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Impact of Morphological and Motor Dimensions on Success of Young Male and Female Karateka

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A B S T R A C T

The aim of this paper is to identify morphological and motor structures which determine the achievement of top results in karate in the age group of younger cadets. With this purpose, a set of 18 morphological measures and a set of 12 motor tests were used on a sample of 60 male and 51 female Croatian karateka aged 13 to 15. Different morphological structures were isolated by factor analysis according to gender. Two morphological factors in male karateka, named: ecto-mesomorphy and fat tissue. Three factors in female karateka, named: endo-mesomorphic somatotype, ecto-mesomorphic somatotype and transverse dimensionality of the skeleton, particularly of the hand and wrist. Also, different motor structures were isolated by factor analysis according to gender. In male karateka: the first factor responsible for cortical regulation of movement, the second one responsible for power-force regulation and the third one named precision. In female karateka: the first factor integrating regulators of speed, force, movement structures and muscle tone with synergetic regulation, the second one responsible for energy regulation integrating core strength and sprint, and the third one named precision. Latent structure of fighting efficiency in karate differs according to gender. Two morphological factors, namely force regulator and factor of cortical regulation of movement, and one morphological factor defined as ecto-mesomorphy factor have a significant impact on determining success in male karateka. In determining fighting efficiency of young female karateka, two motor factors have significant impact, namely: the first factor integrating regulators of speed, force and agility/coordination, accompanied by regulator of muscle tone and synergetic regulation, and the second factor of basic core strength which ensures the initial energy component in technique performance, particularly of kicks. Out of all morphological factors, transverse dimensionality of the skeleton, particularly of hand, significantly determines the fighting efficiency of young female karateka.

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

Introduction

Identifying anthropological characteristics which determine success in karate and understanding the development dynamics of those characteristics is crucial for determining the processes of selection and orientation which lead to forming superior sports quality. Processes of orientation precede processes of selection and required pieces of information are usually obtained by applying a discriminative model which determines the differences in the anthropological status between karateka and those who do not practice karate (e.g. Katić et al., 2012)[1]. On the other hand, by generally applying a regression model, information about the impact of factors of anthropological status on success in karate is obtained, which is important for selection (Katić et al. 2005[2]; Blažević et al., 2006[3]; Katić et al., 2010[4]). Relevant information about the dynamics of forming superior sports quality is obtained by applying regression correlation analysis between dimensions of anthropological status and success in karate, using karateka of different age categories (Katić et al., 2009)[5].

Katić et al.[2] state that longitudinal development of the skeleton is one of predictors of performance in karate. Moreover, elite karateka have a better developed vertical body build, highlighted by average somatotype (mesomorph-ectomorph)[6]. In this context, in a sport which requires a body to move as quickly as possible, it is assumed to be crucial for performance[2,6,7]. Pieter i Berca-

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des[8] have found that male karateka are more ectomorph, which substantiates the findings of Gianpietro et al.[7] for male Italian karateka. Furthermore, it has been found that people who practice karate have a greater bone mineral density than people of same age who are not involved in training (Andreoli et al.)[9].

In comparison to other elite athletes in various sports, VO2max of elite athletes in karate was similar to the one in taekwondo athletes[10,11] and wrestlers[12], but lower than values found in boxers[13]. Aerobic capacity is necessary to prevent fatigue during training, during the breaks between subsequent bouts of fighting activity within a fight and to improve the recovery process between consecutive matches[14,15]. High intensity intermittent sports rely mostly and anaerobic energy sources, with determinant actions being a function of explosive movement[16]. Thereby karateka's decisive actions depend mainly on anaerobic energy pathways[3,14].

Reaching the highest performance in karate is possible by imparting a very high kinetic energy to one segment in the shortest period of time. Thereby, the muscle explosive power plays a major role in achieving top Karate results[4,17,18]. According to the World Karate Federation[25], kumite performance depends on the speed and the power of karateka actions.

Flexibility is crucial in karate athletes in order to execute high kicks (leg kicks to the head) and perform full range movements at high speed. Therefore karatekas have greater flexibility in right and left hip flexion as well as in right and left knee flexion (Probst et al.)[20].

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 reaction (Mori et al. 2002)[21].

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 zuki (Katić et al. 2005.)[2]. Precisely the speed and quality in performance of these actions (techniques) directly affect the efficiency of attack in karate.

Realization of techniques is highly saturated by cognitive abilities because a karateka must be able to identify a situation he/she is in as soon as possible and to choose a reaction which is the most adequate one for achieving the goal[21], i.e. winning a fight.

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[21,22], 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 efficiency in karateka.

Of all the techniques used (kicks), quality of jaku zuki kick was the most important factor in predicting performance in competitions in karate athletes aged 11 and 12, and quality of combination of jaku zuki-mawashi geri and kazame zuki-jaku zuki in karate athletes aged 13 and 14 (Katić et al., 2009)[5].

In a research preceding this paper (Katić et al. 2012)[1], 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 efficiency 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 that male karateka who use basic strength more.

The aim of this paper is to identify morphological and motor structures which determine the achievement of top results in karate in the younger cadet age group. In accordance with that aim and in order to obtain comprehensive information, first, the identification of morphological and motor structures in young karateka will be conducted separately, and then, factors which affect their fighting efficiency will be established according to gender.

Materials and Methods

Study subjects

The subject sample included 111 entities aged 13 – 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 total of 30 variables was used for assessing the biomotor status. 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 12 basic tests of motor abilities, which consisted of the following variables: side steps (s), obstacle course backwards (s), one leg standing

(s), seated straddle stretch (cm), darts (score), arm plate tapping (freq), foot tapping (freq), standing long jump (cm), throwing a 2 kg medicine ball (m), 20 meter sprint from a standing start (s), 60 seconds sit-ups (freq), bent arm hang (s).

Data analysis

Data analysis methods involved calculating descriptive statistical parameters: arithmetic mean (X), standard deviation (SD), minimum (Min) and maximum (Max) result, measure of asymmetry (Skew), measure of distribution peakedness (Kurt) and determining the MaxD value for examining the normality distribution of variables using a KS-test.

Factor analysis was applied on all subsamples to analyze the structure of morphological characteristics and motor abilities, and within the analysis, varimax rotation of principal components of the intercorrelation matrix was conducted, whereas regression analysis was used to determine the relations between the isolated factors as predictors of success in karate, 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 morphological-motor space in young male karateka. Generally, it can be established that the distribution of results in morphological and motor space of almost all variables was within normal parameters (except for triceps skinfold in the morphological set and shooting a target and one leg standing in the motor set of variables).

Latent structures of the morphological status in young male Croatian karateka are presented in Table 2. Two significant factors were obtained, which explain 83% of the total variability.

The first factor was defined by high projections of all morphological measures for assessing longitudinal and transverse dimensionality of the skeleton as well as measures for assessing body mass and volume. This factor explains 54% of the total variability of subjects and describes an ecto-mesomorph somatotype. The second factor was defined by variables for assessing subcutaneous fat tissue and, to a lesser extent, by variables assessing body mass and volume, and it can be named endomorphy. It explains 29% of the total variability of subjects.

Table 3 shows factors of motor space in young female Croatian karateka, obtained by varimax rotation of principal components of the intercorrelation matrix of applied variables. Three significant factors obtained explain 60% of the total variability of subjects in the motor set of variables.

The first and the second isolated factor explain equal percentage of the variance, 26 and 25%, and act as two general motor factors which are dominantly responsible for motor efficiency of male karateka.

Integration of muscle endurance, coordination/agility, balance and psychomotor speed and/or mechanism responsible for cortical regulation of movement lies in the basis of the first factor. Cognitive information processing also participates in the integration of the above mentioned motor abilities[23,24]. Therefore, the first isolated motor factor is dominantly based on the information component of movement, and it can also be related to the speed regulation mechanism.

The second motor factor was predominantly defined by explosive power variables and repetitive core strength, and to a lesser extent, by variables of flexibility and coordination; therefore, explosive power and core strength saturated by muscle tone regulation and coordination are present here. Energy component of movement, i.e. mechanism responsible for power-force regulation, lies in the basis of this factor.

The third morphological factor was predominantly defined only by shooting a target (darts) test for assessing precision, thus it can be named precision factor. It explains the smallest percentage, i.e. only 9% of the common variance. It must be noted that aiming precision is more important than shooting precision in karate, therefore, aiming is present in karate, not shooting.

After factors of morphological and motor space have been defined, regression correlation analysis between those factors as predictors and success in a karate fight as the criterion was applied (Table 4). Identified morphological and motor factors were good predictors of success in a fight in young Croatian karateka, which is indicated by fairly high multiple correlation ($\rho=0.63$).

Two factors had significant contribution in determining success in karate: force regulator and factor of cortical regulation of movement, and a factor morphologically defined as ecto-mesomorphy factor.

Factor responsible for force regulation (energy regulation of movement is dominant) dominantly affects success in a fight in young male karateka. Explosive power of upper extremities, followed by explosive power of lower extremities is manifested in realization of techniques-kicks, which are greatly conditioned by basic core strength and muscle tone regulation, as well as coordination.

Ecto-mesomorphy factor responsible for development of the skeleton and muscle mass is the second most important predictor of success in karate. Karate training, as well as continuity of developmental functions, leads to formation of the morphological set which integrates development of the skeleton and muscle tissue as positive sides of development of the organism as a whole, as opposed to building excessive fat tissue as a negative side of development.

Force regulation (power) factor and ecto-mesomorphy factor must be observed in interaction in relation to fighting efficiency of young karateka. Therefore, karate training affects the increase of muscle mass, which subsequently affects muscle power, which contributes overall to a greater fighting efficiency. A process of integra-

TABLE 1
DESCRIPTIVE STATISTICS OF VARIABLES (OF MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES) IN YOUNG MALE KARATEKA AGED 13–15 (N=60)

Variables	$\overline{X}$	SD	Min	Max	KS	Skew	Kurt
Body height (cm)	167.95	11.88	142.00	198.20	0.07	–0.03	–0.32
Arm length (cm)	73.23	6.20	60.40	88.00	0.08	0.15	–0.09
Leg length (cm)	98.71	7.86	79.80	118.30	0.05	–0.08	0.16
Hand length (cm)	18.86	1.82	15.20	22.80	0.11	0.18	–0.43
Knee diameter (cm)	9.68	0.63	8.10	11.40	0.15	0.26	0.09
Elbow diameter (cm)	6.61	0.53	5.50	7.50	0.13	–0.41	–0.74
Wrist diameter (cm)	5.44	0.44	4.40	6.20	0.08	–0.11	–0.69
Hand diameter (cm)	7.79	0.72	6.50	9.80	0.12	0.35	–0.27
Body mass (kg)	58.02	14.22	33.90	96.50	0.08	0.46	0.14
Upper arm circumference flexed (cm)	26.37	3.85	18.50	34.90	0.09	0.16	–0.54
Upper arm circumference relaxed (cm)	24.25	3.31	18.00	31.50	0.12	0.05	–0.56
Forearm circumference (cm)	23.58	2.46	18.80	29.50	0.09	0.27	–0.34
Thorax circumference (cm)	81.71	8.76	65.00	103.50	0.08	0.34	–0.35
Calf circumference (cm)	34.05	3.62	27.50	44.00	0.11	0.53	–0.12
Triceps skinfold (mm)	11.67	5.94	5.00	26.87	0.23	1.54	1.22
Back skinfold (mm)	10.00	4.68	4.93	23.56	0.18	1.61	2.09
Abdominal skinfold (mm)	12.43	7.53	4.27	31.36	0.18	1.27	0.66
Calf skinfold (mm)	12.36	5.92	5.00	26.98	0.16	1.30	0.89
Side steps (s)#	8.97	0.80	7.52	11.00	0.10	0.31	–0.48
Obstacle course backwards (s)#	12.11	3.12	2.70	21.90	0.07	0.09	1.46
One leg standing (s)	14.17	15.41	2.46	71.09	0.22	2.30	5.37
Seated straddle stretch (cm)	73.17	14.55	37.00	106.00	0.09	–0.26	–0.38
Darts (score)	38.75	8.76	30.00	65.00	0.30	1.33	0.99
Arm plate tapping (freq)	35.82	4.79	20.00	48.00	0.07	–0.19	1.14
Foot tapping (freq)	21.45	2.13	17.00	26.00	0.15	0.27	–0.86
Standing long jump (cm)	192.47	26.37	148.00	244.00	0.10	0.22	–1.03
Throwing a 2 kg medicine ball (m)	6.85	1.72	3.20	10.00	0.09	0.11	–0.87
20 m sprint (s)#	3.65	0.32	3.07	4.25	0.07	0.05	–1.05
60 seconds sit-ups (freq)	47.52	10.86	27.00	76.00	0.14	0.58	–0.24
Bent arm hang (s)	36.89	22.80	2.00	90.28	0.13	0.39	–0.92
						TEST = 0.18	

variable with opposite metric orientation; $\overline{X}$ – arithmetic mean, SD – standard deviation, Min – minimal result, Max – maximal result, KS – Kolmogorov-Smirnov test, Skew – coefficient of asymmetry, Kurt – coefficient of kurtosis

tion of the motor set into a morphological set is present here, which is then the basis for further development of the motor set which predominantly determines the development of superior quality in karate.

Factor responsible for structuring and/or movement regulation (information component of movement is dominant) is the third most important factor in prediction of fighting efficiency of young male karateka. Integration of agility, aerobic endurance, synergetic regulation and speed of movement frequency into a unique motor structure is of particular importance in specific agility – mobility in terms of assuming a fighting stance – guard, i.e. initial position for realization of all techniques either in attack or defense during a karate fight.

In the process of development of sports quality of karateka, selection must be based on a reversed order in relation to the obtained order of size of contribution to fighting efficiency. Thus, first, a selection must be made based on development of basic motor abilities: speed of movement frequency, balance, followed by coordination/agility and muscle endurance. Reached level of development of these motor abilities is the basis for further development of flexibility, repetitive core strength, and explosive power of upper and lower extremities, followed by development of muscle and bone tissue. Described dynamics of the morphological and motor development is reflected on development of technical and fighting efficiency of young male karateka.

TABLE 2
VARIMAX FACTORS OF MORPHOLOGICAL SPACE (V) IN YOUNG MALE KARATEKA AGED 13–15 (N=60)

Variables	V1	V2
Body height (cm)	0.92	–0.12
Arm length (cm)	0.83	–0.05
Leg length (cm)	0.84	–0.18
Hand length (cm)	0.84	–0.27
Knee diameter (cm)	0.81	0.29
Elbow diameter (cm)	0.88	0.15
Wrist diameter (cm)	0.84	–0.05
Hand diameter (cm)	0.88	–0.03
Body mass (kg)	0.87	0.44
Upper arm circumference flexed (cm)	0.75	0.51
Upper arm circumference relaxed (cm)	0.79	0.54
Forearm circumference (cm)	0.89	0.34
Thorax circumference (cm)	0.81	0.45
Calf circumference (cm)	0.72	0.60
Triceps skinfold (mm)	–0.14	0.92
Back skinfold (mm)	0.11	0.95
Abdominal skinfold (mm)	0.06	0.95
Calf skinfold (mm)	0.01	0.93
Eigenvalues	9.80	5.16
% of Variance	0.54	0.29
Cumulative %	0.54	0.83

Table 5 shows basic statistical parameter of morphological motor space of young female karateka. Distribution of results in the morphological and motor space of all variables was within normal parameters, except for shooting a target variable in the motor set of variables.

In female karateka, three factors were isolated by factor analysis in the morphological space, which explain 72% of the total variability of subjects (Table 6).

The first varimax factor was defined by high projections of variables for assessing subcutaneous fat tissue and somewhat lower projections of variables for assessing body mass and volume. The structure of this factor describes an endo-mesomorph somatotype, and it is the main feature of young female karateka because it explains 32% of their total variability.

The second varimax factor was predominantly defined by variables for assessing longitudinal dimensionality of the skeleton, accompanied by medium projections of variables for assessing body mass and volume and as such, describes an ecto-mesomorph somatotype. Such morphological structure can be found in 24% of young female karateka.

The third varimax factor was defined by variables for assessing transverse dimensionality of the skeleton, particularly of hand and wrist, and it can be found in 16% of young female karateka.

TABLE 3
VARIMAX FACTORS OF MOTOR SPACE (V) IN YOUNG MALE KARATEKA AGED 13–15 (N=60)

Variables	V1	V2	V3
Side steps (s)#	–0.72	–0.42	–0.11
Obstacle course backwards (s)#	–0.50	–0.41	0.37
One leg standing (s)	0.68	0.05	–0.06
Seated straddle stretch (cm)	0.35	0.55	–0.13
Darts (score)	0.12	0.14	0.82
Arm plate tapping (freq)	0.65	0.27	0.38
Foot tapping (freq)	0.52	0.34	–0.05
Standing long jump (cm)	0.56	0.64	0.13
Throwing a 2 kg medicine ball (m)	0.12	0.81	0.25
20 m sprint (s)#	–0.40	–0.77	0.08
60 seconds sit-ups (freq)	0.05	0.72	0.15
Bent arm hang (s)	0.74	0.11	0.18
Eigenvalues	3.11	3.06	1.12
% of Variance	0.26	0.25	0.09
Cumulative %	0.26	0.51	0.60

#variable with opposite metric orientation

Processes of differentiation have led to the formation of three morphological dimensions – structures in young female karateka. Thus, in addition to the first morphological dimension which integrates endomorphy and mesomorphy into an endo-mesomorphic somatotype, two factors of the skeleton were identified, these being: the one responsible for skeletal growth in length and the other one responsible for skeletal growth in width. Herein, transverse skeletal dimensionality of the arms enables greater manifestation of power and therefore a more efficient realization of blocks and kicks.

Factors of motor space in young female Croatian karateka are presented in Table 7. Three significant factors obtained explain 66% of the total variability of subjects in the motor variable set.

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

Factor	r	β	p
1. Ecto–mesomorphy	0.36	0.48	0.00
2. Endomorphy	–0.15	–0.20	0.12
3. Movement regulation (muscle endurance/agility)	0.25	0.34	0.00
4. Force regulator (explosive power)	0.54	0.73	0.00
5. Precision	0.09	0.12	0.27
ρ		0.63	0.00
δ		0.40	0.00

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

TABLE 5
DESCRIPTIVE STATISTICS OF VARIABLES (OF MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES) IN YOUNG FEMALE KARATEKA AGED 13–15 (N=51)

Variables	$\overline{X}$	SD	Min	Max	KS	Skew	Kurt
Body height (cm)	163.93	6.52	149.50	175.00	0.09	–0.17	–0.76
Arm length (cm)	69.49	3.41	61.70	77.60	0.14	–0.34	0.25
Leg length (cm)	96.41	4.67	78.50	105.00	0.10	–0.92	2.98
Hand length (cm)	17.77	1.43	14.80	20.30	0.11	–0.12	–1.01
Knee diameter (cm)	8.89	0.35	8.00	9.80	0.12	–0.17	0.62
Elbow diameter (cm)	5.96	0.31	5.10	6.50	0.10	–0.30	–0.14
Wrist diameter (cm)	5.02	0.26	4.40	6.10	0.14	1.15	5.47
Hand diameter (cm)	7.13	0.40	6.20	8.10	0.12	–0.08	0.11
Body mass (kg)	52.99	8.40	36.60	74.30	0.11	0.44	–0.02
Upper arm circumference flexed (cm)	25.20	2.51	20.50	33.00	0.14	0.52	0.99
Upper arm circumference relaxed (cm)	23.42	2.29	18.50	30.20	0.10	0.22	0.99
Forearm circumference (cm)	21.84	1.48	18.00	26.30	0.08	0.13	0.96
Thorax circumference (cm)	79.98	5.55	64.50	88.90	0.09	–0.43	–0.29
Calf circumference (cm)	33.02	2.96	22.00	39.00	0.11	–0.61	2.96
Triceps skinfold (mm)	14.18	4.36	6.60	23.87	0.10	0.42	–0.58
Back skinfold (mm)	11.21	3.94	6.00	23.47	0.14	1.03	0.90
Abdominal skinfold (mm)	14.48	5.31	6.00	27.00	0.11	0.56	–0.59
Calf skinfold (mm)	13.32	4.32	5.50	26.13	0.14	0.78	0.40
Side steps (s)#	9.43	0.82	7.36	11.28	0.09	0.07	0.03
Obstacle course backwards (s)#	13.51	3.36	8.30	26.07	0.09	1.04	2.49
One leg standing (s)	11.88	9.88	1.78	52.95	0.20	2.24	5.97
Seated straddle stretch (cm)	84.57	15.84	59.00	119.00	0.11	0.27	–0.68
Darts (score)	37.35	8.33	30.00	65.00	0.24	1.42	1.93
Arm plate tapping (freq)	37.31	5.18	28.00	52.00	0.13	0.79	0.82
Foot tapping (freq)	21.88	2.29	17.00	26.00	0.10	–0.13	–0.69
Standing long jump (cm)	175.25	21.07	114.00	213.00	0.15	–0.75	0.68
Throwing a 2 kg medicine ball (m)	5.40	0.69	4.00	7.20	0.09	0.11	–0.14
20 m sprint (s)#	3.86	0.32	3.20	4.72	0.07	0.23	–0.03
60 seconds sit–ups (freq)	46.55	8.69	28.00	68.00	0.08	0.32	0.14
Bent arm hang (s)	32.25	16.09	3.21	71.41	0.08	0.16	–0.38
							TEST = 0.19

#variable with opposite metric orientation; $\overline{X}$ – arithmetic mean, SD – standard deviation, Min – minimal result, Max – maximal result, KS – Kolmogorov–Smirnov test, Skew – coefficient of asymmetry, Kurt – coefficient of kurtosis

The first isolated factor defines general motor efficiency in young quality female karateka, explaining 37% of the total variability. The factor integrates basic motor abilities: speed of movement frequency, explosive power, coordination, flexibility, balance and muscle endurance into a unique set (structure). This motor set is a compound of several regulators, particularly of: speed regulator, force regulator, movement structure regulator and muscle tone regulator and synergetic regulation. Integration of the abovementioned motor abilities, i.e. formation of this motor set is carried out accompanied by cognitive information processing[23,24].

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 of movement-sprinting explosiveness, and to a lesser extent, for manifestation of throwing explosiveness. Thus, realization 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 which is finally manifested through kicking and blocking techniques.

The third isolated factor was defined only by variable assessing precision, namely shooting precision, and it can be found in 11% of young female karateka. Psycho-

TABLE 6
VARIMAX FACTORS OF MORPHOLOGICAL SPACE (V) IN YOUNG FEMALE KARATEKA AGED 13–15 (N=51)

Variables	V1	V2	V3
Body height (cm)	0.02	0.95	0.05
Arm length (cm)	–0.11	0.87	0.22
Leg length (cm)	0.07	0.85	0.12
Hand length (cm)	–0.28	0.16	0.75
Knee diameter (cm)	0.47	0.23	0.43
Elbow diameter (cm)	–0.05	0.30	0.48
Wrist diameter (cm)	–0.08	0.03	0.62
Hand diameter (cm)	0.20	0.04	0.76
Body mass (kg)	0.63	0.71	0.18
Upper arm circumference flexed (cm)	0.74	0.43	0.31
Upper arm circumference relaxed (cm)	0.74	0.39	0.39
Forearm circumference (cm)	0.60	0.43	0.57
Thorax circumference (cm)	0.59	0.65	0.18
Calf circumference (cm)	0.59	0.52	0.22
Triceps skinfold (mm)	0.88	–0.13	–0.06
Back skinfold (mm)	0.82	0.01	–0.19
Abdominal skinfold (mm)	0.87	0.01	–0.09
Calf skinfold (mm)	0.83	–0.06	–0.32
Eigenvalues	5.80	4.28	2.85
% of Variance	0.32	0.24	0.16
Cumulative %	0.32	0.56	0.72

TABLE 7
VARIMAX FACTORS OF MOTOR SPACE (V) IN YOUNG FEMALE KARATEKA AGED 13–15 (N=51)

Variables	V1	V2	V3
Side steps (s)#	–0.76	0.39	0.14
Obstacle course backwards (s)#	–0.53	0.36	–0.30
One leg standing (s)	0.58	0.28	0.37
Seated straddle stretch (cm)	0.63	–0.32	0.22
Darts (score)	–0.05	0.10	–0.93
Arm plate tapping (freq)	0.82	0.06	–0.01
Foot tapping (freq)	0.86	–0.14	0.00
Standing long jump (cm)	0.83	–0.22	0.12
Throwing a 2 kg medicine ball (m)	0.54	–0.47	0.16
20 m sprint (s)#	–0.42	0.70	0.10
60 seconds sit–ups (freq)	–0.04	–0.89	0.14
Bent arm hang (s)	0.54	–0.27	0.21
Eigenvalues	4.46	2.12	1.28
% of Variance	0.37	0.18	0.11
Cumulative %	0.37	0.55	0.66

variable with opposite metric orientation

motor precision will, to a certain extent, determine the basic, but also the specific motor efficiency of young female karateka.

After the factors of morphological and motor space have been identified, regression correlation analysis was used between those factors, i.e. latent variables and success in a karate fight (Table 8). A set of 6 factors which included 3 morphological and 3 motor factors, was a good predictor of success in young female Croatian karateka, which was indicated by fairly high multiple correlation (ρ=0.77).

Two motor factors made significant contribution in determining fighting efficiency of young female karateka: firstly, the set integrating regulators of speed, force and agility/coordination, accompanied by regulator of muscle tone and synergetic regulation, and secondly, factor of basic core strength which enables the initial energy component in the realization of techniques, especially of kicks. Out of morphological factors, transverse dimensionality of the skeleton, particularly of the hand, significantly determines the fighting efficiency of young female karateka.

The results show that the motor factor integrating basic abilities of speed of movement frequency, explosive power of horizontal jumping and agility, along with muscle tone regulation, determines the fighting efficiency of young female karateka to the largest extent. Namely, quick, explosive and agile movements of the appropriate muscle tone and amplitude are fully expressed in all segments of a karate fight, primarily in situational mobility and reaction speed.

The second most important motor factor which determines the fighting efficiency of young female karateka is the factor integrating basic core strength and sprinting ability, and therefore the relation between anaerobic-aerobic (repetitive core strength) and anaerobic (sprinting explosive power) energy consumption. Factor of basic strength is particularly expressed in the realization of kicks and blocks, because in order for the techniques, primarily kicks, to be efficient, they must be powerful enough, therefore with adequate energy consumption.

TABLE 8
REGRESSION ANALYSIS RESULTS FOR FIGHTING SUCCESS CRITERION IN THE FACTOR SPACE OF MORPHOLOGY AND MOTOR ABILITIES OF YOUNG FEMALE KARATEKA (N=51)

Factor	r	β	p
1. Endo–mesomorphy	–0.10	–0.12	0.21
2. Longitudinality of the skeleton	–0.11	–0.14	0.18
3. Skeletal transversality of the arms	0.16	0.22	0.04
4. Speed/Leg explosiveness and agility/coordination	0.42	0.57	0.00
5. Core strength#	–0.30	–0.40	0.00
6. Precision	0.09	0.12	0.23
ρ		0.77	0.00
δ		0.59	0.00

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

The first and the second motor factor complete each other in the prediction of fighting efficiency of young female karateka. However, growth and development in itself, as well as karate training, will simultaneously affect the development of basic strength and the development of muscle mass-muscle tissue and the development of the skeleton-bone tissue. Precisely the development of skeletal transversality of the hand contributes significantly to the development of superior quality of young female karateka.

Different morphological structures were isolated by factor analysis according to gender. In male karateka aged 13–15, as a consequence of puberty spurt, increased development of the skeleton-body height and muscle tissue-muscle mass occurs, which leads to the formation of two morphological factors: ecto-mesomorphy and fat tissue. In female karateka, development differentiation occurs which leads to the formation of three morphological structures which describe: endo-mesomorph somatotype, ecto-mesomorph somatotype and transverse dimensionality of the skeleton, particularly of hand and wrist.

Also, different motor structures were isolated by factor analysis according to gender. In male karateka: the first factor responsible for cortical regulation of movement, the second one responsible for power-force regulation and the third one named precision. In female karateka: the first factor integrating regulators of speed, force, movement structures and muscle tone with synergetic regulation, the second one responsible for energy regulation integrating core strength and sprint, and the third one named precision.

Latent structure of fighting efficiency in karate differs according to gender. Two morphological factors, namely force regulator and factor of cortical regulation of movement, and one morphological factor defined as ecto--mesomorphy factor have a significant impact in determining success in male karateka. In determining fighting efficiency of young female karateka, two motor factors have significant impact, namely: the first factor integrating regulators of speed, force and agility/coordination, accompanied by 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 efficiency of young female karateka.

Specific agility, i.e. mobility of karateka in different directions is of particular importance for success in a fight. Good mobility enables avoidance of opponents' attacks and assuming optimal position for efficient realization 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 attacking success 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.

Generally, it can be conclude 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 not a single characteristic of performance that dominates a fighting sport[25]. Karate athletes must perform several high intensity actions during a match. Top level karateka have a high level of body fitness, and, according to Becker and Bell[26], fight in karate is considered a high intensity competition. Also, karate success depends more on speed of contractions than on muscle power/strength[27].

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REFERENCES

1. KATIĆ R, JUKIĆ J, MILIĆ M, Coll Antropol, 36 (2012) 555. — 2. KATIĆ R, BLAŽEVIĆ S, KRSTULOVIĆ S, MULIĆ R, Coll Antropol, 29 (2005) 79. — 3. BLAŽEVIĆ S, KATIĆ R, POPOVIĆ D, Coll Antropol, 30 (2006) 327. — 4. KATIĆ R, BLAŽEVIĆ S, ZAGORAC N, Coll Antropol, 34 (2010) 1341. — 5. KATIĆ R, JUKIĆ J, GLAVAN I, IVANIŠEVIĆ S, GUDELJ I, Coll Antropol, 33 (2009) 123. — 6. SINNING WE, Body composition and athletic performance. In: CLARKE DH, ECKERT HM (Eds) Limits of human performance (Il Human kinetics publishers, Champaign, 1985). — 7. GIAMPIETRO M, PUJIA A, BERTINI I, Acta Diabetol, 40 (2003) S145. DOI: 10.1007/s00592-003-0049-3. — 8. PIETER W, BERCADES TL, Braz J Biomotricity, 3 (2009) 21. — 9. ANDREOLI A, MONTELEONE M, VAN LOAN M, PROMENZIO L, TARANTINO U, DE LORENZO A, Med Sci Sports Exerc, 33 (2000) 507. — 10. BOUHLE E, JOUINI A, GMADA N, NEFZI A, BEN ABDALLAH K, TABKA Z, Sci Sports, 21 (2006) 285. DOI: 10.1016/j-scispo.2006.08.003. — 11. BUTIOS S, TASIKA N, J Sports Med Phys Fitness, 47 (2007) 179. — 12. YOON J, Sports Med, 32 (2002) 225. DOI: 10.2165/00007256-200232040-00002. — 13. SMITH M, J Sports Sci Med, 5 (2006) 74. — 14. BENEKE R, BEYER T, JACHNER C, ERASMUS J, HÜTLER M, Eur J Appl Physiol, 92 (2004) 518. DOI: 10.1007/s00421-004-1073-x. — 15. IMAMURA H, YOSHIMURA Y, UCHIDA K, NISHIMURA S, NAKAZAWA A, Appl Human Science, 17 (1998) 215. DOI: 10.2114/jpa.17.215. — 16. FRANCESCATO MP, TALON T, DI PRAMPERO PE, Eur J Appl Physiol Occup Physiol, 71 (1995) 355. DOI: 10.1007/BF00240417. — 17. RAVIER G, GRAPPE F, ROUILLON JD, Sci Sports, 18 (2003) 134. DOI: 10.1016/S0765-1597(03) 00114-X. — 18. ROSCHEL H, BATISTA M, MONTEIRO R, BERTUZZI RC, BARROSO R, LOTURCO I, UGRINOWITSCH C, TRICOLI V, FRANCHINI E, J Sports Sci Med, 8 (2009) 20. — 19. WORLD KARATE

FEDERATION (WKF): New Kata and Kumite Rules ŠVersion 7.1Ć. Effective 01.01.2012. — 20. PROBST MM, FLETCHER R, SEELIG DS, J Strength Cond Res, 21 (2007) 451. DOI: 10.1519/00124278-200705000-00028. — 21. MORI S, OHTANI Y, IMANAKA K, Hum Mov Science, 21 (2002) 213. DOI: 10.1016/S0167-9457(02)00103-3. — 22. KATIĆ R, SRHOJ LJ, PAŽANIN R, Coll Antropol, 29 (2005) 711. — 23. KATIĆ R, BALA G, Coll Antropol, 36 (2012) 69. — 24. KATIĆ R, BALA G, BAROVIĆ Z, Coll Antropol, 36 (2012) 563. — 25. BEEKLEY M, ABE T, KONDO M, MIDORIKAWA T, YAMAUCHI T, J Sports Sci Med, 5 (2006) 13. — 26. BAKER JS, BELL W, J Hum Mov Stud, 19 (1990) 69. — 27. RAVIER G, GRAPPE F, ROUILLON JD, J Sports Med Phys Fitness, 44 (2004) 349.

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UTJECAJ MORFOLOŠKIH I MOTORIČKIH DIMENZIJA NA USPJEH U KARATEU KARATAŠA I KARATAŠICA MLAĐEKADETSKOG UZRASTA

S A Ž E T A K

Cilj rada je izvršiti identifikaciju morfoloških i 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 18 morfoloških mjera i skup od 12 motoričkih testova. Faktorska analiza je izolirala različite morfološke strukture u odnosu na spol. Kod karataša dva morfološka faktora, imenovana: ektomezomorfija i masno tkivo. Kod karatašica tri, imenovana: endomezomorfni somatotip, ektomezomorfni somatotip i transverzalna dimenzionalnost skeleta i to posebno šake i ručnog zgloba. Isto tako faktorska analiza je izolirala i različite motoričke strukture u odnosu na spol. Kod karataša: prvi faktor odgovoran za kortikalnu regulaciju kretanja, drugi odgovoran za regulaciju snage-sile i treći preciznost. Kod karatašica: prvi integrira regulatore brzine, sile, kretnih struktura i mišićnog tonusa te sinergijske regulacije, drugi odgovoran za energetsku regulaciju integrira snagu trupa i sprint i treći preciznost. Latentna struktura borbene efikasnosti u karateu je različita u odnosu na spol. Kod karataša u determinaciji uspjeha značajni doprinos imaju dva motorička faktora i to regulator sile i faktor kortikalne regulacije kretanja i jedan morfološki definiran kao faktor ektomezomorfije. U determinaciji borbene efikasnosti mladih karatašica značajni doprinos imaju dva motorička faktora i to: prvi koji integrira regulatore brzine, sile i agilnosti/koordinacije što prati regulator mišićnog tonusa i sinergijske regulacije i drugi faktor bazične snage trupa koji osigurava početnu energetsku komponentu u realizaciji tehnika posebno udaraca. Od morfoloških faktora transverzalna dimenzionalnost skeleta posebno šake značajno determinira borbenu efikasnost mladih karatašica.