KINEMATIC PARAMETERS OF MAE GERI-KEKOMI IMPACT IN RELATION TO GENERAL AEROBIC ENDURANCE OF KARATISTS

Dragiša Jovanović[1], Osman Lačić[2], Jasmin Bilalić[2], Tarik Huremović[2], Eldar Goletić[2], Džemal Huremović[2]

[1] *Independent Researcher, Modriča, Bosnia and Herzegovina*
[2] *Faculty of Physical Education and Sports, University of Tuzla, Bosnia and Herzegovina*

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Abstract
Karate is a martial art dominated by a kind of combination of strength, explosiveness and agility, speed and agility, timeliness, timing and determination. The development of karate as a sport requires innovative technologies and a modern approach to the conceptualization of training and competition patterns and diagnostic procedures aimed at analyzing the structure of anthropological dimensions, their relations and specific influences on sports events. This study was conducted on a sample of karate athletes, senior competitors from karate clubs from the Tuzla Canton, with a total of 16 entities, divided into two groups based on maximum oxygen consumption (VO_2max). The entities are male, chronologically aged 18-22, who are in the regular training process and compete in the senior competition of the current system of karate competitions in the Republic of Bosnia and Herzegovina. The kinematic parameters of mae geri-kekomi impact during a three-minute progressive physiological load in relation to general aerobic endurance were monitored. Detection was performed every 30 seconds using KINOVEA 0.8.15 software package, while t-test for dependent samples was applied to determine differences between groups. The kinematic variables monitored were the height of the center of gravity of the body in the kick position, the height of the kick and the speed of the kick. General aerobic endurance was determined using the Shuttle-ran test, and the maximum oxygen consumption (VO_2max) in karate was indirectly calculated. The aim of the research is to determine the kinematic parameters of the mae geri-kekomi foot kick and to detect differences in the manifestation of that kick during time zones of 30 seconds as fatigue effects at three minutes of progressive physiological load based on general aerobic endurance of karate.
Keywords: *Kinematics, karate, mae geri-kekomi, general aerobic endurance, physiological load.*

INTRODUCTION

Karate, as a synonym of Far Eastern civilization, is as polemical and mysterious as the civilization from which it springs. It originated and developed under the influence of yoga, traditional medicine, religion and philosophy. As such, it is an extremely complex research phenomenon.
Within the polystructural acyclic movements, karate belongs to the group of discontinuous movements, which belong to sports activities, where there is a direct reaction to external changing conditions, and they are performed in direct conflict with the opponent, whose resistance should be overcome, anticipated and prevented, which is most often a symbolic destruction of the opponent. For these reasons, karate must have a comprehensive and purposeful repertoire of motor activities, automated during training and development in the training process and high efficiency in operationalization at the competition (Mudrić, 2004).
Kinematic analyzis of sports movement structures are used many times in an effort to make the training process as efficient as possible in terms of achieving the best possible competitive results. Thus, for example, the performance of each athlete can be exactly quantified in space and time. Also, if the kinematic analyzis include ideal motor stereotypes, the obtained results can be treated as model performances. Finally, the data obtained by kinematic analyzis can serve as a basis for imaginary modeling of moving structures.
According to all the above, kinematic analysis is really becoming the standard within the application of existing technologies intended for the efficient creation of the training process (Hraski and Mejovšek 1999).
At the same time, every movement of the human body, especially in sports, has its optimal performance, which is primarily characterized by maximum efficiency and minimum energy consumption and which is determined by aerobic and anaerobic capacities. The term "aerobic capacity" means the general scope of aerobic metabolic processes in the human body and is the basis of the athlete's work ability. The value of maximum oxygen consumption (VO_2max) is the best indicator of differences in aerobic capacity (Hübscher et al., 2010).
Maximum oxygen consumption is the largest amount of oxygen that the body can use during

intensive work, respectively VO_2max is the main indicator of the state of training of the oxygen transport system (cardiovascular and respiratory) and is an important determinant of success in many sports (Hübscher et al., 2010).

Progressive workload is inevitably an accompanying factor in both training and competition, which is manifested by the fatigue of the athlete (Zech et al., 2012). Stimuli that are applied to cause the development and changes of anthropological dimensions must have a certain strength and a certain frequency to reach the level of stimulation of the organism. Achieving an optimal load is especially important for the transformation of anthropological dimensions and the favorable course of adaptation processes (Laird and McLeod 2009).

RESEARCH METHODOLOGY

Sample of respondents

The sample of respondents is represented by senior competitors from karate clubs from the Tuzla Canton with a total of 16 male entities, chronological age 18-22, who are in the regular training process and compete in the senior competition of the current karate system in the Republic of Bosnia and Herzegovina.

Sample variables

Kinematic variables

- Height of the center of gravity of the body VTT
- Kick height VUN
- Kick speed BUN

General aerobic endurance variable

- Shuttle run test

Description of research and instruments

Testing was performed in a sports hall with optimal temperature and material conditions at the time of training. First, a shuttle test was done by running back and forth at 20 meters with an audible signal to time instances. The initial speed was 8 km/h (20 m in 9 seconds) and corresponds to a light run (at the limit of fast walking), and every minute the speed increased by 0.5 km/h. The test was interrupted when the examinee was no longer able to follow the set tempo, respectively when he did not reach the line on the sound signal three times in a row.

After the maximum oxygen consumption (VO_2max) was determined, the sample was divided into two groups of 8 subjects based on it. After three days, a recording was performed to analyze the kinematic parameters of the mae geri-kekomi impact.

The space for performing the blows is bounded by the line for the starting position individually for each examinee, and the kicks were performed in the chest of the training doll. The training dummy was moved in height so that it was identical to the height of the subjects. Parameter monitoring was performed so that one subject performed a light locomotor preparation for 10 minutes after the markers for kinematic monitoring were attached to it. After 30 seconds the subject performs a stroke, then connected one resistance-push-jump. In the 60th second, he takes a shot and repeats the push-up-jump three times. Performs a stroke in the 90th second and performs a push-up-jump six times, then a stroke in the 120th second and nine times a push-up-jump, a stroke in the 150th second and performs a push-up-jump twelve times and the last a blow in the 180th second thus completing the test.

For the purposes of this research, the software package KINOVEA 0.8.15 (video analysis software) was used, which works on the principle of a system in the form of 2D-reconstruction of movement or movement of the athlete in real-time situational conditions, which enables 2D-analysis of athlete's locomotive in real time. APAS (Ariel Performance Analysis System) with manual determination of anatomical locations of the body was applied to determine the investigated kinematic parameters of the karate locomotor apparatus.

RESULTS AND DISCUSSION

Table 1 shows the basic central and dispersion parameters of the sections run as part of the Shuttle run test and the indirectly calculated values of maximum oxygen consumption (VO_2max) for the entire sample of 16 entities. The average value of VO_2max of the total sample was 46.43 mlO_2/kg/min, the minimum was 41.30 mlO_2/kg/min, while the maximum oxygen consumption was 52.60 mlO_2/kg/min. The values of the distribution normality (Skewness and Kurtosis) do not deviate from the theoretical ones, which confirms the normal distribution of the sample. Following these data, the sample was selected on two subsamples based on VO_2max.

In Table 2 we see that the maximum oxygen consumption in the first group is on average 50.56 mlO_2/kg/min with differences within the group of 2.75 $mlO_2/kg/min$ (Group 1) while in the second group the maximum oxygen consumption is 43.41 $mlO_2/kg/min$ with deviations of 7.50 $mlO_2/kg/min$ (Group 2) which makes a statistically significant difference with a t-test size of 11.73 at a significance level of $p = 0.00$.

Table 1. Basic central and dispersion parameters of stocks and maximum oxygen consumption

	Descriptive Statistics							
Variable	Mean	Minimum	Maximum	Range	Variance	Std.Dev.	Skewness	Kurtosis
SATL20	81.94	66.00	103.00	37.00	82.86	9.10	0.73	0.02
VO2MAX	46.43	41.30	52.60	11.30	8.15	2.86	0.65	-0.26

Table 2. Arithmetic means of maximum oxygen consumption by groups and differences within groups

	T-tests; Grouping: Group 1: 1 Group 2: 2						
Variable	Mean 1	Mean 2	t-value	df	p	Valid N 1	Valid N 2
RVO2MUG	2.75000	7.50000	-8.49700	14	0.00000	8	8
VO2MAX	50.56250	43.41250	11.73541	14	0.00000	8	8

Table 3 shows the results of the average height of the center of gravity of the body by groups in the preparatory position for performing the mae geri-kekomi stroke with the progression of physiological load every 30 seconds. In the 30th second, after minimal physiological load, there were no statistically significant differences between the groups. From the 60th to the 180th second, with an increase in physiological load, statistically significant differences in the height of the center of gravity of the body between the groups at the level of acceptance of $p = 0.05$ were recorded. In the 60th second, Group 2 had a statistically significantly higher body center of gravity than Group 1, but declined rapidly from the 90th second. The height of the center of gravity of the body in Group 1 (VTT1), karate athletes with better aerobic endurance, which at the beginning of the test was 100.8 cm, remained the same after 180 seconds. In Group 2, karate athletes with poorer aerobic endurance (VTT2), the height of the center of gravity of the body in the impact position dropped from the initial 100.8 cm to 94.5 cm with a difference of as much as 6 cm and an obvious constant decrease during increasing physiological load to 180 seconds.

The height of the kick is given in Table 4. In the first 30 seconds, there were no statistically significant differences between the groups. As with the height of the center of gravity of the body, significant differences in the height of the kick between the groups occurred from the 60th to the 180th second. In the group of karate athletes with better aerobic endurance, there was a drop in value, from an initial 153.8 cm in the 30th second to 150.7 cm after the 180th second and with minimal differences during the three-minute test. In the group of karate athletes with weaker aerobic endurance of 30 seconds and a stroke height of 153.4 cm, a continuous fall is evident, which in the 180th second is 144.9 cm and a difference of almost 10 cm.

Table 3. Height of the center of gravity of the body in the mae geri-kekomi stroke position

Variable	T-test for Dependent Samples Marked differences are significant at p < ,05000 Mean	Std.Dv.	N	Diff.	Std.Dv. Diff.	t	df	p
VTT1 30"	100.810	4.16618						
VTT2 30"	100.848	3.80245	16	-0.15572	0.87803	-0.1128	14	0.37654
VTT1 60"	100.716	4.10837						
VTT2 60"	101.982	3.88158	16	-1.28870	1.00308	-2.5945	14	0.04421
VTT1 90"	100.638	4.05370						
VTT2 90"	98.934	4.09121	16	1.44690	1.88112	4.2999	14	0.00011
VTT1 120"	102.443	5.10412						
VTT2 120"	97.904	4.96491	16	2.59213	1.70787	8.9904	14	0.000000
VTT1 150"	101.911	5.14064						
VTT2 150"	96.449	4.99421	16	4.11903	1.80045	12.9671	14	0.000000
VTT1 180"	100.177	4.14509						
VTT2 180"	94.525	5.95112	16	6.00021	2.00256	15.9022	14	0.000000

Table 4. Kick height

Variable	T-test for Dependent Samples Marked differences are significant at p < ,05000 Mean	Std.Dv.	N	Diff.	Std.Dv. Diff.	t	df	p
VUN1 30"	153.802	8.28751						
VUN2 30"	153.375	8.16731	16	0.5477	1.91012	1.4013	14	0.16804
VUN1 60"	153.001	8.75033						
VUN2 60"	150.114	8.14517	16	3.5013	2.89651	5.9617	14	0.000000
VUN1 90"	151.441	8.76650						
VUN2 90"	149.014	8.51810	16	5.0591	3.95671	7.1934	14	0.000000
VUN1 120"	150.903	8.14339						
VUN2 120"	147.501	8.80141	16	5.9245	3.78346	7.5489	14	0.000000
VUN1 150"	151.880	8.00654						
VUN2 150"	147.115	9.18106	16	7.0771	6.09145	9.6467	14	0.000000
VUN1 180"	150.733	8.66902						
VUN2 180"	144.918	9.69250	16	10.3026	5.30741	10.7940	14	0.000000

Table 5 shows the kick speed parameters. The speed of the impact was monitored from the moment of separation of the striking leg from the ground to the contact with the chest of the training dummy and the calculated average time. In contrast to the previous two parameters, statistically significant differences from the 90th second to the end of the test were recorded here. Significant differences between groups were not observed in kick speed in the 30th and 60th second of the load. The average speed of the kick in the 30th second was approximate in both groups and was 60 km/h (16.6 m/s). Both groups had a decrease in value, but a statistically significant difference was maintained in favor of Group 1, which in the 180th second had an average impact speed of 58.0 km/h (16.1 m/s), while Group 2 had a speed impact 54.9 km/h (15.2 m/s).

Table 5. Kick speed

Variable	T-test for Dependent Samples Marked differences are significant at p < ,05000 Mean	Std.Dv.	N	Diff.	Std.Dv. Diff.	t	df	p
BUN1 30"	60.00000	4.883679						
BUN2 30"	60.10883	4.801246	16	-0.108880	1.050132	-0.60335	14	0.508
BUN1 60"	61.10030	4.701517						
BUN2 60"	60.11452	4.592042	16	0.088905	1.302207	0.50602	14	0.579
BUN1 90"	60.90712	4.880239						
BUN2 90"	58.10992	4.901166	16	1.890035	2.180903	4.88809	14	0.000
BUN1 120"	59.00806	4.224062						
BUN2 120"	58.02581	4.081135	16	2.900113	2.080345	6.95808	14	0.000
BUN1 150"	58.11109	5.002190						
BUN2 150"	55.15811	4.014561	16	3.339014	2.209122	7.97557	14	0.000
BUN1 180"	58.00109	4.108703						

CONCLUSION

The training and competition process of karate is rich in complex movement structures that are conditioned by multidisciplinary anthropological characteristics, and adequate diagnostic procedures can be performed exclusively by an interdisciplinary approach, implementing a large number of basic and specific, situational measurement instruments. In order to enable better and more accurate kinesiological diagnostics, advanced sophisticated measuring procedures and instruments for registration, detection and analysis of manifestations of specific motor abilities, such as kinematic analysis, have recently been applied in karate sports and other kinesiological disciplines.

Analyzing the obtained results, we see that there are no statistically significant differences in kinematic parameters between groups at the beginning of the test or at low physiological loads.

It is also evident that with the increase of a given load, there is a progression in the differences in favor of Group 1, respectively the group of karate fighters with higher maximum oxygen consumption (VO_2max).

The size of VO_2max of each individual is determined by his genetic inheritance, but can be drastically increased by properly selected training or specific kinesiological operators.

So, in order to get the best possible results, improving VO_2max as one of the ways of training should certainly not be neglected, because by raising the level of aerobic endurance, we also raise other relevant factors for success in sports.

The innovative approach in the segment of planning and programming of kinesiology operators and the operationalization of technical and tactical elements in training and competition conditions will certainly have a positive impact on sports results.

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Corresponding author:
Osman Lačić, PhD.
Faculty of physical education and sport, Tuzla University
e-mail: osman.lacic@untz.ba