lowered to the left-hand (right-hand) fighting stance. The synchronization of the thigh extension phase with the pelvic insertion increases the force of the attack.

It is important to maintain a stable balance at the last moment of the kick because the body weight is supported by only one leg. Maintaining balance is hampered by the kickback that occurs during the kick. To maintain a stable balance, you should use the muscles of the supporting leg to absorb the impact and keep your upper body almost perpendicular to the surface. The trajectory of the kick is directed from the bottom in a forward-upward direction.

You can kick with either the back foot or the front foot. The kick from the back foot is stronger because it has a longer acceleration trajectory. Its performance time is also longer, so the opponent can react and take defensive actions. To perform the technique with the front foot, you just need to slightly move your hip forward and “throw” your foot out at the target. Kicking with the front foot is more difficult, but it is extremely difficult for the opponent to react to it.

The striking surface can be the heel of the foot (*heisoku*) or the shin (*sune*). The kick is performed in 4 stages: raising the knee; extending the leg; bending the leg; returning the leg to the starting position.

The program of training in the technique of *kin geri* kick consisted of the following sequential series of training tasks.

The first series is exercised for developing motor skills.

- I. Development of flexibility and mobility in thigh, knee, and ankle joints. Starting position: a stand on the knees, knees hip-width apart, hands down; 1. Sit on your heels, keeping your knees together, and hold this position for 30s; 2. On exhaling, slowly lie down on your back, leaning on your forearms, hold the position for 30 s, muscles relaxed, and breathe with even and calm breathing; 3. Carefully and slowly, leaning on your hands, raise your torso to an upright position, and sit on your heels; 4. Starting position Repeat the exercise 5 times.
- II. Development of explosive power of leg muscles. Starting position: ‘*heisoku dachi*’ stand, feet together, hands on the waist; 1. Swing the knee forward and upward, touching the shoulder of the same side; 2. Starting position 3-4; do the same with the other leg; repeat the exercise 10 times.
- III. Development of static strength of legs, arms, and back muscles. Starting position: standing with the back to a gymnastic wall, gripping the left hand at the level of the chest, the right hand bent, and the elbow below. The feet are in ‘*musubi dachi*’ stance. Heels together, toes apart at an angle of 60° between the feet; 1. Raise the knee up and forward to the level of the waist. 2. Straighten the leg, forming a striking surface; keep the leg straight for 15 s, keeping the torso and right arm upright. 3. Bent the leg, perform a whip-like kicking movement. 4. Return the leg to the starting position. Do the same with your left leg. Repeat the exercise 2 times with each leg.

The second series – starting and ending positions. The ‘*heisoku dachi*’ stance: to perform this stance, you need to put your feet shoulder-width apart, feet parallel to each other, back straight, shoulders relaxed, and body weight in this position should be evenly distributed on both legs. This stance is used to practice kicks, allows you to control the rival’s technique, and serves as an intermediate stance for moving to other positions depending on the situation.

The *zenkutsu-dachi* stance is left-sided and right-sided. Feet apart, shoulder width apart, left foot forward; stance length is two shoulder widths.

spy. Oshchepkov spent several years living in Japan and training in **judo** under its founder **Jigoro Kano** [40].

Training load – “A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may become unclear whenever the quantitative factor is called ‘workload volume’ or ‘training volume’ interchangeably with ‘volume of physical activity’. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (...) As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as ‘*workload volume*’. (...) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of **training load** defined as the amount of workload. It is useful in analyses with a high level of generality. (...) In current research and training practice the product of effort duration and HR was referred to as conventional units’ or further calculations have been made to convert it into points.” [41, p. 238].

The feet are fully supported on the floor, the left foot is forward, and the right foot is at an angle 45° with the toes outward. The shin of the left foot is perpendicular to the floor, the knee is over the heel, and the right leg is straight. The torso is in a 45° position with the left shoulder forward, approximately 70% of the body weight is forward. Hands on the waist. The *zenkutsu-dachi* stance is performed from the *yoi dachi* stance [30].

The third series is actions without which it is impossible to perform the exercise.

To remove control over balance, understand and analyse the mechanics of the body, it is better to perform the phases of the strike while lying on the floor. Gradually perform the elements that make up the bio kinematic scheme of *kin geri* kick. It is necessary to control the formation of the striking surface – the rise of the foot *haisoku*. The strike is performed in four stages.

Starting position: lying on your back on the floor, legs bent, feet hip-width apart, arms along the torso, palms down; 1. Raising of the knee. 2; The extension of a leg. 3; Bending the leg; 4. Return the leg to the starting position. Repeat 10 times with each leg.

The fourth series is training the ability to control movements:

- I. Starting position: kneeling; 1. Arching of the back, head down, inhalation; 2. Bending of the back, the head rises up, exhalation.
- II. Starting position: lying on the back, legs bent at the knees, arms along the torso with palms down; 1. To raise the pelvis, supporting the palms, shoulders, and feet, inhale; 2. Return to the start position, exhale; the repeat 3-5 times.

The fifth series – separate parts of the target exercise and preparatory exercises:

- I. Starting position: stand on the left knee – the thigh of the left leg is perpendicular to the floor, and the right leg is bent and put forward on the toe so that its shin is parallel to the thigh of the left leg; the torso is upright; perform this stance by stepping the right foot forward or stepping the left foot back, and by extending the right foot forward from a kneeling stance; 1. Lift the right knee upwards, with

the shin and thigh as bent as possible (the 'bent leg' phase); 2. Quick whip-like extension of the leg and return of the shin back to the phase of 'bent leg', the toe is pulled back as much as possible, and the fingers are tense; 3. Starting position Repeat 10 times with each leg.

- II. Starting position: kneeling stand – hips are placed at an angle of 90° to the shins, which are on the floor; knees, heels, and toes are hip-width apart, and feet rest on the floor with the bottom of the foot just under the toes *chusoku*; 1. Bring the right knee quickly forward and upward, trying to touch the shoulder of the same name; 2. Starting position 3-4; do the same with the left leg; repeat 10 times.
- III. Starting position: as in exercise 2; 1. Extend the knee of the right leg forward and upwards, entering the phase of bent and active extension of the leg; 2. After fixing the leg bent, place it in front of you on the toe; 3. Starting position 4-6; do the same with the left leg; repeat 10 times.

The sixth series is the complete exercise: exercises are used to help develop the stable skill of performing *king geri*; the kick is performed under different conditions; during kick performance, pay attention that the striking limb does not stay in the phase of hip extension.

- I. From the stance *zenkutsu dachi* from the place with the leg standing behind in the air.
- II. The same with focus mitts.
- III. The same with a step forward. Perform all exercises 10 times with each leg.

The technique *king geri* performing was evaluated by a group of experts with the level of skill 'first dan' and above on a 10-point scale. Minor, significant, and gross errors were fixed. The values were subtracted from the total number of points.

Minor errors (0.1 points): 1. Breath-holding at the time of exercises; 2. A slight lean back of the torso from the vertical position before or during the technique performance; 3. The kick is not performed as a complete motor act, and pauses between stages are allowed; 4. A slight change in the trajectory of the striking links in the sagittal plane and in the height of the strike;

5. There is a slight excessive tension in the muscles of the trunk and arms.

Significant errors (0.2 points): 1. During the kick fixation, the body significantly leans backwards; 2. The shin is not sufficiently pressed to the thigh during knee raising and leg bending; 3. The foot is not tense during contact with the target; 4. Incorrect force distribution; 5. Errors made in the stances, which are the starting and ending positions during the kick, are allowed (weight distribution and body position do not meet the requirements for the stance); 6. The foot does not return to the starting position after the kick.

Gross errors (0.3 points): 1. The significant loss of balance; 2. The striking surface of the foot is not formed in a 'haisoku' manner; 3. Excessive knee extension of the kicking leg in the final phase of the kick can lead to joint hypertension; 4. The supporting leg is fully straightened or bent too much; 5. There is no synchronization of the hip extension phase with pelvic tension; 6. There was no whip-like extension of the leg in the knee joint.

To reveal optimal conditions of loading during mastering of a technique of performance of a forward kick *king geri* the influence of the following factors was studied: the number of sets (X_1) and rest intervals (X_2). The number of experiments necessary for drawing up a mathematical description of the studied process is determined by the following formula:

$$N = 2^k$$

Where: N is the total number of experiments of the plan and k is the number of factors.

In this case (k = 222), the participants were divided into four experimental groups (Table 1).

Note that when choosing the upper and lower levels of the factors, the limitations associated with the properties of the research object were considered. The boundary levels of the factors were chosen based on literature data [20, 22, 13]. Note that the age, gender, level of physical and technical preparedness of the respondents, and the time limit of the training session were also considered.

Statistical analysis

In this study, we used methods for analysing the results of mathematical planning of the FFE 2^k experiment [31, 32].

Methodological note regarding the presented results

Due to the use of a unique mathematical model, the 'Results' section contains sentences explaining some procedures and subsequent steps of calculations.

RESULTS

The data demonstrate the regression dependence of the studied value on the selected factors during the six stages of the motor skill formation *king geri* kick. According to the results of Cochran's criterion, the hypothesis of the homogeneity of experimental data dispersions is accepted ($G_{diff} < G_{table}$). The obtained values of Fisher criterion (F) indicate the adequacy of the obtained mathematical models ($F_{diff} \leq F_{table}$). The results of the analysis of the full factorial experiment (FFE 2^2 see Table 2).

To draw conclusions concerning the establishment of optimal conditions of loading during the motor skill formation (MSF) of *kin geri* kick performing, it is necessary to interpret the regression equation, analysing coefficients by their absolute value. The magnitude of the modulus

Table 1. Type 2^2 experiment planning matrix.

Code of experiment	X_1	X_2	$X_1 X_2$	Y
	the number of sets (NS) [times]	rest interval (RI) [s]	interaction of factors	value under study
1	– (2)	– (60)	+	Y_1
2	+ (4)	– (60)	–	Y_2
3	– (2)	+ (120)	–	Y_3
4	+ (4)	+ (120)	+	Y_4

Table 2. Results of full factorial experiment (FFE 2²) analysis.

Series of motor skill formation	Regression equation for coded variables	Percentage impact on the value under study		
		X ₁	X ₂	X ₁ X ₂
1	$Y = 8.902 + 0.502X_1$	87.8	9.8	2.4
2	$Y = 7.966 + 0.288X_1 - 0.269X_2$	52.8	46.1	1.1
3	$Y = 8.936 + 0.255X_1 - 0.292X_2$	42.9	56.4	0.7
4	$Y = 8.034 + 0.519X_1$	84.1	10.3	5.6
5	$Y = 8.623 + 0.573X_1 - 0.236X_2$	83.8	14.2	2.0
6	$Y = 9.373 + 0.358X_1 - 0.202X_2$	75.59	23.99	0.42

of the regression coefficient is used to evaluate the importance of this indicator solving the problem. Indicators with insignificant coefficients are not considered.

The first equation shows that in the first series of exercises for motor skills formation, the strongest influence is exerted by factor X₁ (NS). Because the coefficient is positive, the response increases with the level of the factor.

$$Y_1 = 8.902 + 0.502 (+1) = 9.404$$

The percentage impact on the studied value of Y₁ is significant and amounts to 87.8%. The factor X₂ had an insignificant coefficient; therefore, it was not included in the equation. The load volume of the first series of MSF can consist of 4 sets and a rest interval in the range of 60–120 s.

The second series of MSF is characterized by an additional manifestation of the action of the second factor X₂ (RI). Considering the signs of the coefficients of the two factors, we can see that the growth of the assessment of the performed action Y₂ occurs when using the first factor (NS) at the upper and the second factor (RI) at the lower levels. The importance of the influence of both factors is almost equal:

$$X_1 = 52.8\%, X_2 = 46.1\%; Y_2 = 7.966 + 0.288 (+1) - 0.269 (-1) = 8.523$$

As a result, during the training of stances helped to perform *king geri* kick, the load is 4 sets with

a rest interval of 60 s. Training in this mode, children are quite confident in mastering the starting and ending positions.

The regression equation obtained after the third training series shows that the influence of both factors remains, without considering their interaction. Since the coefficient at X₁ is positive, the response increases with the increase in this factor, i.e., the skill improves. The coefficient at X₂ is negative, which means that the response value will increase with a decrease in X₂.

$$Y_3 = 8.936 + 0.255 (+1) - 0.292 (-1) = 9.483$$

This mathematical model makes it possible to create the most favorable load conditions when training actions, without which it is impossible to perform a kick. These include the ratio of NS to RI within 4 sets and 60 s of rest. The contribution of factors X₁ and X₂ to the training result reached 42.9% and 56.4%, respectively.

Factor X₁ (NS) in the process of teaching the ability to control movements in the fourth series had a significant positive influence (84.1%) on the value of the dependent variable (technique assessment). At this stage of the developed program of educational tasks, the maximum effect of the studied value Y₄ was obtained from the following volume of exercises, consisting of 4 sets and rest intervals of 60–120s.

$$Y_4 = 8.034 + 0.519 (+1) = 8.553$$

In the fifth series of the program, factor X_1 (NS) has the highest absolute value, which indicates the importance of this indicator for mastering certain parts of the target exercise in the shortest possible time. The percentage of its influence is 83.8%. The contribution of factor X_2 to the MSF result is 14.2%.

$$Y_5 = 8.623 + 0.573 (+1) - 0.236 (-1) = 9.432$$

In the last two series of training, the calculated values of response functions (Y_5, Y_6), considering the coded variables obtained in the fourth experiment (with the mode of work “4s/120s”), are close to the value of the second experiment in which children showed better results (mode of work “4s/60s”). Therefore, the rest interval, in our opinion, can vary in the range of 60–120 s between sets. The number of sets is 4.

Processing of the obtained results after the sixth series shows that the level of mastering the exercise $Y X_1$ (NS) 75.59% X_2 (RI) 23.99%; $Y_6 = 9.373 + 0.358 (+1) - 0.202 (-1) = 9.933$

The coordination difficulty in the kick training program gradually increased and reached its maximum in the fifth and sixth series. To achieve better training results, we recommend keeping the load within the suggested limits.

The use of a full factorial experiment allowed us to obtain mathematical models of the process of training *king geri* kick and to identify the optimal modes of loading during mastering the technique: 1 series (4 sets, rest interval 60–120 s); 2 series (4 sets, rest interval 60 s); 3 series (4 sets, rest interval 60 s); 4 series (4 sets, rest interval 60–120 s); 5 series (4 sets, rest interval 60–120 s); 6 series (4 sets, rest interval 60–120 s).

DISCUSSION

In accordance with the results of the full factor study, the most effective modes of work during the formation of the skill of performing the *king geri* kick have been identified, which will contribute to the optimal organization of the training load. Conducting training without considering data on the impact of the modes used on the body of junior schoolchildren significantly reduces the effectiveness of training young karate athletes and their further achievements in sports activities.

The program for mastering kicking techniques in kyokushinkai karate developed by Marchenko and Kovalenko [19], Marchenko and Taranenko [20], Minenko and Marchenko [29], Litvin and Marchenko [30], and others have been supplemented. The peculiarities of teaching *king geri* kick are revealed. The distribution of the kick execution by phases is performed. A set of physical exercises aimed at mastering *king geri* kick is structured, and the order of their execution is determined in accordance with the tasks provided by the training series.

The obtained results extend the data of Ivashchenko et al. [31], Ivashchenko [21], Marchenko and Taranenko [20] on the rationality of using FFE 2^k plans in training the peculiarities of motor skills formation in primary schoolchildren. This is confirmed by the data of Garcia-Moya et al. [33], Iermakov et al. [34], Marchenko et al. [23] on the possibility of using factorial experimental designs in studies involving children and adolescents. Collins et al. [35] emphasise that a factorial experiment can have excellent statistical power even if few subjects participate in each experimental condition. The use of fractional factorial experiments allows researchers to further investigate important assumptions at the refinement stage [36].

Howard and Jacobs [37] draw attention to the predominant use of a single method in training evaluation studies. This leads to a tendency to analyse the effectiveness of the completely integrated training rather than individual elements or identifiable components of the curriculum. This often overlooks factors that could make the training more effective. A comprehensive evaluation makes it possible to identify individual training elements and develop optimal programs.

The data obtained confirm the information about the effectiveness of algorithmic instructions in the motor skills formation in young martial arts athletes [22, 23]. Knowledge about the coherence of different elements of the structure of training in martial arts is supplemented to achieve coherence between them. The factors that make up the training system vary and influence the results [38].

New data were obtained. The developed research program made it possible to determine the regularities of the development of children abilities to

perform motor actions, to build a phased system of teaching physical exercises in kyokushinkai karate, to promote preparation for the use of the studied *king geri* kicking technique as an element for more complex foot techniques, and to obtain models of the training process of karateka.

Because of the implementation of the research program, the factor plans for studying the influence of alternating modes of physical exercises and rest on the effectiveness of the development of motor skills and the effectiveness of training young karate athletes to meet certification requirements were substantiated.

CONCLUSIONS

The result of training depends on the number of sets by 87.8% in the first series, 52.8% in the second, 84.1% in the fourth, 83.8% in the fifth, 75.59% in the sixth. In the third series of exercises, the rest interval influenced the training outcome (56.4%).

The developed methodology makes it possible to distribute the means of training and determine the target indicators that athletes need to achieve in the training process. This will reduce the period of mastering techniques in karate.

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