

Professional paper

AN ANALYSIS OF LEG TECHNIQUES IN KARATE

UDK 796.853.26.012.424(049.32)

Radomir Mudrić¹

College of Sports and Health, Belgrade, Serbia

Miloš Mudrić

Faculty of Sports and Physical Education, University of Belgrade, Serbia

Velizar Ranković

Master of karate at 5 Dan

Abstract: Karate is today practiced in three forms: as a sports discipline, as a skill of self-defense and in the form of recreation and health. Regardless of the forms of practice, their place and roles, the leg techniques which are executed are very significant. Today karate is primarily a modern sports event in which strikes dominate and where leg techniques influence the scoring system (points made by the leg strikes and kicks are larger than those made by the arms). The paper has carried out an analysis of leg techniques which are presented from several aspects, as well as from methodical aspects with short methodological instructions which are significant in training. Also, there is a short analysis of the muscle structure, with a review of all the significant and relevant muscle groups which take part in the strikes. Also, the technical elements which are significant in executing and applying the leg techniques are defined. The techniques are presented as structural elements of the assault itself, with time dimensions and the processes describing them. This significant work segment affirms the scientific and research approach to the issue of karate, as well as martial arts in general and it is presented with the results of research in this area. The techniques are also illustrated with adequate pictures – drawings, diagrams and accompanying tables.

Keywords: *karate, methodology of training, structure, time dimension research work*

¹ ✉ radomir.mudric@vss.edu.rs

INTRODUCTION

Until the beginning of the 20th century, karate was considered a self-defense skill and was carried out in secrecy as a martial art originating from Japan from as far back as the 16th century. Due to some Okinawa-based masters from the Far East and Japan, primarily Anko Itosu² and Anko Azatou³, also a teacher and the first reformer of karate Gichin Funakoshi⁴, karate was introduced into the educational system of Okinawa, which put a stop to the long-time, secretive practicing of this skill. Namely, in medieval, feudal Japan, all martial arts were learned and practiced mostly in secrecy. This situation of covert practicing was especially carried out in the 17th century, with an imperial decree in Japan and the official decision about banning practice for the “ordinary” people. This ban of carrying arms and learning martial arts occurred at a time of period of peace lasting a long time during the dynasty of Tokugawa shogunte (1600-1868). This was a thriving period in Japan in every regard (cultural, military and other areas of life), as well as the development of martial arts.

With the appearance of Gichin Funakoshi, karate moved from Okinawa to continental Japan. This teacher carried out the reform of karate which started the transformation of mere self-defense skills into a sports discipline. The measures which in that sense were taken up consisted of the following:

- Cutback of techniques (all the techniques which could cause grave injuries or death were left out of the training program),
- Revision of katas (starting from the change of the kata names, with the translating of the Chinese meaning to Japanese letters, as well as introducing new katas in the training system),
- Changes of contents and training methods (thus far the method of a traditional approach to training was known and was reflected in long-term hard work with constant, numerous repetitions of the learned technique. The new concept of learning and training took into consideration the facts that karate was practiced as a school subject in schools all over Japan, with different age categories and within a limited time duration),
- Ranking players according to belts (after judo, karate also introduced the system of following and assessing the achieved level of knowledge via the kyu/dan system⁵) and
- Introducing competitions.

² Anko Itosu (1831 - 1915), a karate expert from Okinawa, considered to be the father of karate by many, as in 1905 he introduced karate into the school system of Okinawa.

³ Anko Azato (1827 – 1906), one of the most renowned karate teachers of his time in Okinawa.

⁴ Gichin Funakoshi (1871-1957), a great Okinawa karate master, known as the creator of sport karate.

⁵ This system of belts, starting from the white beginner one, via the yellow, orange, green, blue and pre-master brown belt, to the highest master one, the black belt and ranks in that position, was established and created by the creator of judo Kanō Jigorō (1860-1938).

Thanks to these changes, in the 50ties of the last century the first tournaments started, which definitively initiated the transformation of the traditional form of exercising in sports karate.

The karate techniques which are applied in sport martial arts those carried out by the arms or hands as well as leg or foot techniques which are very attractive and have very quickly and successfully affirmed karate as a new sports event all over the world.

In the contemporary world today, sports karate, that is, the training, learning, practicing and applying of techniques in fights or carrying out katas is carried out according to contemporary sports principles of the training system (process), which is also valid for other contemporary sports events. Also, there is an increasing inflow of science by implementing the results of scientific research, via scientific and research projects which consider karate training, education and techniques from several aspects, structural, functional, informational, energetic, biomechanical, biochemical, methodical, educational, the training aspect, etc.

1. THEORETICAL WORK BASIS

Karate has plenty of different techniques which are executed with the arms and the legs. Some of these techniques, which Funakoshi marked as dangerous, nevertheless found their place among the dominant training model by practicing katas.

Today karate is practiced in three most significant forms, such as:

- a sports event
- a skill of self-defense
- a health and recreational form.

Karate as a contemporary sport event is today the most dominant form of exercising based on the principles of karate federations, and enables the practitioners (competitors) to express themselves in various events, two of which are the most represented:

- a) sports contests (teams and individual in their own categories and as absolute categories)
- b) competitions in katas (individual and team).

Some of the international karate federations also have their own specific competitions: demonstrations of breaking hard objects, displays of arranged sparring (some type of arranged contest in situationally complex conditions), competitions between the handicapped, etc.

With the appearing of sport karate, the executed leg techniques have attained an increasing significance. This in particular relates to the federations which with the very system of refereeing favor these techniques, giving them

a larger number of points than the techniques carried out by the arms or hands⁶. This was done in order for the sport of karate to gain in attractiveness and interest and to attract as many spectators as possible, as there is a noticeable decline of visitations to large competitions. However, there were results of researches of some large world championships, whereupon there was a follow-up of the parameters of technical and tactical features of the karatekas as well as the parameters which speak of the representations and correlation in which the arm and leg techniques appear and that, regardless of this additional “stimulus,” leg techniques seem to be executed less than the arm ones (Gužvica, M. 2000., Mudrić, R. 1999., Vučenović, B. 1998). Thus, the results of these research papers show that the most represented techniques continue to be those which are carried out by the arms (yjaku zuki and kizami zuki), in a range between 89% and 94%. This is not an accident as it is known that arm strikes are more natural movements than leg kicks, as well as that they are easier to control, last shorter, and thus they are more difficult to prevent and block, which sufficiently explains their greater representation.

When we reflect on leg techniques, it should be known that they are carried out from a greater distance (often extended), they are realized on a longer path, they have a decreased precision, and they are easier to “recognize” due to compensatory movements which are made prior to and following the execution, and also, they are more risky during balancing and harder to control in the final stage of execution.

One explanation for this significant phenomenon lies in the very methodology of training and unchanged methodical contents which are executed in the sport of karate as well as in the fixed methodology of the training itself, which has to a large extent remained linked with the methodology of training and coaching, which in turn corresponds to the traditional approach and correlation.

1.1. Systematization of karate techniques

Karate techniques which are learned and applied in practice can be divided into the following:

- Stances
- Movements
- Strikes
- Blocks
- Cleaning

⁶ An example of this is the largest World Karate Federation (WKF) which in its rulebook of contesting and refereing allowed the scoring system between the foot and hand techniques to be 3:1, in favor of executed leg techniques.

Foot kick techniques are divided depending on the following criteria:

1. direction of execution
2. form of execution line
3. striking surface

According to the first criterion, the strikes are divided into the following:

- strikes towards the front (*Mai geri koshi* – with the top part of the ball of the foot, *Mae kakato geri* – with the heel, *Mae hiza geri* – with the knee)
- back kicks (*Ushiro geri* – with the heel or the ball of the foot, *Ushiro mawashi geri* – with the heel or the ball of the foot)
- side snap kick (*Yoko geri keage* – with the side of the foot; a kick with a “jerk” from the knee and a kick to the side with “inserting” the hip into the kick)
- kick downwards (a kick with the side of the foot - *Fumikomi geri*).

According to the second criterion, strikes are divided into the following:

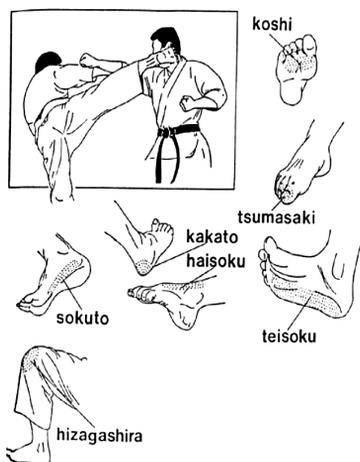
- front kick with the front leg (direct: *Mae geri koshi* – with the top of the ball of the foot, *Mae kakato geri* – with the heel, *Mae hiza geri* – with the knee, *Ushiro geri* – with the heel or the ball of the foot);
- roundhouse kick (spin kick: *Mawashi geri* – with the ball of the foot or the upper part of the foot).

According to the criterion of the striking surface, we mention striking surfaces such as the following (Fig. 1):

- the top of the ball (*Mae geri koshi*)
- the flat side of the foot (external)
- the upper side of the foot
- the toes
- the knee
- the heel
- the toes.

A special feature of the foot techniques is the striking surface which helps to make contact with the target. Such as the case with the hand, thus also with the foot, which represents from all sides a large striking surface (the toes, the ball, the part of the ball under the toes, the arch of the foot, the bottom of the foot and the heel) and this is also the case with the knee. Each of the striking surfaces is distinctive for one of the techniques and it is specially formed in order to be successfully “thrust at” the opponent. Forming the striking surfaces requests good coordination and mobility of toes, joints, feet and ankle and sometimes demands a special exercise. It is especially relevant to firm up the foot in the ankle part to avoid any possible injuries, as well as to make the kick more efficient.

Figure 1. Surfaces which make contact with the target



1.1.1. Stances

Stances belong to the group of the most significant technical elements in karate and have multiple significance for an efficient execution of defense and offense techniques as without them there are no executed and applied techniques, either with the hand or the foot.

Stances are static positions defined more or less by an appropriate position of the body, the arms and feet from which all actions of defense and offenses start and are used according to the aim and techniques which can be executed from them (Mudrić, R. and associates, 2004).

A stance in karate indicates a specific position of the body which is defined by the following elements:

- the position of the feet (the distance, the angle of the expanded axis)
- the correlations of the foot segments
- the position of the projection of the brunt of the body in comparison with the area of the support
- the position of the hips, the torso and the shoulders.

Only in the so-called optimal karate stance can techniques be manifested efficiently and such a stance must meet the following criteria (Jovanović, S. and associates, 1989):

- stability (balance)
- mobility
- optimal anatomical and biomechanical conditions for displaying maximal muscle forces.

1.1.2. Movements

Movements are techniques which serve to reach the most optimal, but also the most dominant position in relation to the opponent. All movements can be divided into defense, assault, and maneuver movements according to the basic aim or demands for their application and realization.

Defining movement as a special element of karate techniques, whether this involves basic training or in the application of a combination of karate techniques as well as sports contest is not easy, considering that movement represents an integral part of a technique. In the wider sense of the word, when we speak about technique, we speak about “movement activities” and “movement.” It is impossible to imagine the practical application of any technique of assault and defense without a specifically improved movement technique, which is achieved by special karate training. Such a movement is “interwoven” into the assault and defense technique and gives them a special motor recognizability and specific nature, in comparison with other motor skills. Thus the technique of movement implies “the part of quality of technical ability which enables the maintaining of an optimal distance, avoiding the opponent’s attack and an efficient execution of appropriate assault techniques” (Jovanović, S. 1992). Also, movement can be defined as a “change of the position of the body in space which is carried out with a certain aim” (Mudrić, R. 2004).

In practice, there is the occurrence that practitioners did not dedicate sufficient attention to movement. This ensued from a deficiency to review the real function of movement (especially in preparing for the very realization of some technique). Thus, very frequently there are irrational movements and hops which, mildly put, can be denoted as “pro forma” movements or an execution of movements which ensued from copying the movements of the more successful competitors. On the other hand, a series of conducted studies of the time dimensions of the assaults have shown that movement is the basic generator of the quality of the assault technique and that it to the largest extent explains the variability of the time dimensions of the assault in karate (Mudrić, R. 1994).

The ability for “rational” movement is acquired by long-term training, which primarily implies the improving of the ability to take up an optimally preparation stance, an adequate function of the supporting and the leading foot, as well as perfecting the appropriate physical abilities (especially explosive strength, elasticity and coordination). The external picture of “rational” movement is shown through the sliding of the feet along the surface, as well as a maintaining of an approximate vertical position during the movement. The basic principle of maintaining movement in any direction is based on causing (producing) the force of the reaction of a hard surface by the quadriceps of the supporting foot (Jovanović, S. 1992).

“The demand for a horizontal path of the brunt of the body during all types of movements (and as little as possible fluctuating of the brunt in the vertical direction) can be taken as the most representative criterion for determining the rationality of movement” (Jovanović, S., Ćirković, Z. 1992).

Movements can be divided according to the following:

- forwards movement
- backward movement
- sideways movement
- rotational movement

There are many known movements which are used in karate and they are mostly determined by the character of the applied technique. Thus, it can be said that blocks are mainly efficiently executed by backwards movements (step, backward sliding, rotational movement around a protruding foot, etc.), while nearly all forward movements (sliding, double step, step, combined movements) are efficiently used along with the execution of the technique in assaults (strikes which are carried out with the feet or hands).

Movements in sports karate are adapted to the demands of the finals and thus they are also different from the so-called “classical ones.” This type of movement, according to the way of realization, is similar to the movements which are executed in boxing (a highly raised brunt, support on the toes). They are depicted by the following: hopping forwards, backwards and sideways (moving diagonally backward or forward), a frequent change of guard, softness of movement, as well as movement by hopping laterally. These movements, according to some authors, have been systematized into several modalities: hops, jump – leap, leap - hop – jump (Gužvica, M. 2000).

2. LEG TECHNIQUES

Techniques which are carried out by the legs or the feet are the real depiction of karate and make this type of martial art especially attractive. Roughly, they can be divided into strikes and blocks which are carried out by the legs.

Even though these techniques are very attractive, the success of their application depends on several factors: the level of training (it is, of course, implied, that the ethnical level is the first, then the level of preparedness for execution in the sense of joint mobility, elasticity, agility, the strength of the leg muscles, as well as the stomach and the back muscles), the assessment of distance, coordination, stability of the balancing position, especially in the moments when the practitioner is on one leg, where the surface of the support is only on the ball of the standing leg, but also in the moment of realizing contact of the foot with the target.

2.1. Strikes executed with the feet

All strike techniques, whether they are those which are carried out with the hands or the feet, can be defined as “moving structures of a differing complexity which are executed with the aim of destroying the opponent” (Mudrić, R. 2004). The level of destruction depends on the specific application of the technique. Thus, in a sports contest there is a symbolical destruction which is conditioned by the rules of refereeing, while in some typical situations of executing security affairs (policing), the strike techniques are executed with the aim of a part or, ultimately, a total destruction as the last option, caused by the specific nature of the situation during the use of authority.

Leg strikes can be spectacular, especially today in modern sports karate, where these techniques have found their rightful place.

The first leg techniques were natural movements which could be carried out easily, and these are a foot kick (Mae geri) and back thrust kick (Ushiro geri). Created later on were the semicircular strikes in which the attacker swings with the front of the leg or foot strike (Mawashi geri). Only with the appearance of sports karate were there attractive leg techniques such as the circular strike with the heel (or the ball of the foot) backwards, the spinning heel kick (Ushiro mawashi geri), and the semicircular strike with the heel or the hook kick (Ura mawashi geri).

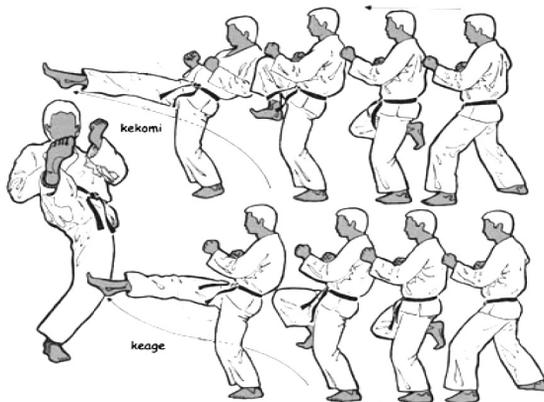
According to the method of execution, leg techniques are carried out in two ways, as strikes called a snap kick when the knee of the kicking leg is pointed at the target (keage) and as strikes that are thrust kicks (kekomi). Such an execution is applied with several techniques, such as the following: Mae geri, Joko geri, Mawashi geri and even some specific variants of the back kick - Ushiro geri. Both variants of execution are shown via the direct forward leg strike Mae geri (Fig. 2).

The basic difference in carrying out the mentioned techniques consists of a thrust of the pelvis and carrying over that thrust to the muscle groups according to the open end of the kinetic chain, from the position of a raised knee. The height to which the knee can be raised is known as a position of the knee in a preparation position for executing the technique - Hiki ashi. It must be noted that the height or the position of the knee in the preparation position (hiki ashi) is in the strike direction, and that the maximally bent knee in the knee joint is one of the requirements for the size of the muscle force which can be displayed. Of course, the corner which tilts the knee with the direction of execution is of a vital importance for displaying the strength of the strike.

The height of the raised knee is also decisive for the height of the realization of the strike technique. The higher the position of the knee, the higher is the strike which is to be carried out at the “imposed” and appropriate height, and it is never under the level of the knee position. Thus,

the starting position for carrying out the technique should correspond to the set demands.

Figure 2. *Mae geri kekomi and Mae geri keage*



2.2. Methodical review with a muscle analysis of the leg strike technique

Even though the leg techniques are from the methodological aspect processed in detail in the available literature, all the same, by improving the regulations of the contest and refereeing as well as the demands of the sports contest, a form of practicing karate today, and also perfecting the desired or aimed effects (results) in training various target groups, there is always a problem of training and the model of the practice, as well as the model of education, open and current. Every one of the mentioned elements has its clearly defined aims and tasks whose solving depends on the disposable time for training (the time framework within which the training should be realized), the disposable training means, age and education groups and profile of practitioners, etc. Of course, the solutions should also be sought in permanent improvement and education a training staff, as well as in the demands for improving and innovating the methodical contents of training.

Namely, the scientific and expert public, which is present in karate and has had a significant effect especially in the last 30 years, recognizes the mentioned problems and gives its opinions and specific solutions. It can be said that today the theoretical support of practice prevails. However, in the practicing public, it seems that there is not enough feeling or support for the efforts invested for the prosperity of karate generally speaking, and not just like a contemporary sports discipline.

One of the accepted models of training, recognized by these three forms such as: basic, directed and situational training also has its defined

aims from which ensue the training tasks. Each of these segments demands a special methodological treatment with the methodological contents adapted to all three forms of training. The methodology of training of the same technique will be different if it is carried out on the following: recreational exercises, competition orientated practitioners, practitioners interested in the traditional (self-defense) approach, practitioners of various specialist courses starting from security guards, to operational coaches in a sports contest, students of coaching colleges or universities, members of various police specialized security services, army members, etc. The aims and desired training results differ for all the mentioned structures of practitioners. According to this, various methodological forms and contents will be applied with adapted and specialized training means.

The most rational choice of methods (Mudrić, R. and associates 2004):

- Method of verbal emission of information
- Synthetic method
- Analytical method
- Combined method
- Iterative method
- Method of transferring to other signal systems
- Ideomotor method
- Methods for developing CNS
- Methods for developing strength
- Methods for developing speed
- Methods for developing endurance
- Methods for developing agility
- Methods for developing suppleness

2.2.1. Direct kick and forward kick - Mae geri

The strike, like already noted, can be carried out in two ways: with a “snap” from the knee - Mae geri keage, and a “snap” from the hip - Mae geri kekomi (Fig. 2). Mae geri keage is carried out at a short distance (accessible for that leg technique) and can be efficient if applied to the body or even the head of the opponent (chin). Kekomi is a long strike forwards and it is carried out from an extended distance. It is the most efficient if applied to the body of the opponent.

A specific striking surface (the ball of the foot underneath the toes) demands a special position of the feet in relation to the calf (the foot is “broken up” in the ankle and almost extended in comparison to the calf) in order for the strike not to be carried out with the entire ball of the foot.

The technique is most often applied in a karate stance (Fudo dachi), with the arms in a middle guard position. At the moment of striking, the

standing leg is on the floor with its entire surface and it is bent in the knee, while the body is insignificantly bent towards the leg executing the strike.

It must be noted that this very attractive and efficient technique is not represented enough in contemporary sports karate and almost not even applied. The reason for this is primarily in the specific movement in contemporary sports contests, but also a diagonal contest applied by the opponents, which narrows down the surface of the body upon which the strike can be executed.

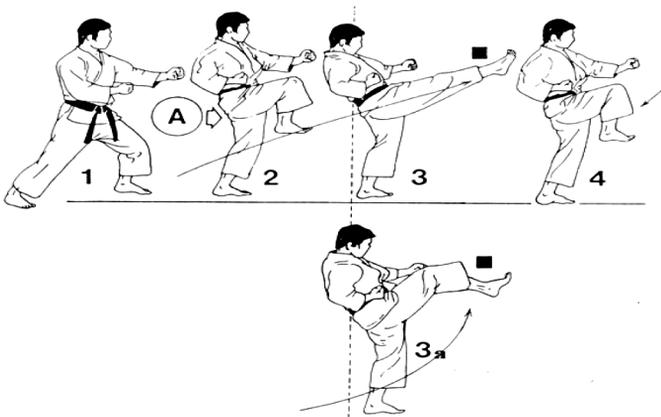
As the principle of conveying the amount of movement is very significant for carrying out the technique, it will be explained in detail here.

The starting position for carrying out a strike is the stance (Fudo dachi - Fig. 3, no. 1). From this position, the leg in the back stance (the one executing the strike) with a speedy contracting of the ankle triceps (m. triceps surae; m. plantaris; m. tibialis posterior; m. peroneus longus) and the knee (m. quadriceps femoris), leads to the elementary position (hiki ashi), for further realization. The most active in this movement are the triceps in the hip joint (m. iliopsoas; m. tensor fasciae latae; m. sartorius; m. rectus femoris; m. pectineus; m. adductor longus; m. adductor brevis) and the knee (m. biceps femoris; m. semitendinosus; m. semimembranosus; m. sartorius; m. gracilis; m. popliteus; m. plantaris). This movement transfers the body weight to the kicking (now bearing) leg (Fig. 3, nos. 2 and 3). Also, at the same time that the foot of the standing leg moves, it leads to the side which enables the thrusting of the pelvis forwards with the hips, anatomically thrust in the direction of the execution of the technique. This leg movement is carried out with the lower ankle with the "help" of compensatory movements in the hip and the knee joints, which are in a mild flexion. These movements of twisting with abduction and with leading have in the lower ankle a movement amplitude of 15°, that is, 25° (a total of 40° - Opavsky, P. 1976).

The bearing leg maintains a bent position in all joints with which it prevents the oscillating of the brunt of the body in a vertical direction, and at the same time it creates a prerequisite for pushing from the surface during the strike (this position of the standing leg is enabled by the following: m. rectus abdominis; m. vastus medialis; m. vastus lateralis; m. rectus femoris; m. tensor fasciae latae). The knee of this leg extends the movement forwards for the maintaining of the starting impulse (strike). This movement is followed by an appropriate "swaying" of the pelvis (nutation of the pelvis). With the abrupt stopping of the movement of the knee and the pelvis there is strong support created for the strike of the leg forwards. Using this support and the created strike, from the position of a raised knee, the effect of the quadriceps of the joint of the right leg (m. quadriceps femoris), there is

a thrusting of the calf of this leg forward and directing the top of the toe against the opponent's body (m. extensor hallucis longus). At the same time, with the extension of the leg there is also a compensatory flexing of the torso forwards and retreating of the arms on the hips. At the moment of the strike, the isometric contracting of all muscles in the kinetic chain enables a maximum transmission of the force of the strike, as well as fixing those joints closest to the striking surface (Fig. 1 - koshi). Immediately after the impact, depending on the target, intention or the following activity, the feet and knee can return to the hiki ashia position, be lowered to the initial stance or take up a new one.

Figure 3. Technique shown in characteristic stages of performance



2.2.2. Roundhouse kick - Mawashi geri

The roundhouse or spin kick is executed mostly at targets directly in front or on the side of the executor. The kick is usually directed towards the areas of the head, the neck, the stomach or the sides of the body.

The area for executing the kick is the part of the ball of the foot underneath the toes (or the sole), which should be turned upward at the moment of the kick (towards the upper side of the foot) in order for the striking surface to be formed successfully. This striking surface is known as the “koshi” and it has a great penetrating power (Fig. 1). It is mostly executed towards the body of the opponent, from either side. The striking surface which is applied in executing this strike can also be the arch of the foot (over the toes) and it is known under the name “kubi.” During the forming of this striking surface, it is necessary for the foot with the toes to be stretched out and in an “extension” from the calf and the ankle (Fig. 1). The path of the strike is an arched flicking out from the body and towards

the target, in any form of execution, and does not depend on the choice of striking surface. Of course, an arched path of the feet is conditioned by the starting position for executing this strike (*hiki ashi*) when the foot which executed this strike is bent completely at the knee (a position from which great force can be executed), and beside the body (from the side). The calf is, as much as possible, bent towards the thigh so that the knee is in a higher position than the foot (Fig. 4). A characteristic moment in the training of this technique is a rotation of the feet of the standing leg (already described in the previous technique), during its movement towards the target (Fig. 4, no. 3). The rotation of the foot of the standing leg is exceptionally significant as only in this way can the striking surface be struck. Every unfinished, insufficient or in any way disabled rotation of the foot (foot movement blocking) does not permit an efficient executing of the technique and increases the possibility of injury (especially the knee joint in the area of the meniscus, but the ligaments as well). Injuries are inevitable, as blocking the movement of the feet in the knee joint of the standing leg leads to a simultaneous executing of two movements: extension and rotation. In comparison, in this way (this strike can be compared with a volley strike in football) there are injuries of the meniscus and ligaments in football players.

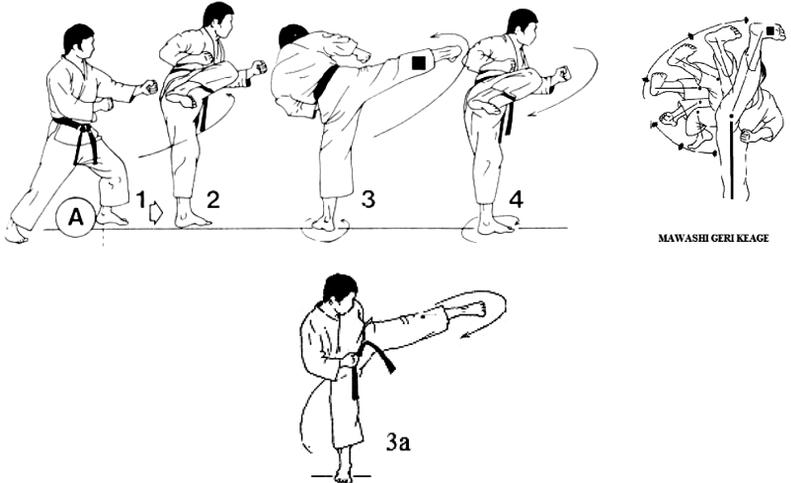
During the executing of a movement, the arms are in a guard position, and among other things, they also have a function of maintaining the body's balance (Fig. 4). The body follows the executing of movements and the position of the body is conditioned by the way of executing the technique, the height of throwing out the striking surface, as well as the demands which are set for the executor (if the body takes up a position towards the leg which is executing the strike, forwards or more or less straight).

Executing the semicircular strike (*Mawashi geri*) from the fight stance (Fig. 4):

- The elementary position is the stance with the arms in the position of a middle guard (Fig. 4, no. 1).
- The leg which executes the strike is on the side beside the body (abductio in the hip joint - *m. gluteus maximus*; *m. gluteus medius*; *m. gluteus minimus*; *m. piriformis*; *m. tensor fasciae latae*) and with a flexion in the knee joint. The arms are in a guard position, the body somewhat bent towards the leg executing the strike. The foot with the formed striking surface is in a somewhat lower position than the knee (Fig. 4, no. 2).
- A semicircular movement forwards (extension in the knee joint - *m. quadriceps femoris*), initiates the leg movement, along with a simultaneous rotating of the standing leg or foot (Fig. 4, no. 3). When the knee of the leg executing the strike is found near the imaginary, horizontal line of execution (forwards), its movement is

blocked, which enables the calf movement which flicks out the foot with the striking surface towards the target

Figure 4. *Mawashi geri – phase execution*



2.2.3. Side thrust kick - Yoko geri

Previous practice has shown that the side thrust kick, whether this is a thrust from the knee or the hip, is very hard to understand and adopt due to the complexity of movement, complex coordination, a weak mobility of the hip, knee and ankle joints, a poor leg flexibility, a weak strength of the stomach and leg muscles — adductors and abductors) (Fig. 5, nos. 2, 3, 4).

The “striking surface” is represented by the ball of the foot (the sole of the leg (Fig. 1).

Unlike the “snap from the knee” strike, which is somewhat more natural, yoko geri kekomi demands a very complex coordination of body movements, of the arms and the legs, especially the leg which is being extended and executes the strike. The leg is at the same time extending and rotating, so that in all three joints (the hip, the knee and the ankle) there are strong and complex movements, and thus a great concentration and attention is needed during the execution to prevent injury. The standing leg is slightly bent in the knee, the foot follows the leg movement, rotating in the opposite direction from the one of the strike. The body and head are directed towards the direction of the “striking” leg. The arms are in the “guard” position.

Executing the technique (Fig. 5):

1. Elementary position: taken up is a stance with the arms in a guard position.

2. Lifting the legs in the elementary for carrying out the technique. Taken up is the position in which the leg with the knee and the foot is lifted in a position for executing strikes (*hiki ashi*).
3. Executing the strike on the side (m. quadriceps femoris; m. gluteus medius). Rotation of the torso (m. latissimus dorsi; m.obliquus abdominis internus; m. obliquus abdominis externus; m. transversus abdominis). The standing leg actively takes part in the movement (extension in the knee joint; m.quadriceps femoris; m. gastrocnemius; m. soleus), with a foot rotation in the field (the foot movement has already been analyzed).
4. Returning the leg the same way backwards (bringing in the knee joint adductio: m. gluteus maximus; m. adductor magnus; m. adductor longus; m.adductor brevis; m. adductor minimus; m.pectineus; m.gracilis; m. iliopsoas; m. biceps femoris; m. semitendinosus; m.semimembranosus).

Figure 5. Direct side thrust kick - *Yoko geri*



2.2.4. Back kick (with the heel) - *Ushiro geri*

All the principles which are exclusive for executing the feet technique are very significant for the back kick as well, for several reasons: the kick is executed in an unfavorable position backwards when it is very hard to maintain a balance, and previously a proper position must be taken with the eyes towards the target, which is often not feasible due to the speed of executing the strike, and the kick must be executed very precisely or there may be a possibility for an efficient counterstrike (due to the fact that after the executed strike it is very hard to return to a “safe” position from which there can be an adequate reaction, while the standing leg cannot be maximally extended in the knee joint at the moment of executing the strike due to a larger stability in the one-legged stance; also, in order to contract the necessary muscles, there must be a unity of the upper and lower body, as without a synergy of the entire body there is no strong and efficient strike, and the strike must be executed directly backwards by a straight

line, as in the contrary the target can be easy to miss (then the strike gains an undesired semicircular path from which an imprecision of execution can ensue).

In the final stage of movement, the leg is maximally extended in the knee joint and can be found in the “extension” of the hips and the body. The body and the leg are lined up and via the hip joint constitute a line. The foot with the toes is bent towards the calf which enables flicking out the striking surface (the heel) towards the target (Fig. 6).

Executing the strike from the stance of feet brought together (Fig. 6):

1. Elementary position — the stance of feet brought together with the arms beside the body.
2. The leg which executes the strike is raised in an elementary position, bent in the knee and towards the chest (a position similar with the forward leg strikes).
3. With the flicking out of the leg backwards, that is, the thigh of the standing leg, the execution of the strike is initiated. Already in this stage, the foot with the calf forms such a position which enables the flicking out of the striking surface (dorsal flexion: *m. extensor hallucis longus*, *m. peroneus*, *m. tibialis anterior*, etc.).

In the final stage of the movement, the leg is extended in the knee and can be found in the extension of the body (*m. quadriceps femoris*, *m. gluteus medius*, *m. gluteus maximus*). The rotation of the body was enabled by the following: *m. latisimus dorsi*, *m. trapezius*, *m. obliquus abdominis externus*. A maximal contraction of the thigh muscles enables a larger strength of the strike. The standing leg is standing on the surface with its entire surface, and the muscles which actively take part are the following: *m. rectus femoris*, *m. gastrocnemius*, *m. soleus*; in a passive form also *m. vastus lateralis*. The arms are beside and in front of the body and have the function of maintaining balance (*m. trapezius*, *m. deltoideus*). The eyes are directed towards the target of executing the strike. After the executed strike, the leg returns to the elementary position in front of the body or in the desired direction.

The strike can be executed in the area of the stomach, the solar plexus, the genitalia and the groin area, as well as the calf. Avoided are direct and high strikes in the area of the head as they are quite risky. Very often they are executed in a combination with other leg kicks. The strike is most often executed from a fighting stance by turning around the front, standing leg, where special attention should be paid to the rotation of the foot of the standing leg and bringing the body into a position for executing the technique (the muscles which execute the rotation of the hip externally: *m. gluteus minimus*, *m. iliopsoas*, *m. gluteus maximus*, *m. gluteus medius*, *m. piriformis*, *m. obturatorius internus* (Fig. 7).

Figure 6. Direct back kick - *Ushiro geri*

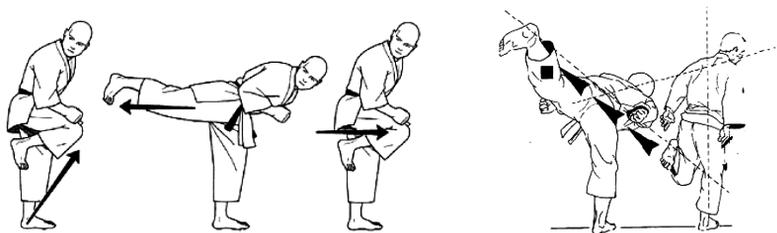
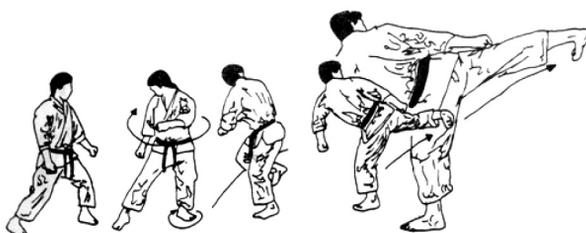


Figure 7. Back kick (with the heel) – *Ushiro geri*



2.3. Time parameters of karate kick techniques

The lasting time of karate technique was the subject of research papers as early on as the 80ties of the past century (Jovanović, S. 1981, 1988, 1992; Zulić, M., Milošević, M. 1988; 1989; Arlov, D. 1993; Milošević, M., Jovanović, S., Ćirković, Z. 1993; Mudrić, R. 1994, 1999; Milošević, M., Mudrić, R., Mudrić, M. 2012; Mudrić, M. 2015). The obtained results of this research have enabled a better planning and realizing of the training process in karate.

By researching the time dimensions of karate techniques, for the first time were obtained results which have practically demystified the possibilities of karate experts. The obtained results shows that karate experts in all levels, from beginners to masters, are merely “ordinary” people, some with exceptional motor abilities and others with average qualities.

A special problem of research of this kind were not ideas. The largest problem was for the visions of the measuring instruments to be realized (created), as no measuring instrument existed anywhere in the world until then (Jovanović, S. 1988). Of course, what helped was new information technology, enabling the mechanical parts of the entire measuring system (the metal construction from the original solutions of the striking surfaces, tensiometric platforms, etc.), to be skillfully linked with the computerized

parts of the equipment which enabled reaching relevant results measured in milliseconds via a certain measuring procedure.

The measuring of time parameters of the basic techniques was carried out with the help of contact tensio platforms which were linked by a computer into a unique system which enabled registering and memorizing relevant times (Mudrić, R. 1994). Research helped to isolate the **partial and integral** times of karate techniques. The obtained results enabled the explaining and defining of the assault in later research papers, as the most significant element of contemporary sports karate (Mudrić, R. 1999). The obtained results showed that the configuration of partial and integral time of assault changes depends on the situational complexity of the assault as well as from the type of applied technique.

The time parameters of karate techniques can be divided into integral and partial, depending on whether they define an integral or a partial realization of simple or complex structures, with the accompanying processes.

The integral time parameters represent a sum of partial time parameters, and they are measured by the total of lasting of the applied technique in the assault, from the giving of a certain signal for initiating an assault to the ending of the assault.

Partial time parameters represent a time realization of certain structure segments or groups of segments, and they are assessed by measuring the time from the start to the end of each segment.

The way of assessing the partial time parameters can be direct (cinematographic analysis) or indirect (removing the time of lasting of certain segments from the total measured times).

“The time parameters of an attack represent a time measurement of planning and realization, the structure and its segments of a diverse complexity, as well as the accompanying processes” (Mudrić, R. 1999). In the given research treated were the karate techniques which are most often executed in karate, whether individual or in combination with other techniques. From the kick techniques, analyzed were the following: a direct back kick, Mae geri and a semicircular foot kick, Mavashi geri.

This research project produced results which explained some techniques from the aspect of integral and partial time which in turn can be defined via the planning time (introductory programming) of the movement and the time of the motor realization of the technique. The obtained partial times, especially the planning time, is exceptionally significant, whose deciding factor is primarily the efficiency of the executed technique. The partial planning time practically explains the time from the moment of recognizing the optimal moment⁷ for bringing decisions about the execution of a certain

⁷ In the conducted research process (Mudrić, R.1999) this part began with giving a light signal (by way of a light indicator) by tapping on a computer keyboard.

technique, to bringing decisions about including the relevant muscle groups which are responsible for initiating the movement. In the biomechanical sense of the word, the movement starts with the adductors of the ankle and knee joints. The motor realization of the movement represents the continuation of the initiated movement and its execution to the realizing of contact with the target.

After the analysis of the correlation between the partial and integral time in different types of assaults, the following has been concluded:

- Partial time planning parameters in a situation of an unconditional⁸ executing (application) of technique have insignificantly different values, depending on whether the assault is carried out with the arms or hands or the legs or feet. However, it has also been concluded that the process of planning the assault, regardless whether this involves an assault with the arms or legs, in average amounts to around 30%, and the time of the realization of the attack is 70% of the integral time of attack.
- Partial time planning parameters, in a situation of an elective assault⁹ also have different values, depending on whether the attack is executed with the arms or legs, and the average time for this kind of attack amounts to around 38% of the total time of attack.

It must be noted that this involves the partial time obtained as a product of analysis and resolving complex information processes which speak only about the initiating of the movement. In the majority of cases, this involves techniques which last too little (around 300 milliseconds) which enables gaining feedback information on a proprioceptive level. However, what is the most significant fact and it is linked with the extracted time with processes which describe them, is the possibility to shorten the time of processing by a special training method, that is, to speed up the information processing processes. In this way, it is possible to increase the number of unknowns which can be processed. The international unit for these processes is a bit/sec.

The descriptive indicators of the lasting time of these leg techniques in situations of unconditional and optional reacting are shown in Table 1.

⁸ In the conducted research process (Mudrić, R.1999) this part began with giving a light signal (by way of a light indicator) by tapping on a computer keyboard.

⁹ “An elective assault” is a complex situation in which the respondent before the execution (application) of the technique knew only which technique to execute, according to the obtained signal - the signaling system switched on four light indicators arranged on four different places which symbolized certain parts of the “opponent’s” body (two striking surfaces of a square shape set one next to another or beside a sack hung at a certain height – see the measuring procedure in Mudrić, R. 1999).

Table 1. Descriptive indicators of leg techniques (Mudrić, 1999)

No.	Varijable	Mean	Std. Dev.	Min.	Max.	% Var.	Ske.	Kur.
Registered times of mae geri and mavashi geri leg techniques in an unconditional assault.								
1.	MGSILV (planning time for mae geri in an unconditional assault)	271.373	65.657	186	591	24.194	2.346	7.685
2.	MGSIVP (movement realization time)	593.333	92.447	302	906	15.581	.835	2.782
3.	MGSIUVP (total movement time)	864.794	104.018	644	1268	12.028	1.148	2.209
4.	MWGSILV (planning time of mavashi geri in an unconditional assault)	292.745	78.666	189	720	26.872	2.241	8.005
5.	MWGSIVP (movement realization time)	693.402	101.669	275	989	14.662	-.508	4.151
6.	MWGSIUVP (total movement time)	986.147	100.573	553	1285	10.199	-.261	3.145
Registered times of mae geri and mavashi geri leg techniques in an elective assault.								
1.	MGS4LV (planning time for mae geri in an elective assault)	403.833	105.795	216	705	26.198	.719	.081
2.	MGS4VP (movement realization time)	619.922	85.735	425	875	13.83	.421	1.043
3.	MGS4UVP (total movement time)	1023.755	131.152	781	1554	12.811	1.154	2.751
4.	MWGS4LV (planning time of mavashi geri in an unconditional assault)	406.843	103.524	240	672	25.446	.491	-.401
5.	MWGS4VP (movement realization time)	668.294	112.689	316	879	16.862	-.588	.724
6.	MWGS4UVP (total movement time)	1075.137	117.72	683	1468	10.949	-.002	1.212

By comparing the obtained results of the research at various levels of complexity, it can be concluded that the average values of the executed karate techniques are different. Namely, there is a longer lasting of the techniques executed in more complex situational conditions.

Partial time planning parameters, in a situation of an elective assault in average amount to around 37% of the integral time, while the realization of the assault in the same situations amount to about 63% of the total time. By comparing the assault with the arms and the legs, it can be concluded that the partial time planning parameters of assault which are carried out with the arms amount to 35.9% of the total time, while with the leg assaults, this time is 38.5% (Mudrić, R. 1999). This is another indicator why arm techniques continue to be applied in sports contests (the degree of complexity is smaller), regardless of the score favoring of leg techniques.

2.4. Karate leg techniques as structural elements in an assault

All karate techniques which are executed in defense and assault can be defined as “movable structures¹⁰ of a different complexity which are carried out with a certain aim” (Mudrić, R. 1999). Each of these movable structures build up integral segments and they are represented by stances, movements, cleaning and strikes (Diagrams 1 and 1a).

Diagram 1. *Segments of a one-off assault with the reverse foot*

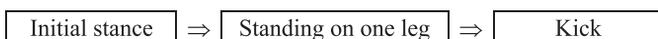
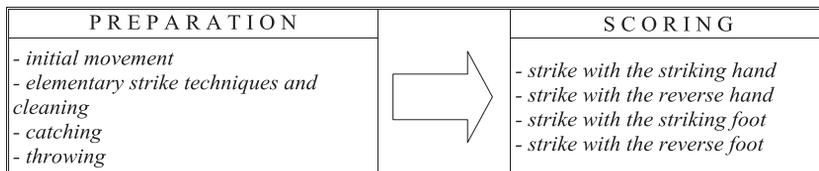


Diagram 1a. *Segments of a one-off assault with the kicking foot*



An assault as an integral motor activity, conditionally speaking, consists of two stages: the stage of preparation and the stage of scoring, and in practical situations – the final stage (Diagram 2).

Diagram 2. *General model of assault*



The number of segments which build up such an assault can differ, depending on the biomechanical complexity and external conditions in which they are realized, that is, they depend on the type of stances, movements, strikes and cleansing, as well as the distance and time within which the given frame can be realized.

The links between the segments can be different. With one type of this assault (basic linear), made up of two two or more segments, the assigned realization of every attack segment is given in advance. There is only one possibility for its realization, which means that the next segment cannot begin until the previous one has finished. With such assault constructions, the schedule of carrying out the segments does not depend on the external conditions (the situational complexity), but is realized according to a previously

¹⁰ According to the Vujaklija Dictionary: structure (Lat. structura), mode of building, construction, or organization; arrangement of parts, elements or constituents; a complex system considered from the point of view of the whole rather than of any single part construction; structuralism.

defined schedule and within a programmed time. The characteristic of this structure of assault is that the attacks last for a short time, most often up to 300 milliseconds or longer, and that it is not possible to establish control over their realization based on the visual and proprioceptive feedback.

Such assault structures are applied in situations of carrying out a direct attack with a previously planned segment structure. The number of segments depends on the distance from which the assault is carried out, the expected behavior of the opponent, the assessment of his or her abilities as well as their technical qualities.

The other type of assault (basic branched), is made up of four or more segments which can be realized once at the most, although there are segments which can remain unrealized. In this kind of structure, there must be at least one condition for branching (a deviation from the assigned), which in the total structure also exists as a segment. This modality of structure assault is characteristic for situations when a particular kind of reaction by the opponent is provoked (forced), after which a previously planned structural composition is realized.

In relation to the previously described structure, this type of assault has a greater complexity due to a longer lasting time of the segment in which, among other things, there is an analysis of the disrupting of the initiated assault carried out.

The third kind of assault structure (basic cyclical) are those structure in which one or more segments can be realized more than once. This type is structured in such a way that it is most often made up of two basic line structures, with one conditional segment. The number of repetitions of one or more segments depends on the meeting of the external conditions.

This type of assault structure is typical for sports as well as real-practical situations. It is usually present in the conflict between the equal qualities of the opponent, who has the ability of recognizing a large number of assaults (Mudrić, R. 1999).

Regardless of the type of structure, every structural segment is realized within a certain time interval.

Assault structures can be divided into simple and complex, depending on the number of decisions and compositions of segments during the realization of the current assault structure.

The basic characteristic of the simple structure is that there is only a one-time decision at the beginning of the realization.

The basic feature of a complex structure is that it consists of several simple structures and that the decisions about their further realization are brought several times.

With both types of structures, the following processes precede the initiating of the realization: recognizing the given signal (in a real situation,

this is some sort of sign which “uncovers” the opponent, a specific movement which precedes the assault); comparing the given signal which should be realized; a choice of the given structure and giving the order for a realization, including the necessary muscles which are responsible for initiating movement.

All these processes can be called thus: **Processes of introductory programming or planning an assault.**

These processes of planning or programming have their time of duration and differ according to the fact whether the assault was carried out with the arms or the legs. According to the research results (Mudrić, R. 1999), the time separated for these processes amounts to a total of 30% of the total time. Also, the obtained results speak of the fact that the processes which are responsible for the leg assaults are somewhat more complex than those planned to be realized by the arms.

With complex assault structures, the decisions on branching¹¹ precede the following processes: analysis of technical and tactical tasks; perception of disruptions; problem analysis; muting the realization of the initiated structure; choice of appropriate branches which continue with the realization; and the reprogramming of the realization of the initiated structure. These processes, due to the specific character of the impact on the total realization of the assault, can be called as follows: **Processes of reorganization or reprogramming of assault.**

Along with the processes which are called processes of programming and reorganization of assault, there are also processes which follow the time of realization of the simple as well as complex assault structures: the realization of intensity and lasting of excitation of motor units; control of a number and types of motor units; control of the speed of motor units; control of the change of the speed of generating force; analysis of appearance of assault; analysis of logical connecting of structure; analyses of situation certainty (uncertainty) of assault realization. Considering the need for a definition, these processes can be marked as such: **Processes of the motor realization of an assault.**

The processes of assault realization take part in the total time with 70%. Here too it was shown that the more complex processes are those which are linked to the realization of the assault executed by the feet or legs.

¹¹ Branching is an expression which implies that at some moment, due to a variety of reasons, some disruption occurred for the realization of the anticipated assault, and thus the continuation of the action need to be restructured and some other alternatives have to be looked at (or other ways). Bringing decisions for such actions requires that at that moment (which should be as short as possible) there is an observing and processing of the new situation and the most efficient decisions are brought. The progression of the new situations demands a certain time period. The shorter the time, the better the efficiency will be. The speed of processing the information is measured by an international measurement unit: bit/sec.

IN LIEU OF A CONCLUSION

Leg techniques are a representative of karate in a specific way with their attractive character, which is expressly reflected in their execution and application, and they contribute to the vast difference between karate and other martial arts. These techniques play a significant role in all forms of practicing karate today. In contemporary sport karate, where the contest is mostly led by the assault, unlike before, in the defense and counterattack, these techniques become decisive factors in the victory of any competitor.

However, even though leg strikes are quite prominent in contests and they have greater value and number of points in comparison with the arm techniques, they are nevertheless represented much less. This is confirmed by the results of a large number of research papers on the topic of the technical and tactical features of competitions in the sport of karate. The problem is expressed in unchanged methodical contents and work forms in a stereotypical training, still based on traditional principles. Also, the results of scientific research, especially those involving time parameters of karate techniques and the processes describing them, clearly point to the fact that arm techniques, techniques of a lesser complexity, last longer and thus are also more secure for executing and application.

But regardless of the obvious problems which are expressed in sport karate, leg techniques will continue to be the focus of experts in this area, primarily from the methodical aspect, and then via the training technology. Largely contributing to this is the education of the training staff, but also further scientific research in this area, with results which will be able to be implemented in karate practice in an adequate manner.

REFERENCES

1. Arlov, D. (1993). *Modelovanje osnovnih tehnika karatea realizovanih iz dijagonalnih i linijskih stavova na bazi njihovih vremenskih parametara*. Beograd: Fakultet fizičke kulture. Magistarska teza.
2. Gužvica, M. (2000). *Tehničko-taktičke karakteristike težinskih kategorija u jugoslovenskom karateu*. Beograd: Fakultet fizičke kulture. Magistarski rad.
3. Jovanović, S. (1981). *Rezultati ispitivanja specifičnih brzinskih sposobnosti karate sportista*, Beograd: Fizička kultura (br. 4).
4. Jovanović, S. (1988). *Uticaj osnovnih psihomotornih faktora na ispoljavanje specifičnih sposobnosti karate sportista za rešavanje simuliranih tipičnih zadataka sportske borbe*. Beograd: Fakultet fizičke kulture. Doktorska disertacija.

5. Jovanović, S. (1992). *Karate - teorijska polazišta*. Novi Sad: Sports World.
6. Jovanović, S., Bačanac, Lj., Mudrić, R. (1989). *Uticaj nekih psiholoških karakteristika karate vežbača na usvajanje određenih tehnika i njihovu primenu u uslovima sportske borbe*, Beograd: Fizička kultura (br. 5)
7. Jovanović, S., Ćirković, Z. (1992). *Borenja Boks – Karate*. Beograd: Fakultet fizičke kulture.
8. Jovanović, S., Milošević, M. (1992). *Istraživanje vremenske strukture tehnika presretanja, odbrane i kontranapada*, Beograd: Fizička kultura (br. 3-4)
9. Milošević, M., Mudrić, R., Mudrić, M. (2012). The biomechanical analysis of the karate kick (mae geri) in the function of defining educational training aims and methods, Beograd: *Sport – Science & Practice* (Vol. 2, No.4)
10. Milošević, M., Zulić, M. (1988). *Strukturalni model brzina karate tehnika*. Beograd: 13 Maj, br. 6.
11. Mudrić, M. (2015). *Brzina reagovanja vrhunskih karatista različite specijalizacije merena korišćenjem savremene video tehnologije*. Beograd: Fakultet sporta i fizičkog vaspitanja. Doktorska disertacija.
12. Mudrić, R. (1994). *Uticaj motoričkih faktora na objašnjenje modela složenih struktura napada u karateu*. Beograd: Fakultet fizičkog vaspitanja. Magistarski rad.
13. Mudrić, R. (1999). *Varijabilitet vremenskih parametara napada u karateu*. Beograd: Fakultet fizičke kulture. Doktorska disertacija.
14. Mudrić, R., Milošević, M., Jovanović, S. (2004). *Napad u karateu edukacija i trening*. Monografija. Zemun: Viša škola unutrašnjih poslova.
15. Opavsky, P. (1976). *Osnovi biomehanike*. Beograd: Naučna knjiga
16. Vučenović, B. (1998). *Analiza načina poentiranja u modernom karate sportu*, Beograd: Fakultet fizičke kulture. Diplomski rad.

Other sources:

1. http://decisooclinica.com/?page_id=2251 - za mae geri, joko i mavaši
2. <http://www.csvaran.ro/arteMartiale/pagina-practicantului/kihon/lovituri-de-picior-2-za-mavaši>
3. <http://okinawaclubkarate.altervista.org/okinew/index.php/lo-stile-shotokan/le-tecniche/le-gambe.html>
4. <http://karatetechnic.blogspot.rs/2014/01/geri-keage-yoko-geri-keage.html>
5. http://sistema.bushidoryu.com/arte/bases_ataques.asp - USHIRO GERI
6. <http://www.vokabular.org/> - vujaklija