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CINEMATIC ANALYSIS OF THE KICKING LEG VELOCITY AND ITS POSITION DURING PERFORMANCE OF THE MAWASHI GERI TECHNIC ON TARGET

Fadil Rexhepi¹, Shemsedin Vehapi^{2*}, Fatmir Pireva², Besim Gashi²

¹University of Tetova, Department of Physical Culture and Sport, MACEDONIA

²AAB College, Faculty for Physical Culture and Sport, KOSOVO

ABSTRACT

In this study is analyzed the kicking leg velocity and its position during performance of the technique by mawashi geri on target. The technique is performed by seven athletes with a maximal engagement on target. The target is fixed at a 1,8m height from the floor. All athletes are of male gender, with solid experience in karate sports and are black belt carriers. The analyzed results reflect the velocity of the kicking leg, including the knee and hip angles for both lower limbs. The maximal kicking leg velocity is 13.97 (m / s) and this is achieved before the target is kicked, or 76.74% of the movement trajectory. The angle on knee at the moment of the peak velocity is 118.14 °, while at the kicking moment; the angle achieves a value of 163 °. The hip angle of the kicking leg is smaller during the peak velocity 112.71 °, while at the moment of kicking the angle achieves the value of 108.42 °. On the supporting leg the knee angle value is almost the same with the moment of the peak velocity and the kicking moment (about 155). Meanwhile, the angle on hip joint of the supporting foot at the moment of the peak velocity is 125 °, respectively 122 °. The obtained results indicate an attempt to reduce the velocity just before the kicking and at the moment of kicking target, which probably presents practice achieved during the training process. The supporting leg takes angles that responding to the balance maintenance, while the kicking leg tends to be more stretched on knee in order to empty all its energy.

INTRODUCTION

The spread of martial arts is stretched out almost all over the world. A good part of these skills is involved in more sports, arranged according to rules and sports ethics. Karate as part of this large family is mainly based on foot and hands hitting, but with strict restrictions for health reasons. Karate, like any other sport recently is developed rapidly as a result of the training process perfection based on a scientific basis. This sport has a great range of kicking leg techniques, including the mawashi geri technique, with its variants. In this sport victory depends from their correct usage. Karate competition has two types of major manifestations, which have their own characteristics. One of them is an imaginary war (Kata) and the other is real war called (Kumite) [1].

All techniques must be implemented in accordance with the rules of the sport. Conditions of kicking realization depend on the athlete's intent and circumstances in which are realized, example: if the kick is realized by contact or without contact, if the kick is realized in the demonstration form without opponent's reaction, or if the kick is realized after opponent's reaction? It is understandable that under different circumstances and conditions mentioned, depends the change of the karate athlete's engagement in order to achieve the most effective kick [2-3]. Leg-kick techniques are achieved with a whole body engagement and with an appropriate position maintaining a balanced attitude. As is known, leg kicks have the advantage, because are several times more powerful than hand hitting and with less risk from the opponent's reaction. For these reasons, special attention is paid to regular and efficient leg kicking training. Among the leg kicking techniques is also the mawashi geri technique with its variants which in many fights (tournaments) defines victory. Numerous variants and the possibilities to be realized from different positions and in surprising moments for opponent, have caused high level attendance of the mawashi geri technique [4, 5, 6].

The leg kicking in karate sport is a segmented stereotype and is realized in all three spatial system spheres. Significant factors during the leg's performing technique are: the kicking velocity with maximal explosive force and the foot's movement in an appropriate trajectory.

The kicking successful evaluation is partly made with the coaches and experts eye. But accurate evaluation of body's movement and karate athlete's limbs can be done with the help of the kinematic analysis systems and other biomechanical equipment. Such analyzes, as in any other sport, are made in laboratory conditions, and are hardly realized in situational conditions [7]. The kinetic and kinematical characteristics analysis of mawashi geri technique has proved that this kick has advantages comparing with many other techniques.

Correct determination of biomechanical indicators such as leg's trajectory movement, hand or gravity centre of the athlete's body, their velocity and accelerations, enables coaches to correct mistakes during the performance of the technique. From these information is scheduled the training process with all its elements, in order to increase the technique's motor skills and performance.

During the kicking performance, the foot must have high velocity which is convertible to the maximum kinetic energy. Performing effect of the technique in question depends on the movement of the attacking

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*Corresponding Author

Email:

shemsedin.vehapi@aab-edu.net

Tel.: +37744250982

leg, as well as by the support of the supporting leg which at the kicking moment tends to rest (due to the movement amount), but maintaining stability with the corresponding muscle contraction.

Comparing the data found from more studies, is seen that studies are more focused on the description of the athlete's movement by explaining the kicking part details, but also the description of the supporting leg position, including the technique comparison between different styles [8]. In addition, researchers have analyzed foot's velocity and other leg segments during the kicking, for different conditions, for ex. leg's ankle velocity just before contact with the very close distance, or moreover, kicking comparison between dominant leg and the other leg etc. [9, 10, 11, 12].

Ariel Performance Analysis System. Ariel Dynamics [1994] in their study had a purpose of analyzing the kicking kinematic variables with traditional karate-style under attacking conditions on target and without stroke. Eight professional karate athletes with brown and black belt are taken for analysis. They have performed three kicks with and without contact on both sides, which then are analyzed in software Skill spector 1.3.2. Study results concluded that kicks by contact performed with dominant limbs have higher velocity values; however non-contact kicks have better angle conditions for the attacking technique. So, it is suggested that contact kicks have precedence in sports karate training and they are used more in comparison to non-contact kicks.

The performing conditions of mawashi geri technique vary constantly. They depend on many factors, among others are: attacking situation or repelling, and its target or position ect. Taking in consideration these conditions, the study purpose is to determine the kinematic indicators of the athlete's leg position and the kicking velocity during the performance of the mawashi geri technique on target with full contact.

MATERIALS AND METHODS

The performance of the kicking technique by mawashi geri leg is made by 7 men karate athlete's of different categories. All of them are from Kosovo, with a high level of the technique mastery (karate master) and have achieved solid results during their career. The athlete kicks the target with maximum engagement, accurate and as fast as possible. The target is fixed at a 1.8m height from the floor.

Measured body sizes are the height and body mass. Kinematic variables are extracted with the help of Kinematic Analysis System [14]. The indicators in question can be termed as variables of kicking leg position and the athlete's man supporting leg that demonstrates (performs) technique, the kicking velocity and the realization time of the technique.

The leg's position variables are the angles in: the hip joint of the attacking leg, the knee joint of the attacking leg, the hip joint of the supporting leg and the knee joint of the supporting leg. The velocity and time variables are: the maximal linear velocity of the attacking leg (foot) before the kicking, trajectory duration of the leg hitting movement until the maximal velocity achievement, the trajectory duration of the kicking leg (foot) until achieving the target.

The material was filmed with the help of three cameras placed at optimal angles to each other. The frequency of the cameras is 60 frames per second. They are fixed on an appropriate trolleys and vibration is eliminated. Previously is made recording of calibration frame with sizes (200cm x 200cm x 200cm) which is under the eyepiece of three cameras together with a reference point.

All further phases are made according to the performance of the Kinematical Analysis System (APAS), drawing the necessary values of the kinematic indicators.

Based on the purpose and objectives of the study, the basic statistical methods are selected in order to enable the extraction of sufficient information.

RESULTS AND DISCUSSION

During performance of the mawashi geri kicking on target, are achieved different values between the karate's athletes, but the results are as a product of body size, respectively different body lengths. These are applied for both phases during the kicking, even for the preparatory phase when the foot is still on the floor and during flight phase, when the foot starts its journey. The structure of the attacking leg movement of this technique is that the leg's velocity starts from the hip, transmitted on gristle, and finally passed on to the foot in the kicking form. In [Table 1] are presented data for two main dimensions of the athletes' body.

Table 1: Body height (ALT) and body mass (AMT) values for karate's athletes

Body mass	TORI (N=7)							Mean
	T.G.	A.K.	A.M.	A.B.	J.H.	A.H.	A.B.	
ALT (cm)	167	165	175	170	173	184	180	173,42
AMT (kg)	55	62	64	68	73	75	80	68,14

Realization of the mawashi geri technique on the target is made with strong muscle engagement and with great amplitude of movement. Such movements are enabled by achieving optimal angles in the main joints during this movement, such as the knee joint and the hip joint.

[Table 2] presents the knee joint and the hip joint values at the moment of the peak velocity and the kicking moment. The change of angle's value in the two analyzed joints of the kicking leg is given in [Fig. 1].

The angles values according to joints depend also on the karate's athlete body size and his technical and motor skills (especially flexibility). The highest angle point at the knee joint is achieved during the kicking moment (163°), which means that while target is kicked the knee tended to be stretched as much as possible. The value of 118.14° in the knee joint is reached at the moment of the foot's maximal velocity, followed by hip joint value (112.71°) during the maximal velocity and finally during kicking the target the value is (108.42°). During the performance of the mawashi geri kicking on target are reached different values between the karate athletes, as a result of their body size and the length of the lower limbs. These angle values differ greatly to each other on the knee joint of the kicking leg at the moment of maximal velocity (S.D. = 25.23°). Surely these changes are as result of different style of the performing technique but as well as a different karate athletes body sizes.

Table 2: The hip joint and knee kicking leg angles and karate athletes supporting leg angle during the performance of mawashi geri technique on target

Angles on joints (°)	Kicking leg		Supporting leg	
	Mean	St. deviation	Mean	St. deviation
Knee joint (max. velocity.)	118,14	25,23	155,42	11,68
Knee joint (kicking moment)	163,00	14,09	155,71	9,48
Hip joint (max. velocity)	112,71	8,95	125,00	11,93
Hip joint (kicking moment)	108,42	17,36	122,42	14,71

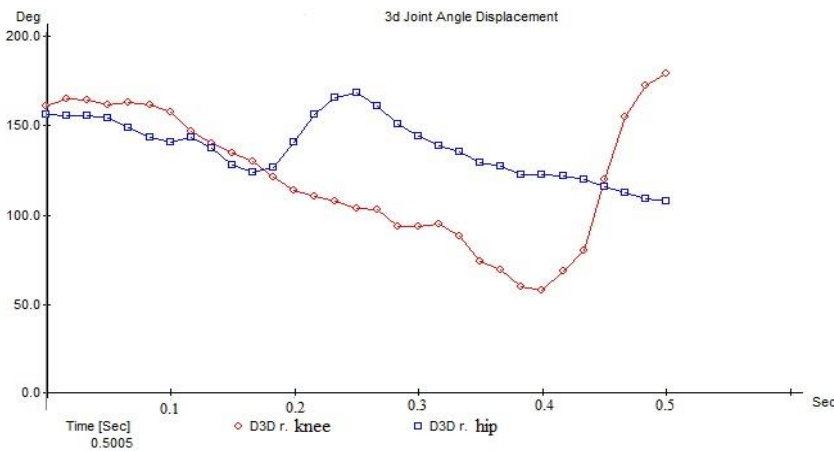


Fig. 1: The joint angle displacement on the knee joint and on the hip joint of the kicking leg (right leg), during the performance of the mawashi geri technique on target (subject J.H.).

The supporting leg is positioned so that the athlete maintains the balance from the beginning of the kicking realization, during the kicking moment, until the leg is released on ground. In [Table 2] are given the knee and hip joint values at the moment of reaching foot's maximal velocity and at the kicking moment. During the performance of the mawashi geri kick on target, as a result of their body size, respectively of the lower limbs length, are reached different values between the karate athletes. Approximately identical angles values of the supporting leg are reached on the knee joint during the maximal velocity of the foot's movement and during the target kicking (about 155°). The mirror of arithmetic middle values for all athletes shows that the biggest angle is reached in the knee joint and this is almost equivalent with the kicking moment and with the foot's maximal velocity moment of the kicking leg (155°). Also on the hip joint, the angle values are approximately the same for both analyzed moments, 125° during the maximal velocity of the leg's kicking foot, respectively 122° during kicking the target. This value gives the impression that during the kicking on target, knee supporting leg is slightly bent. The value displacement of the angle, on knee joint and on the ankle joint is shown in [Fig. 2].

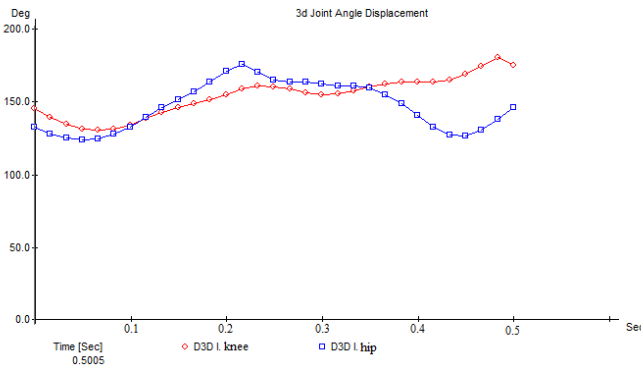


Fig. 2: Joint angle displacement on knee joint and on the hip joint of the supporting leg (left foot), during the performance of the mawashi geri technique on target (subject J.H.).

The foot's maximal linear velocity of the kicking leg, achieving time of foot's maximal velocity and the time to implement the mawashi geri technique up to kicking are shown in [Table 3]. These values are quite heterogeneous depending on the karate athlete category and his qualities. The linear velocity chart of the kicking leg is given in [Fig. 3].

Table 3: The foot's maximal linear velocity of the kicking leg, the reaching time of foot's maximal velocity and the implementation time of the mawashi geri technique up to kicking

Foot's kicking velocity and implementation time	Kicking leg		% of technique's implementation time
	Mean	St. deviation	
Maximal velocity of the kicking foot (m/s)	13,97	2,30	
The time at the moment of maximal velocity(s)	,33	,07	76,74%
The time at the kicking moment-total time	,43	,13	100%

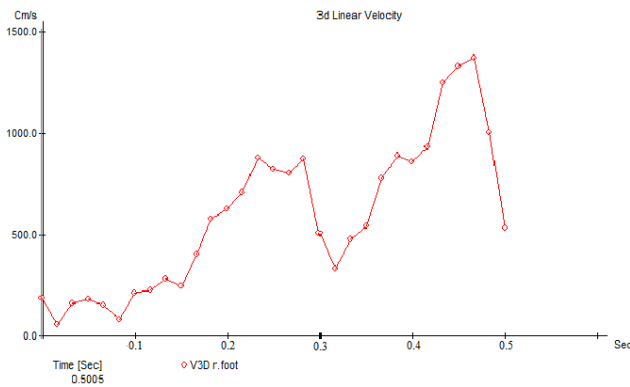


Fig. 3: The linear velocity of the foot's leg kicking on target at mavashi geri technique (J.H.).

The mawashi geri technique is performed with strong muscle engagement and with a great amplitude movement. Such movements are enabled by achieving optimal angles in the main joints during this movement, such as the knee joint and the hip joint. During the performance of the mawashi geri kicking on target are achieved different values between the karate athletes. The highest angle value is achieved on the knee joint during the maximal velocity of the foot's movement.

CONCLUSION

The performing conditions of the mawashi geri technique, in a real competition circumstances may vary from moment to moment, because the karate athlete is constantly obstructed by the opponent. The developed studies show that values of the kinematics indicators of athlete's position and the performing velocity of the mawashi geri technique on target depend on their body size, physical abilities and technical qualities.

Attacking leg changes position from the beginning of its establishment until reaches maximal velocity and hitting the target. Understandably, throughout this trajectory change the joints angles. At the kicking moment, the angle is bigger in the knee, because the athlete tends to stretch the leg more, while the hip

angle decreases as a result of the hip contraction. The supporting leg maintains the balance of the whole body; on the other hand while the technique is in progress, the angles difference on joint is much smaller compared to the attacking leg. At the moment that kicking leg movement achieves the maximal velocity, the knee angle joint of the supporting leg remains almost unchanged compared with the kicking moment on target (about 155°).

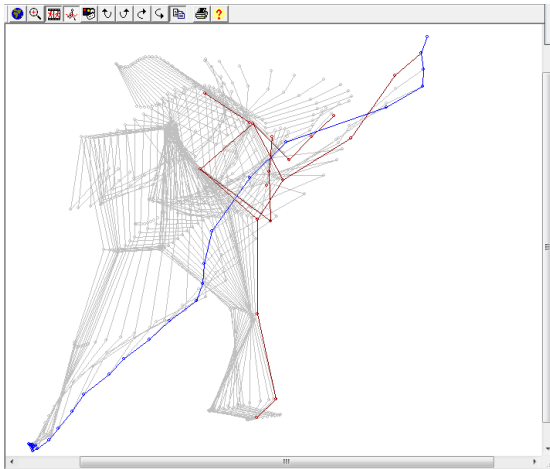


Fig. 4: Contourgram with foot's trajectory during the performance of mawashi geri technique- (subject A.SH.).

The duration of the implemented technique is one of the main factors for its effectiveness. This is applied throughout technique implementation as well as for the preparation stage, which means during detachment phase and the raising of the kicking leg. Another important factor is the reaching moment of maximal velocity and kicking moment on target. The foot's velocity during the technique performing is higher before it touches the target. Expressed in percentage this represents about 76.74% of the foot's movement trajectory. This means that the karate athlete reduces the kicking velocity just before kicking the target. Probably it is athlete's formed habit, as a result of karate's rules so that the opponent should not be kicked, which with regular exercises has shifted in stereotype. The kinematic analysis of indicators at certain moments gives a realistic picture of the movement performing state in mawashi geri technique including other techniques. The obtained results are useful information for researchers, coaches and karate sportsmen, in order to improve the technique and the whole training process.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

None

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