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Morphological, Motor and Technical Determinants of Fighting Efficiency of Croatian Female Cadet Age Karate Athletes

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A B S T R A C T

The aim of this research was to determine the significance of morphological factors, factors of basic motor and specific motor abilities, and the factors of technical efficiency, on the karate fight success in Croatian female cadet karate athletes. With this purpose, the group of 18 anthropometric measures, 10 basic motor tests, 5 situational karate motor tests, the group of 8 evaluations of 6 basic karate techniques, and 2 karate kata performances was applied on the sample of 101 Croatian karateka aged 14 to 16. Inside the morphological area, the factor analysis isolated: Body mass and volume factor, Subcutaneous fat tissue factor, Longitudinal skeleton dimensionality factor, and Transversal fist dimensionality factor; in the basic motor area: General motor efficiency factor; in the situational motor area: General specific motor efficiency factor; in the area of karate technique performance evaluation: General technical efficiency factor. After that, the application of canonical discriminative analysis determined the differences between high and lower quality karate athletes in the overall area of the isolated factors. The discriminative function showed that high quality female karate athletes compared to those of lower quality differ the most in higher technical efficiency, higher basic and specific motor efficiency, while having somewhat less fat tissue and somewhat wider wrist and fist diameter.

***Key words**: biomotor status, female karateka-cadets, fighting efficacy*

Introduction

In Karate, the morphological characteristics of an athlete are extremely important. Study of the karate athletes' anthropometric characteristics can provide a specific outline of the morphological and functional biotype particularity, best suited to the specific requirement of this kind of combat sport[1]. It is desirable that karate athletes have a small percentage of body fat[2,3].

Katić et al.,[4] reported longitudinal skeletal development to be one of the predictors of karate performance. Moreover, elite karateka athletes have greater development of the vertical physical build, highlighted by an average somatotype (mesomorphic-ectomorphic)[3]. In this context, in sport where the body has to be propelled through space as fast as possible, being more endomorphic is suggested to be detrimental to performance[3–5]. In general, top-level male karate athletes have high ratings of both mesomorphic-ectormorphic characteristics and low endomorphic characteristics. Concerning female karate athletes, the endomorphic component is very close to the mesomorphic one[6–8].

Furthermore, it has been found that people who practice karate had a greater bone mineral density than people of same age who were not involved in training (Andreoli et al.)[9]. Drozdzowska et al.[10], suggested that karate was a sport with a positive influence on the skeletal status, with the most significant benefits occurring in adults.

Explosive muscle power plays a major role in achieving top results in karate[11–15]. According to the World Karate Federation[16], kumite performance depends on the speed and the power of karateka actions. The decisive actions during kumite karate (leg and hand kick) mainly depend on the explosive muscle power, meaning that the karate match performance was exclusively influenced by the higher level of power/speed generation of upper and lower extremities.

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Generally, there is not a single characteristic of performance that dominates a fighting sport[17]. Karate athletes must perform several high intensity actions during a match. Top level karateka has a high level of body fitness, and, according to Becker and Bell[18], fight in karate is considered a high intensity competition. Also, karate success depends more on speed of contractions than on muscle power/strength[15].

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, is integrated into a morphological system in time[19,20], by optimizing sizes and relations of somatotype components of karateka.

The research (Katić et al 2012)[21], ascertained the differences in biomotor status between young male and female karate athletes aged 13–15 years, in relation to those who do not practice karate. It is shown that in female karate athletes success in karate was determined dominantly by integration of power, coordination, muscle tone and speed regulation. Female karate athletes in their motor function use fine muscle tone regulation more often than male karate athletes, who mostly use basic strength.

Jukić et al., (2012)[22], performed the identification of the morphological and motor structures that determine the achievement of elite karate results in young cadet age. Two motor factors had a significant influence on the determination of the young female kareteka fighting efficiency: first one integrates speed, power and agility/coordination regulators, followed by muscle tone and synergy regulation regulator, and the second factor was of basic trunk strength, securing the initial energy component in the technique realisation, especially kicks. Of the morphological factors, the transversal dimensionality of the skeleton, especially fist, significantly determined the fight efficiency of young female karateka.

The following research (Katić et al., 2013)[23], ascertained the tie-connection of basic and specific motor abilities in the determination of fighting efficiency of elite karate athletes of cadet age. In male athletes, this tie was achieved by the mechanism that was at the same time responsible for the specific speed of kick realisation and regulation of basic strength-power, that is, an energetic regulation of movement dominates (Strength regulator). In female karate athletes the tie of basic and specific motor abilities was achieved by the mechanism that is at the same time responsible for speed, power, agility and flexibility regulation, as the basic motor abilities, and the specific agility and speed of technique realisation, that is, an information movement regulation dominates (Speed regulator).

After the listed research determined the influence of the morphological characteristics, basic and specific motor abilities on the fighting efficiency of Croatian cadet age karate fighters of both genders, the aim of this research was to determine the significance of the motor factors, factors of basic motor and specific motor abilities, and factors of technical efficiency, that is, quality of performance of basic karate techniques, on the karate fight success of Croatian female karate athletes of cadet age. In concordance with that, the factor structure of the applied variables of the morphological, basic-motor and specific motor area will be ascertained, and of specific motor knowledge (evaluation of basic karate techniques performance), followed by the application of the canonical discriminative analysis that would ascertain the differences between higher and lower quality level female karate athletes in the overall area of the isolated factors.

Materials and Methods

Study subjects

The sample of examinees in this research consisted of 101 female karate athlete, competing in fights (kumite), aged 14–16 years, making 80 % of the highest quality registered kumite female cadet contestants in the Republic of Croatia.

Besides the competition quality and age, the condition for the tests was clinical health of all the contestants and no expressed motor aberrations, and free will to enter the tests.

Instruments

Predictor group of variables

Measures of anthropometric characteristics were represented by 18 variables, these being: Body height (cm), Arm length (cm), Leg length (cm), Hand length (cm), Knee diameter (cm), Elbow diameter (cm), Wrist diameter (cm), Hand diameter (cm), Body mass (kg), Upper arm circumference flexed (cm), Upper arm circumference relaxed (cm), Forearm circumference (cm), Thorax circumference (cm), Calf circumference (cm), Triceps skinfold (mm), Back skinfold (mm), Abdominal skinfold (mm), and Calf skinfold (mm).

The space of basic motor abilities was defined by a set of 10 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), and Bent arm hang (s). The first five variables assess the general factor of movement regulation, and the other five variables 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).

While selecting the tests for assessing situational motor abilities, it was taken into consideration that the tests selected were 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 performance[21]:

1) Sidesteps on taking guard with arms up (Sidesteps on taking guard). 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 (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 (gedan barai block). 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 (Mawashi geri). 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 (Block-blow). The subjects' task was to perform a combination of gedan barai – gyako 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 gyako 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 gyako zuki. On the measurer's mark, the subject started performing the combination of gedan barai gyjako zuki as quickly as possible from a fighting position. The combination was performed five times, and the final Gyako zuki kick to the wall makiwara or a vertical mat marked the end of the task. The task was repeated three times, and the result was measured in tenths of seconds.

The jury of 3 independent experts for the karate sport has been used for the evaluation of the technical efficiency, that is, technique quality evaluation, using the evaluation of 6 basic karate techniques and 2 karate kata. The following techniques were evaluated individually: Gyako zuki, Kizame zuki and Mawashi geri, and in combinations Gyako zuki – Mawashi geri, Gyako zuki – Uraken and Kizame zuki – Gyako zuki. Technical efficiency was determined based on the subjective evaluations of three reviewers as well, for the performance of two karate kata: Kata 1 and Kata 2.

Criterion variable

Fighting efficiency was determined based on the competition results achieved on the cadet regional competitions and state championship. Based on the achieved results the reviewers classified the karate athletes in two categories: high quality and lower quality. The high quality group consisted of the examinees who won 1st place at the regional championship and/or one of first three places at the state championship. To avoid the classification error, the category of the high quality karate athletes, besides the listed rankings at the two competitions, should satisfy the minimum criterion of two wins per individual competition.

Data analysis

Data analysis methods involved calculating descriptive statistical parameters: arithmetic mean (X), standard deviation (SD). Factor analysis was applied to analyze the structures of: morphological characteristics, basic motor abilities, specific motor abilities and technical efficiency. All factor analyses were performed by factoring correlation matrices of variables. Hotelling's method of principal components and Guttman-Kaiser's criterion for determining the number of significant principal components, i.e., factors. The initial solution was transformed into oblique solution, which allows inter-correlations between the factors, using promax solution.

The canonical discriminative analysis was applied in determining differences between high and lower quality karate athletes in the isolated factors of the morphological area, area of basic and specific motor abilities and area of specific knowledge – technical efficiency.

Results and Discussion

In female karate athletes the factor analysis in the morphological area isolated four factors, explaining 75.8 % of the overall variability of the examinees (Table 1).

The first promax factor was defined by the high projection of the variables for evaluation body mass and volume, followed by elbow and knee diameters. The structure of this factor describes the mesomorphic somatotype and it is a main feature of female karate athletes of young cadet age (Table 2).

The second promax factor was dominantly defined by the variables of subcutaneous fat tissue. The structure of this factor was described by the endomorphic somatotype.

The third promax factor was dominantly defined by the variables of longitudinal skeleton dimensionality, describing the ectomorphic somatotype.

TABLE 1
DESCRIPTIVE STATISTICS OF VARIABLES (ANTHROPOMETRIC CHARACTERISTICS) (M, SD) AND PRINCIPAL COMPONENTS (H)

Variable	$\overline{X}$	SD	H1	H2	H3	H4
Body height (cm)	162.43	6.89	0.64	0.49	0.43	–0.25
Arm length (cm)	69.22	3.67	0.49	0.60	0.35	–0.20
Leg length (cm)	95.45	4.52	0.58	0.49	0.50	–0.09
Hand length (cm)	16.96	1.54	0.34	0.48	0.23	0.45
Knee diameter (cm)	8.91	0.37	0.64	0.09	–0.17	0.05
Elbow diameter (cm)	6.00	0.34	0.43	0.34	–0.45	–0.05
Wrist diameter (cm)	4.98	0.26	0.35	0.45	–0.07	0.62
Hand diameter (cm)	7.15	0.41	0.46	0.46	–0.29	0.41
Body mass (kg)	52.54	8.28	0.91	0.03	0.04	–0.22
Upper arm circumference flexed (cm)	24.92	2.37	0.89	–0.14	–0.22	–0.07
Upper arm circumference relaxed (cm)	23.42	2.25	0.90	–0.16	–0.27	–0.08
Thorax circumference (cm)	80.01	5.89	0.88	–0.02	0.01	–0.18
Calf circumference (cm)	32.89	2.64	0.80	–0.09	–0.18	–0.22
Forearm circumference (cm)	21.97	1.38	0.86	0.07	–0.39	–0.07
Triceps skinfold (mm)	13.66	3.86	0.57	–0.65	0.07	0.13
Back skinfold (mm)	9.96	3.44	0.57	–0.53	0.31	0.23
Abdominal skinfold (mm)	13.67	4.93	0.65	–0.54	0.20	0.27
Calf skinfold (mm)	12.66	3.91	0.53	–0.61	0.31	0.12
Lambda			7.96	3.04	1.47	1.17
% variance			44.24	16.87	8.16	6.49
Cumulative % variance			44.21	61.11	69.27	75.76

TABLE 2
PATTERN MATRICES OF MORPHOLOGICAL AREA (A)

Variable	A1	A2	A3	A4
Body height	0.10	–0.07	0.92	–0.04
Arm length	0.07	–0.22	0.85	0.04
Leg length	–0.09	0.06	0.90	0.11
Hand length	–0.22	0.16	0.35	0.66
Knee diameter	0.57	0.05	0.03	0.17
Elbow diameter	0.78	–0.43	–0.10	0.16
Wrist diameter	0.02	0.11	–0.01	0.85
Hand diameter	0.42	–0.13	–0.09	0.66
Body mass	0.64	0.14	0.37	–0.12
Upper arm circumference flexed	0.82	0.21	–0.03	0.00
Upper arm circumference relaxed	0.89	0.19	–0.08	–0.01
Thorax circumference	0.63	0.19	0.29	–0.09
Calf circumference	0.79	0.08	0.09	–0.15
Forearm circumference	0.98	–0.06	–0.07	0.08
Triceps skinfold	0.20	0.79	–0.21	–0.04
Back skinfold	–0.09	0.91	0.02	0.09
Abdominal skinfold	0.06	0.90	–0.08	0.14
Calf skinfold	–0.07	0.90	0.02	–0.06

The fourth promax factor was defined by the variables of transversal skeleton dimensionality, especially hand and wrist (Transversal hand dimensionality).

The processes of differentiation led to the formation of four morphological dimensions – structures in young female karate athletes. Thus, besides the first morphological dimension responsible for the development of the muscle tissue, two skeleton factors were identified: one responsible for the skeleton upward growth, and another responsible for its breadth wise growth. The transversal dimensionality of the arm skeleton secures the greater

TABLE 3
DESCRIPTIVE STATISTICS OF VARIABLES (MOTOR ABILITIES) (X, SD) AND PRINCIPAL COMPONENT (H)

Variable	$\overline{X}$	SD	H1
Standing long jump (cm)	174.26	22.71	0.83
Arm plate tapping (freq.)	37.61	4.53	0.58
20 m sprint (s)#	3.86	0.31	–0.68
Side steps (s)#	9.68	0.90	–0.75
Bent arm hang (s)	31.98	17.39	0.50
60 seconds sit–ups (freq.)	46.81	8.78	0.42
Obstacle course backwards (s)#	12.71	2.77	–0.52
Seated straddle stretch (cm)	79.66	14.20	0.67
Foot tapping (freq.)	21.04	2.13	0.77
Throwing a 2 kg medicine ball (m)	5.24	0.76	0.72
Lambda			4.32
% variance			43.25

#variable with opposite metric orientation

strength manifestation and thus more efficient block and kick realization.

Table 3 presents the factors of the motor area in the Croatian young cadet female karate athletes. Only one significant factor was determined, explaining the 43 % of the overall examinees variability in the motor group of variables. The isolated factor defines the general motor *efficiency* of young high quality karate athletes, integrating the basic motor abilities: explosive power, agility/coordination, movement frequency speed and flexibility, into a unique structure. The named motor structure is a combination of more regulators: power regulator, movement structures regulator, speed regulator and muscle tone regulator. The integration of the listed motor abilities, that is, formation of the listed motor structure occurs when the cognitive information process participates[24,25].

TABLE 4
DESCRIPTIVE STATISTICS OF VARIABLES (SPECIFIC MOTOR ABILITIES) AND PRINCIPAL COMPONENT (H)

Variable	$\overline{X}$	SD	H1
Gedan barai	31.89	5.36	–0.76
Block–blow#	3.93	0.64	0.74
Mawashi geri	32.05	6.00	–0.73
Side steps on taking guard#	9.66	0.84	0.57
Movement in a triangle#	9.50	0.97	0.66
Lambda			2.42
% variance			48.45

#variable with opposite metric orientation

TABLE 5
DESCRIPTIVE STATISTICS OF VARIABLES (TECHNICAL EFFICIENCY) AND PRINCIPAL COMPONENTS (H)

Variable	X	SD	H1
Gyako zuki	2.98	0.70	0.95
Kizame zuki	3.36	0.72	0.93
Mawashi geri	3.25	0.82	0.90
Gyako zuki–Mawashi geri	3.11	0.72	0.93
Gyako zuki–Uraken	2.82	0.66	0.91
Kizame zuki–Gyako zuki	3.32	0.71	0.94
Kata 1	3.36	0.71	0.95
Kata 2	3.01	0.69	0.94
Lambda			6.96
% variance			86.97

Table 4, using the factor analysis of the specific motor area, isolates also one significant factor, explaining 48 % of the overall variability of the examinees. The factor integrates specific technique realization speed and specific agility-mobility (General specific motor efficiency).

Table 5, using the factor analysis of the specific knowledge evaluation variables, isolates one significant factor, explaining 87 % of the overall examinees variability. All the techniques, as well as the kata performances, had high projections on the isolated factor (from 0.90 to 0.95), determining the factor of general technical efficiency in young female karate athletes.

Table 6, using the factor analysis of 7 isolated factors, that is, primary factors: morphological, motor and specific motor, gained 3 secondary factors – second class factors.

First secondary factor was motoricaly defined by the high projections of the three primary factors (0.87–0.91): motor factor responsible for basic motor efficiency, specific factor responsible for specific motor efficiency and technique knowledge factor, responsible for technical efficiency. The first secondary factor integrates basic and specific motor abilities and knowledge into a unique motor structure, upon which the motor function of the cadet female karate athletes is dominantly based, a combination of basic, specific and technical efficiency and fight success achievement, that is, fighting efficiency.

The second secondary factor was morphologically dominantly defined by the primary factors: Body mass and volume and Subcutaneous fat tissue and in less extent Longitudinal skeleton dimensionality. The second sec-

TABLE 6
PRINCIPAL COMPONENTS (H) AND PATTERN MATRICES (A) IN THE FACTOR AREA OF MORPHOLOGICAL, BASIC AND SPECIFIC MOTOR ABILITIES, AND TECHNICAL EFFICIENCY

Factor	H1	H2	H3	A1	A2	A3
Body mass and volume	0.33	0.81	–0.05	0.00	0.81	0.20
Subcutaneous fat tissue	–0.04	0.76	–0.49	–0.10	0.89	–0.35
Longitudinal skeleton dimensionality	0.53	0.57	0.18	0.15	0.53	0.43
Transversal hand dimensionality	0.43	0.22	0.80	–0.10	–0.08	0.97
General specific motor factor#	–0.80	0.25	0.18	–0.87	0.01	0.04
General motor efficiency	0.86	–0.23	–0.18	0.91	0.02	–0.02
General tehnical efficiency	0.80	–0.30	–0.18	0.89	–0.06	–0.05
Lambda	2.60	1.80	1.00			
% variance	37.07	25.70	14.30			
Cumulative %	37.07	62.77	77.07			

#variable with opposite metric orientation

ondary factor describes the morphological structure dominated by the endomorphic and mesomorphic components, and less ectomorphic, an endo-meso-ectomorphic somatotype.

The third secondary factor was defined only by Transversal fist dimensionality. The factor of transversal fist dimensionality proved to be an important predictor of fighting efficiency of young female karate athletes (Jukić et al., 2012)[22].

After defining the factors of morphological, basic and specific motor area, and technique performance, a canonical discriminative analysis between the karate athletes of high and lower quality level was applied, in the area of the isolated factors (Table 7).

Coefficient of canonical discrimination of 0.70 was significant on the $p<0.001$ level, meaning that the karate athletes, considering their quality, considerably differed in the area of the isolated factors. The centroids clearly define the position of the groups of examinees on the discriminative function: Centroid 1 on the negative pole represents karateka of lower quality, Centroid 2 on the positive pole represents high quality level karateka.

On the discriminative function (DF), all three primary motor factors dominantly differentiate karate athletes of high quality level from the lower quality level karate athletes, as follows: General technical efficiency, General motor efficiency, and General specific motor efficiency. The discriminative function shows that the high level karate athlets have somewhat less fat tissue and somewhat wider fist and wrist width.

Fighting success, that is, fighting efficinecy, is mostly and dominantly influenced by knowledge and/or technique mastering (Technical efficiency), which is significantly saturated by the basic and specific motor abilities. Therefore, the optimum interrelation between the karate techniques performance quality and the level of basic and specific motor abilities strongly determines the fighting efficiency of young female karate athletes.

TABLE 7
RESULTS OF CANONICAL DISCRIMINATION ANALYSIS IN FACTOR AREA OF MORPHOLOGY, BASIC AND SPECIFIC MOTOR ABILITIES, AND TECHNICAL EFFICIENCY

Factor	DF
General tehnical efficiency	0.89
General motor efficiency	0.62
General specific motor facto #	–0.55
Subcutaneous fat tissue	–0.13
Transversal hand dimensionality	0.13
Body mass and volume	0.07
Longitudinal skeleton dimensionality	0.00
CanR	0.70*
Centroid 1	–1.13
Centroid 2	0.84

#variable with opposite metric orientation, *$p<0.001$; DF – discriminant function, CanR – coefficient of canonical discrimination

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MORFOLOŠKE MOTORIČKE I TEHNIČKE DETERMINANTE BORBENE EFIKASNOSTI HRVATSKIH KARATISTICA KADETSKOG UZRASTA

S A Ž E T A K

Cilj istraživanja je utvrditi značaj morfoloških faktora, faktora bazičnih motoričkih i specifičnih motoričkih sposobnosti, te faktora tehničke efikasnosti na uspjeh u karate borbi hrvatskih ženskih karatista-kadetskog uzrasta. U tu svrhu na uzorku od 101 karatašice RH, uzrasne dobi od 14 do 16 godina, primijenjen je skup od 18 antropometrijskih mjera, skup od 10 bazičnih motoričkih testova, skup od 5 situacijskih motoričkih testova iz karatea, skup od 8 ocjena izvedbe 6 osnovnih karate tehnika i 2 karate kate. Faktorska analiza je izolirala u morfološkom prostoru: Faktor volumena i mase tijela, Faktor potkožnog masnog tkiva, Faktor longitudinalne dimenzionalnosti skeleta i Faktor transverzalne dimenzionalnosti šake; u bazičnom motoričkom prostoru: Faktor generalne motoričke efikasnosti; u situacijskom motoričkom prostoru: Faktor generalne specifične motoričke efikasnosti; i u prostoru ocjena izvedbe karate tehnika: Faktor tehničke efikasnosti. Zatim su primjenom kanoničke diskriminativne analize utvrđene razlike između kvalitetnih i manje kvalitetnih karatistica u ukupnom prostoru izoliranih faktora. Diskriminativna funkcija je pokazala kako se karatašice veće kvalitete u odnosu na karatašice manje kvalitetne najviše razlikuju u većoj tehničkoj efikasnosti, zatim u većoj bazičnoj i specifičnoj motoričkoj efikasnosti i koje su ujedno sa nešto manje masnog tkiva i nešto većih dijametara ručnog zgloba i šake.