

Motor Determinants of Fighting Efficacy in Croatian Youth Karateka

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ABSTRACT

The aim of this paper was to identify basic and motor structures which determine the achievement of top results in karate among younger cadets. For this purpose, a set of 10 basic motor tests and a set of 5 situational motor karate tests were applied on a sample of 60 male and 51 female Croatian karateka aged 13 to 15. Different motor and specific motor structures according to gender were isolated by factor analysis. In male karateka, in the space of basic motor tests: Factor of explosive strength and/or force regulator, and Factor integrating muscle endurance, agility and speed of movement, and in female karateka: Factor integrating movement speed, leg explosiveness and agility and/or speed regulator, and Regulator of basic core strength and sprinting. In male karateka in the space of specific motor tests: Specific agility and Specific speed of kicks performance; and in female karateka: Factor integrating agility-mobility and speed of technique performance. Latent structure of fighting efficacy in karate differs according to gender. Thus, in male karateka, determination of efficacy is significantly contributed by two motor factors: specific speed of kicks performance as a specific factor and force regulator as a basic factor; and in female karateka: the first factor which integrates regulators of speed, force and agility, accompanied by the muscle tone regulator, as a basic factor, and the second factor which is responsible for specific agility and speed of technique performance as a specific factor.

Key words: motor status, male karateka-cadets, female karateka-cadets, fighting efficacy

Introduction

Top performance in karate requires a high level of physical fitness. Elite karateka are characterized by a low level of body fat and mesomorphic-ectomorphic somatotype features¹. Katić et al. (2005)¹ state that longitudinal development of the skeleton is one of the performance predictors in karate. Pieter & Bercades² revealed that karateka are more ectomorph, which confirms the findings of Giampietro et al.³ for male Italian karateka. Research studies investigating the body structure and somatotype on female samples are rare.

Explosive muscle power plays a major role in achieving top results in karate⁴⁻⁶. According to the World Karate Federation⁷, kumite performance depends on the speed and the power of karateka actions.

Flexibility is crucial in karateka in order to execute high kicks (leg kicks to the head) and perform full range movements at high speed. Therefore karateka have great

flexibility in right and left hip flexion as well as in right and left knee flexion⁸.

Reaction time, or the speed at which a person moves in response to a stimulus, is a critical element in most sports, especially in karate, since high level performance is based essentially on explosive techniques. There is a significant difference between high level and novice karate athletes regarding the choice reaction time. Furthermore, Karate is a good example of a competitive sport with high levels of temporal and spatial constraints which require fast reaction⁹.

Congruent with previous findings, it has been established that specific motor abilities factors which define the fighting efficacy best are specific agility-mobility and specific speed, i.e., speed of technique performance¹.

Top results in karate can be achieved only by those karatekas who potentially have motor abilities developed

above average, primarily explosive power, speed and coordination, which can be seen especially in realization of karate kicks performed in combination: jaku zuki-mawashi geri and kizame zuki-jaku zuki¹. Precisely the speed and quality in performance of these actions (techniques) directly affect the efficiency of attack in karate.

Acquisition of karate techniques is a time-consuming process which depends both on basic motor abilities and specific motor abilities alike. Motor knowledge in karate, as well as general and specific motor abilities, are integrated into a morphological system in time^{9,10}, by optimizing sizes and relations of somatotype components of karateka. Moreover, the level, i.e. quality of integration of specific motor skills into a morphological system significantly determines the fighting efficacy in karateka.

Of all the techniques used (kicks), quality of jaku zuki kick was the most important factor in predicting competitive performance in karateka aged 11 and 12, and quality of combination of jaku zuki-mawashi geri and kazame zuki-jaku zuki in karateka aged 13 and 14¹¹.

In a research preceding this paper¹², differences in the biomotor status were established between young male and female karateka aged 13–15 in comparison to those who do not practice karate. It has been shown that in male karateka, general motor efficacy in karate is based on jumping explosive power, repetitive core strength and coordination, which is accompanied by flexibility, static strength of the arms, and speed of movement frequency, while in female karateka, integration of force, coordination, regulation of muscle tone and speed is dominant in achieving success in karate. Female karateka use more speed and fine muscle tone regulation in motor functioning than male karateka who use basic strength more.

Jukić et al.¹³ identified the morphological and motor structures which determine the achievement of top results in karate in young cadets. The latent structure of fighting efficacy in karate was different according to gender. Two motor factors, namely force regulator and factor of cortical regulation of movement, and one morphological factor defined as the ecto-mesomorphy factor have a significant impact in determining success in male karateka. In determining fighting efficacy of young female karateka, two motor factors have significant impact, namely: the first factor integrating regulators of speed, force and agility/coordination, accompanied by the regulator of muscle tone and synergetic regulation, and the second factor of basic core strength which ensures the initial energy component in technique realization, particularly of kicks. Out of all morphological factors, transverse dimensionality of the skeleton, particularly of hand, significantly determines the fighting efficacy of young female karateka.

After previous research studies have determined the impact of morphological and basic motor factors on fighting efficacy of karateka, this paper is aimed at determining the impact of basic motor abilities and specific motor abilities on fighting efficacy in karate among Croatian cadet karateka of both genders. Accordingly, in order to obtain a comprehensive information set, quantitative

gender differentiations in basic and specific motor abilities will be determined, basic and specific motor structures according to gender will be identified and compared, and the impact of the identified basic and specific motor factors on fighting efficacy will be established, on a sample of young karateka cadets.

Materials and Methods

Study subjects

The subject sample included 111 entities aged 13 to 15, divided into two subsamples. The first subsample consisted of 60 young male karateka, while the second subsample consisted of 51 female karateka, also of the age group of younger cadets.

Instruments

The space of basic motor abilities was defined by a set of 10 basic motor abilities tests which include the following variables: side steps (s), obstacle course backwards (s), seated straddle stretch (cm), arm plate tapping (freq), foot tapping (freq), standing long jump (cm), throwing a 2 kg medicine ball (m), 20 meter dash from a standing start (s), 60 seconds sit-ups (freq), bent arm hang (s).

The first five tests assess the general factor of movement regulation, and the other five tests assess the general factor of energy regulation. In this way the motor status is defined by two components, which are: the information (coordination, speed and flexibility) and the energy component (action strength factors: repetitive, explosive and static).

In the selection of tests for assessing situational motor abilities, it was taken into consideration that the tests selected are the best in assessing the most important factors for achieving success in a fight, which are specific agility-mobility and specific speed, i.e., speed of technique performance¹:

1) Sidesteps on taking guard with arms up. The test was intended to assess specific speed of movement, and the subjects' task was to cross a four meter path as quickly as possible by sidesteps in both directions six times. The test was repeated three times with an adequate recovery break, and the result was measured in tenths of seconds;

2) Speed of movement in a triangle. The test was intended to assess specific speed of movement, and the subjects' task was to move as quickly as possible in a fighting guard position along a marked triangle on the ground. The dimensions of the equilateral triangle were three meters. A subject moved quickly from one point of the triangle to the second point, around a medicine ball which was positioned there, and returned sideways to the third point, where he/she also went around a medicine ball, returning sideways to the starting point. He/she returned sideways, sideways forward and sideways back to the starting position. Speed of movement in a triangle was measured in tenths of seconds, and the task was repeated three times;

3) Speed of gedan barai block technique performance. The subjects' task was to perform as many blocks as he/she can in 30 seconds from an initial fighting position. The task was repeated three times, and the result was recorded as a total number of correctly performed blocks;

4) Speed of mawashi geri leg kick technique performance. The subjects' task was to perform as many mawashi geri kicks on the bag in 30 seconds from an initial fighting position. The reach of the kick was determined in relation to the height of the subject, and every subject was supposed to reach at least the height of his/her neck. The height a subject was supposed to reach on the bag was, for better control, marked by a belt above which the kick was supposed to be performed. The task was repeated three times and the result was recorded as the total number of correctly performed mawashi geri kicks; and

5) Speed of performing blocks and arm kicks as a combined technique. The subjects' task was to perform a combination of gedan barai – jaku zuki with maximum speed five times in a row. In order to ensure fair conditions for both tall and short subjects, the distance from the target which was to be hit by a jaku zuki kick was measured by the distance from the subject to the target. The distance from the target was defined by the length of an arm performing the jaku zuki. On the measurer's mark, the subject started performing the combination of gedan barai-jaku zuki as quickly as possible from a fighting position. The combination was performed five times, and the final jaku zuki kick to the wall makiwara or a vertical mat marked the end of the task. The task was re-

peated three times, and the result was measured in tenths of seconds.

The criterion of fighting efficacy – expert evaluation of fighting efficacy was performed based on the questionnaire given to coaches, i.e., on the marks they assigned to their karateka. The marks ranged from 1 to 3, so the coaches assigned the highest mark 3 to those male and female karateka who have won medals on Croatian championships and competitions scheduled by the Croatian Karate Federation for particular age and category group. The coaches assigned mark 2 to the karateka they considered average and always a step from winning a medal in competitions mentioned. Karateka who was considered not ready to achieve success in a fight yet and whose results in are below average was evaluated by mark 1 by the coach. The evaluation of fighting efficacy was formed based on expert assessment of 5 karate coaches.

Data analysis

Methods of data analysis included calculating descriptive statistical parameters: mean (M) and standard deviation (SD).

The significance of quantitative differences in the overall space of variables was defined from the results of univariate analysis of variance (ANOVA).

Factor analysis was applied to analyze the structure of basic and specific motor abilities, and within the analysis, varimax rotation of principal components of the intercorrelation matrix was conducted, whereas regres-

TABLE 1
DESCRIPTIVE STATISTICS OF VARIABLES (BASIC AND SPECIFIC MOTOR ABILITIES) AND ANALYSIS OF VARIANCE (F) IN YOUNG MALE AND FEMALE KARATEKA AGED 13-15

Variables	Male (n=60)		Female (n=51)		F	p
	M	SD	M	SD		
Side steps (s)#	8.97	0.80	9.43	0.82	9.12	0.00
Obstacle course backwards (s)#	12.11	3.12	13.51	3.36	5.17	0.02
Seated straddle stretch (cm)	73.17	14.55	84.57	15.84	15.61	0.00
Arm plate tapping (freq)	35.82	4.79	37.31	5.18	2.50	0.12
Foot tapping (freq)	21.45	2.13	21.88	2.29	1.06	0.31
Standing long jump (cm)	192.47	26.37	175.25	21.07	14.08	0.00
Throwing a 2 kg medicine ball (m)	6.85	1.72	5.40	0.69	31.97	0.00
20 m sprint (s)#	3.65	0.32	3.86	0.32	12.33	0.00
60 seconds sit-ups (freq)	47.52	10.86	46.55	8.69	0.26	0.61
Bent arm hang (s)	36.89	22.80	32.25	16.09	1.49	0.23
<i>Gedan barai</i> (f)	32.80	4.38	33.02	4.74	0.06	0.80
Block-blow (s)#	3.70	0.51	3.70	0.49	0.01	0.93
<i>Mawashi geri</i> (f)	34.88	5.49	32.98	6.11	2.99	0.09
Sidesteps on taking guard (s)#	9.29	0.87	9.64	0.76	4.93	0.03
Movement in triangle (s)#	9.19	0.69	9.56	0.87	5.92	0.02
Fighting efficacy	2.17	0.74	2.37	0.75		

variable with opposite metric orientation, M – mean, SD – standard deviation

TABLE 2
VARIMAX FACTORS OF BASIC MOTOR SPACE (V) IN YOUNG MALE AND FEMALE KARATEKA AGED 13–15

Variables	Male (n=60)		Female (n=51)	
	V1	V2	V1	V2
Side steps [#]	-0.39	-0.77	-0.75	-0.36
Obstacle course backwards [#]	-0.38	-0.47	-0.59	-0.35
Seated straddle stretch	0.64	0.22	0.64	0.36
Arm plate tapping	0.25	0.74	0.86	-0.14
Foot tapping	0.27	0.59	0.87	0.11
Standing long jump	0.71	0.49	0.83	0.23
Throwing a 2 kg medicine ball	0.85	0.11	0.58	0.43
20 m sprint [#]	-0.77	-0.39	-0.39	-0.73
60 seconds sit-ups	0.60	0.21	-0.02	0.90
Bent arm hang	0.08	0.81	0.57	0.27
% of Cumulative Variance		58.94		63.59

[#]variable with opposite metric orientation

sion correlation analysis was used to determine the relations between the isolated factors as predictors and success in karate as the criterion, calculating: coefficient of correlation (r), regression coefficient (β), multiple correlation (ρ), coefficient of determination (δ).

Results and Discussion

Table 1 shows basic statistical parameters of basic and specific motor space in karateka of younger cadet age group. Quantitative differences according to gender were determined by applying the analysis of variance (ANOVA).

The results of variance analysis have shown that male karateka, in relation to female karateka, are superior in tests assessing explosive power and basic and specific agility, whereas female karateka, in relation to male karateka, are superior in motor flexibility, i.e., muscle tone regulation and somewhat in movement frequency. This is why fighting efficacy in male karateka is predominantly determined by explosive power and in female karateka by flexibility and speed of movement frequency. Therefore, the energy component of motor functioning is dominant in male karateka and the information component is dominant in female karateka.

Factors of basic motor space in Croatian male karateka of younger cadet age group, which were obtained by varimax rotation of principal components of the inter-correlation matrix of the applied variables, are presented in Table 2. In male karateka, two significant factors were obtained which explain 59% of the total variability of subjects in the motor set of variables: Factor of explosive power and/or force regulator, and Factor integrating muscle endurance, agility and speed of movement.

The first motor factor is predominantly defined by variables of explosive power, repetitive core strength, and, to a lesser extent, flexibility variable and coordina-

tion variables. Therefore, here, explosive power and core strength are saturated by muscle tone regulation and coordination. The energy component of movement, i.e., mechanism responsible for power-force regulation, is underlying this factor.

Integration of muscle endurance, coordination/agility, balance and psychomotor speed and/or mechanism responsible for cortical regulation of movement underlies the second factor. Cognitive information processing also participates in the integration of the abovementioned motor abilities^{14,15}. Therefore, the second isolated motor factor is dominantly based on the information component of movement, and it can also be related to the speed regulation mechanism.

Factors of basic motor space in Croatian female karateka of younger cadet age group are also presented in Table 2. Two significant factors were obtained which explain 63% of the total variability of female subjects in the basic motor variable set: Factor integrating movement speed, leg explosiveness and agility and/or speed regulator, and Regulator of basic core strength and sprinting.

The first isolated factor defines general motor efficacy of quality young female karateka and integrates basic motor abilities: speed of movement frequency, explosive power, coordination, flexibility and muscle endurance into a unique set (structure). The abovementioned motor set is a compound of several regulators, particularly of: speed regulator, force regulator, movement structure regulator and muscle tone regulator. Integration of the abovementioned motor abilities, i.e. formation of this motor set is accompanied by cognitive information processing^{14,15}.

The second factor was predominantly defined by two variables, these being the variable for assessing repetitive core strength and the variable for assessing sprinting explosive power. The factor shows that basic core strength is, to a great extent, essential for manifestation

TABLE 3
VARIMAX FACTORS OF SPECIFIC MOTOR SPACE (V) IN YOUNG MALE AND FEMALE KARATEKA AGED 13-15

Variables	Male (n=60)		Female (n=51)
	V1	V2	V1
<i>Gedan barai</i>	-0.61	0.07	0.66
Block-blow [#]	-0.03	0.86	-0.59
<i>Mawashi geri</i>	-0.10	-0.84	0.72
Side steps on taking guard [#]	0.90	0.12	-0.87
Movement in triangle [#]	0.86	0.09	-0.76
% of Cumulative Variance		67.57	53.01

[#]variable with opposite metric orientation

of movement-sprinting explosiveness, and to a lesser extent, for manifestation of throwing explosiveness. Thus, performance of all techniques in karate depends greatly on the intensity of energy regulation in a way that core musculature provides the initial impulse for manifestation of acceleration-movement explosiveness, and explosiveness-leg power is transmitted through core musculature onto the musculature of the upper extremities and is finally manifested through kicking and blocking techniques.

Factors of specific motor space in Croatian karateka of younger cadet age group, which were obtained by

varimax rotation of principal components of the inter-correlation matrix of the applied variables, are presented in Table 3. In male karateka, two significant factors were obtained, explaining 67% of the total variability of subjects in the specific motor variable set, while in female karateka, one significant factor was isolated, explaining 53% of the total variability of female subjects in the specific motor variable set.

In male karateka: Specific agility and Specific speed of kicks performance.

In female karateka: Factor integrating agility-mobility and speed of technique performance.

After the factors of basic and specific motor space had been defined, regression correlation analysis was performed between those factors as predictors and efficacy in a karate fight as the criterion, which is presented in Table 4 for male karateka and in Table 5 for female karateka. The identified basic and specific motor factors are good predictors of fighting efficacy in young Croatian karateka, which is indicated by a fairly high multiple correlation for both boys ($\rho=0.69$) and girls ($\rho=0.72$).

In male karateka, two specific motor factors contribute significantly to determination of efficacy in karate: specific speed of kicks performance and force regulator.

Factor responsible for specific speed of kicks performance and Factor responsible for force regulation (energy regulation of movement is dominant) predominantly affect fighting efficacy of young male karateka. Herein, explosive power of upper extremities and then ex-

TABLE 4
REGRESSION ANALYSIS RESULTS FOR THE FIGHTING EFFICACY CRITERION IN THE FACTOR SPACE OF BASIC AND SPECIFIC MOTOR ABILITIES OF YOUNG MALE KARATEKA (N=60)

Factor	r	β	p
Factor of explosive power and/or force regulator	0.28	-0.32	0.03
Muscle endurance, agility and speed	0.10	-0.08	0.47
Specific agility	0.19	-0.21	0.15
Specific speed of kicks performance	0.48	-0.42	0.00
ρ		0.68	0.00
δ		0.47	0.00

r – coefficient of correlation, β – regression coefficient, ρ – multiple correlation, δ – coefficient of determination, [#]variable with opposite metric orientation

TABLE 5
REGRESSION ANALYSIS RESULTS FOR THE FIGHTING EFFICACY CRITERION IN THE FACTOR SPACE OF BASIC AND SPECIFIC MOTOR ABILITIES OF YOUNG FEMALE KARATEKA (N=51)

Factor	r	β	p
Set of movement speed, leg explosiveness and agility	0.37	0.37	0.01
Regulator of basic core strength and sprinting	0.27	0.21	0.06
Set of specific agility and speed of technique performance	0.33	0.35	0.02
ρ		0.72	0.00
δ		0.52	0.00

r – coefficient of correlation, β – regression coefficient, ρ – multiple correlation, δ – coefficient of determination, [#]variable with opposite metric orientation

plosive power of lower extremities is manifested in the performance of techniques-kicks, which are greatly conditioned by basic core strength and muscle tone regulation, as well as coordination.

In female karateka (Table 5), a set of 3 factors composed of 2 motor and 1 specific-motor factor is a good predictor of fighting efficacy in young Croatian karateka, which is indicated by fairly high multiple correlation ($\rho=0.72$).

In determining fighting efficacy of young female karateka, two factors have significant contribution: first, a Set integrating the regulators of speed, force and agility/coordination, followed by the muscle tone regulator, and second, a Set of specific agility and speed of technique performance.

The results show that the motor factor integrating basic abilities of speed of movement frequency, horizontal jumping explosive power and agility, along with muscle tone regulation, is the greatest determinant of fighting efficacy of young female karateka. Namely, quick,



Fig. 1. Ivan Martinac, European Vice-Champion in karate in the cadet age group and 3rd ranked at the World Championship (2011). European Champion in karate in the cadet age group (2012). First ranked among cadets in the World Karate Federation (WKF) ranking.

explosive and agile movements with proper muscle tone and amplitude are fully manifested in all segments of karate fight, primarily in situational mobility and speed of reaction.

A set of specific agility and speed of technique performance is the second most important in determining fighting efficacy of young female karateka, followed by the factor responsible for energy regulation which integrates core strength and sprinting.

Latent structure of fighting efficacy in karate differs according to gender. Thus, in male karateka, determination of efficacy is significantly contributed by two motor factors: specific speed of kicks performance as a specific factor and force regulator as a basic factor. In determining fighting efficacy of young female karateka, two motor factors contribute significantly: the first one which integrates regulators of speed, force and agility, accompanied by the muscle tone regulator, as a basic factor, and the second factor which is responsible for specific agility and speed of technique performance as a specific factor. Here, the factor of basic core strength ensures the initial energy component in technique performance, especially of kicks.

Specific agility, i.e., mobility of karateka in different directions, is of particular importance for fighting efficacy. Good mobility enables avoidance of opponents' attacks and assuming optimal position for efficient performance of one's own techniques (blocks and kicks).

In actual fighting conditions, speed of action performance plays a key role in defense, but also in the attack efficacy of a fighter. Herein, explosiveness plays a great role. Physiologically, explosiveness is manifested through the activation of a large number of muscle units in a short period of time. From a physical point of view on the other hand, explosiveness is mass mobilization or change of movement direction, therefore performance of the initial conditions of concrete movement by acceleration. Of course, it is by no means irrelevant what these initial conditions of movement are, because wrong movement and/or particular karate techniques will produce poor results.



Fig. 2a and 2b. Ivan Martinac, brown-black belt holder, cadet (under 63 kg), in action performing his famous DJAKU ZUKI.

Generally, it can be concluded that explosive power and coordination have a dominant impact on success in karate. The achievement of top results requires above-average abilities that are mostly innate, i.e. genetically determined, these being explosive power, speed and coordination. Therefore, the selection of entities for karate should be based on these very abilities.

Generally, there is no single characteristic of performance that dominates a fighting sport¹⁶. Karate athletes must perform several high intensity actions during a match. Elite karateka have a high level of body fitness, and, according to Becker and Bell¹⁷, a fight in karate is considered a high intensity competition. Also, karate success depends more on speed of contractions than on muscle power/strength¹⁸.

Conclusion

The results have described the coupling-complex of basic and specific motor abilities in determining the fighting efficacy of elite karateka in the cadet age cate-

gory. In male karateka, this complex is realized through a mechanism which is simultaneously responsible for specific speed of kicks performance and regulation of basic power-force, thus energy regulation of movement (Power regulator) is dominant. In female karateka, the complex of basic and specific motor abilities is realized through a mechanism which is simultaneously responsible for regulation of speed, force, agility and flexibility as basic motor abilities and specific agility and speed of technique performance, therefore the information regulation of movement (Speed regulator) is dominant. As an example of optimum complex of basic and specific motor abilities, the best karateka in the world in the cadet category is singled out from the sample (Figures 1 and 2a/b).

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MOTORIČKE DETERMINANTE BORBENE EFIKASNOSTI KOD HRVATSKIH KARATISTA KADETSKOG UZRASTA

SAŽETAK

Cilj rada je izvršiti identifikaciju bazičnih i specifičnih motoričkih struktura koje determiniraju postizanje vrhunskih rezultata u karateu kod mlađe kadetskog uzrasta. U tu svrhu na uzorku od 60 karataša i 51 karatašice RH uzrasne dobi od 13 do 15 godina, primijenjen je skup od 10 bazičnih motoričkih testova i skup od 5 situacijskih motoričkih testova iz karatea. Faktorska analiza je izolirala različite motoričke i specifično motoričke strukture u odnosu na spol. Kod karataša u prostoru bazičnih motoričkih testova: Faktor eksplozivne snage i/ili regulator sile, i Faktor koji integrira mišićnu izdržljivost, agilnost i brzinu pokreta, a kod karatašica: Faktor koji integrira brzinu pokreta, eksplozivnost nogu i agilnost i/ili regulator brzine, i Regulator bazične snage trupa i sprinta. Kod karataša u prostoru specifičnih motoričkih testova: Specifična agilnost i Specifična brzina realizacije udaraca, a kod karatašica: Faktor koji integrira agilnost-pokretljivost i brzinu realizacije tehnika. Latentna struktura borbene efikasnosti u karateu je različita u odno-

su na spol. Tako kod karataša u determinaciji uspjeha značajni doprinos imaju dva motorička faktora i to: specifična brzina realizacije udaraca kao specifični i regulator sile kao bazični faktor, a kod karatašica: prvi koji integrira regulatore brzine, sile i agilnosti što prati regulator mišićnog tonusa kao bazični faktor i drugi faktor odgovoran za specifičnu agilnost i brzinu realizacije tehnika.