ORIGINAL ARTICLE

The influence of morphological characteristics on the specific motor skills of junior-age karate athletes

Dušica Rakita [1] • Dušan Rakonjac [1]✉ • Mila Vukadinović-Jurišić [1] • Jelena Obradović [1]

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Abstract

The aim of this study was to determine the relations between morphological characteristics and specific motor skills of karate athletes, where by the obtained results would be used in better planning and programming of training. Twenty-five young adults karate athletes (15.32 ± 0.22 years) members CC "Šotokan" from Loznica with a sports experience of not less than 8 years participated in this study. The research involved the measurement of certain morphological characteristics and specific motor skills of forward hand punch and foot strikes using standardized tests. The application of the regression analysis showed that there is a statistically significant influence of the system of predictor variables on the criterion variables ($p \leq 0.05$) reverse punch - gyaku-zuki (P=0.00), lunge punch - oi-zuki (P=0.00) and front kick - mae-geri (P=0.01). The total variability ranged from 50% of the criterion of the front kick - mae-geri to 60% of the criterion of lunge punch - oi-zuki. The values of the standardized regression coefficient Beta indicate the individual positive and statistically significant influence of the body height and muscle mass variables on the criteria tested: gyaku-zuki, oi-zuki and mae-geri, and the negative impact of the body weight variable on the oi-zuki criterion ($p_\beta \leq 0,05$). A positive influence of the overall body water quantity variable on the gyaku-zuki criterion ($p_\beta \leq 0,05$) was also determined. It can be concluded that there is a connection between the morphological characteristics and the specific motor skills of junior-age karate athletes from Loznica.

Keywords martial arts • motor skills • body composition

✉ rakonjac992@gmail.com

[1] University of Novi Sad, Faculty of Sport and Physical Education, Novi Sad, Serbia

Introduction

Karate is today one of the most massive individual martial and non-Olympic sports, which is distinguished by two competition disciplines: form (kata) and sports fight (kumite) (Koropanovski et al., 2011; Tabben et al., 2013). Kata has a conventional structure were athletes perform predetermined series of movements and techniques in known order against imaginary opponents, whereas kumine involves overcoming competitor with a use of various movements, defensive and offensive techniques (Vujkov, Calleja-Gonzalez, Krneta, Drid, & Ostojić, 2015). Top performance and sports results in both disciplines are conditioned not only by the high level of technical performance but also by the high level of motor, morphological, functional abilities and mental stability (Amusa & Onyewadume, 2001; Jukić, Katić, & Blažević, 2012).

In one study (Sterkowicz, 1992), among thirteen athletes of kyokushin karate, the percentage of fat mass was 12.16 ± 2.31 %, while the percentage of lean body mass was 87.84 ± 2.22 %, and it is believed that karate athletes are characterized by predominantly low percentage of fat mass. The similar results are obtained in other researchers (Sterkowicz-Przybycień & Żarów, 2005; Chaabène, Hachana, Franchini, Mkaouer, &

Chamari, 2012).

However, the percentage of fat mass varies in different studies in karate athletes of different nationalities. Thus, karate athletes of Japan have 7.5% fat mass (Imamura et al., 1997), while Polish karate athletes have 16.8% (Sterkowicz-Przybycień, 2010). Abdel-Baser (2010) concluded that, in addition to the technique, the longitudinal dimensionality of the skeleton, accompanied by a lower percentage of fat, plays an important role in success in sport.

Analysis of anthropometric characteristics and sports performance (Koropanovski et al., 2011) on male karate athletes, members of the Serbian national team, showed that there is no statistically significant difference in body composition between the kumite and the kata athletes. However, in this study, it can be noticed that the kumite were larger in body dimensions compared to kate. If we are talking about comparing karate athletes of a different competitive level, the research by Giampietro, Puija, & Bertini (2003) found that there is no difference in the body composition between middle and high-level competitors, although the percentage of fat mass was much smaller at top competitors.

The influence of motor skills on sports performance (Ravier, Grappe, & Rouillon, 2003; Blažević, Katić, & Popović, 2006; Katić, Jukić, Glavan, Ivanišević, & Gudelj, 2009) have been investigated to a great extent, where the emission of explosive force, the speed of movement and coordination in karate is present in most of the above studies. Jukić et al. (2012) and Blažević et al. (2006) found that explosive power, speed and coordination have a dominant effect on success in karate, while a group of authors (Mori, Ohtani, & Imanaka, 2002; Ravier et al., 2003) conclude that technique, speed of reaction and ability to anticipate attacks by opponents are also crucial to success in karate. In their research, Katić et al. (2009) point out that sports performance is even more determined by the integration of defense and attack actions, such as the ability to operate combinations of techniques in a series, and that combat effectiveness is predominantly determined by specific speed and agility skills.

A group of authors (Vences Brito, Rodrigues-Ferreira, Cortes, Fernandes, & Pezarat-Correia, 2011) investigated specific motor skills through kinematic and electromyographic analysis of the straight punch (choku-tsuki) in karate athletes and non-athletes. The results of this study (Vences Brito et al., 2011) show that karate athletes achieve a better ballistic performance of the straight punch choku-tsuki, through greater angular velocity and the highest EMG value closer to the contact surface, with a tendency of lower volume and duration of the movement itself and with a higher contact force by the non-sportsman. This research also confirmed the results obtained by a group of authors by examining the effectiveness of ballistic movements in the performance of techniques (Zehr, Sale, & Dowling, 1997).

When it comes to the relations of morphological characteristics and specific motor skills, a very small number of research has been done so far. Therefore, the aim of the research was to determine the relations between morphological characteristics and specific motor skills of junior age karate athletes.

Method

Twenty-five male karate athletes (kata n=10; kumite n=15) of junior age (15.32 ± 0.22 years) participated in this study. All participants were members of CC "Šotokan" from Loznica and they were engaged in karate for at least 8 years (kata and kumite). Participants were trained at least 4 times a week, with a weekly scope of training of about 6 hours.

Body height was measured by the Martin anthropometer of 0.1 cm (GPM in Switzerland), while the body mass was measured on a calibrated beam balance platform scale to the nearest 0.1 kg.

A digital scale (Omron BF511, Serbia) was used to assess the body composition parameters: fat mass (%), muscle mass (%) and overall body water (%).

Specific motor tests in karate were used to assess specific motor skills and briefly described in Kovač, Trivun, & Bajrić (2012). Selected karate attacks with explanations (Witte, Emmermacher, Bandow, & Masik, 2012).

1) Kizami - Zuki (snapping the leading fist forward);
2) Gyaku - Zuki (reverse punch);
3) Oi - Zuki (lunge punch);
4) Mawashi - Geri (roundhouse kick) with front leg, and
5) Mae - Geri (front kick).

All tests of specific motor skills were carried out so that the karate athletes who were tested must make the first step to create and form an adequate distance, that is, the distance from the kicking hooks and to carry out as many times as possible the strikes that

meet the criteria of the pointing techniques in karate combat for 10 seconds (only properly executed techniques are taken into account). The result is expressed in the frequency of technically correct strokes.

Measurement was carried out at the sports hall of CC "Šotokan" in Loznica. During testing, the temperature ranged from 22 to 25ºC. Testing started at 10 a.m. and ended at 1 p.m. Anthropometric characteristics and body composition were measured in the morning. Specific motor tests were performed after measuring anthropometric characteristics and body composition. Before performing specific motor tests, the participants performed a warm-up. Each athlete performed a standardized 15-minute warm-up consisting of 5 min running and 10 min dynamic and static stretching.

The statistical data processing method determines the basic descriptive statistics of motor variables: the arithmetic mean (M), the standard deviation (S) of the minimum (Min), and the maximum (Max) value of the measurement results. To test the normal distribution, a Shapiro-Wilk test was used. In order to determine the impact of the system of predictor variables on the criterion variables, as well as the individual contribution of the predictor to the definition of criterion variables, Linear Regression Analysis was applied.

Results

The values of descriptive statistics are shown in Table 1. Based on the statistical significance of the Shapiro-Wilk coefficient, the distribution normalities of the analyzed variables can be estimated (S-W<0.05) (Table 1).

Table 1. Descriptive statistics of analysed variables karate athletes (N=25)

Variable	Min	Max	Mean	S	S-W
Kizami-Zuki (freq.)	8	11	9.24	0.93	0.10
Gyaku-Zuki (freq.)	8	10	9.20	0.76	0.12
Oi-Zuki (freq.)	7	11	9.24	1.23	0.38
Mawashi-Geri (freq.)	8	12	10.00	0.96	0.27
Mae-Geri (freq.)	10	14	11.32	1.28	0.13
Body height (cm)	157.0	185.0	174.92	7.16	0.14
Body mass (kg)	46.3	81.0	63.25	9.18	0.43
Fat mass (%)	18.60	25.20	21.25	1.69	0.11
Muscle mass (%)	42.40	56.10	46.65	2.84	0.09
Overall body water (%)	48.00	54.40	51.46	1.67	0.71

Legend: Min-minimum values; Max-maximum values; Mean - arithmetic mean; S - standard deviation; S-W - level of significance of Shapiro Wilk test

Regression analysis of the variable Kizami-Zuki (Table 2) found that there was no statistically significant influence of the system of predictor variables on the criterion (P=0.12) at the value of the multiple correlation coefficient R=0.59, which explained 35% of the common variability of the predictor system and criteria. Taking into account the adjusted value of the coefficient of determination with respect to the small sample of the participants, considerable less values of the common variability (from 17%) are observed. In analyzing the sample on the speed of Kizami-Zuki, some other characteristics and abilities had a greater influence. However, the muscle mass had a statistically significant effect on Kizami-Zuki.

Table 2. Influence of morphological characteristics on Kizami-Zuki in karate athletes (N=25)

Variable	r	p	r_{part}	p_{part}	Beta	p_{β}
Body height (cm)	0.21	0.16	0.36	0.11	0.52	0.11
Body mass (kg)	0.05	0.40	-0.20	0.40	-0.27	0.40
Fat mass (%)	0.14	0.25	0.08	0.72	0.08	0.72
Muscle mass (%)	0.38	**0.03**	0.45	0.04	0.46	0.04
Overall body water (%)	0.18	0.20	0.18	0.07	0.39	0.07
R = 0.59	$R^2 = 0.35$		P = 0.12		Adjusted $R^2 = 0.17$	

Legend: r - Pearson coefficient of correlation; p - level of statistical significance for r; rpart - value of the partial correlation coefficient; ppart - level of statistical significance for rpart; Beta - regression coefficient; p_{β} - level of significance of regression coefficient; R - multi-correlation coefficient; R2 - determination coefficient; P - significance of the multi-correlation coefficient; adjusted R2 - coefficient of determination that is adjusted for small samples

Considering the results of the regression analysis of the Gyaku-Zuki (Table 3.), there is significant influence of the system of predictor variables on the criterion variable (P=0.00). The relatively high values of the multiple correlation coefficient R=0.75 explain 57% of the common variability (or 45% of the adjusted coefficient). Individual analysis, Beta coefficients shows that the participants with higher body height and muscle mass achieved significantly better results in the test. Higher values of the fat mass and overall body water did not reduce the speed and efficiency of performing this movement by hands. Based on the Pearson coefficient, fat mass and muscle mass were in positive statistically significant correlations (p=0.02, and p=0.01). Observing the values of the partial correlation coefficient for the variable body height, fat mass, muscle mass and body water, it can be noticed that the correlation with these predictor variables is statistically significant (ppart<0.01). However, body height appears as the dominant predictor of success in performing this test because the partial correlation coefficient increased with respect to the Pearson coefficient and became statistically significant (Table 3).

Table 3. Influence of morphological characteristics on Gyaku-Zuki in karate athletes (N=25)

Variable	r	p	r_{part}	p_{part}	Beta	p_{β}
Body height (cm)	0.29	0.08	**0.57**	**0.01**	**0.76**	**0.01**
Body mass (kg)	0.05	0.41	-0.42	0.06	-0.52	0.06
Fat mass (%)	**0.41**	**0.02**	**0.44**	**0.05**	**0.36**	**0.05**
Muscle mass (%)	**0.47**	**0.01**	**0.51**	**0.02**	**0.43**	**0.02**
Overall body water (%)	0.07	0.37	**0.47**	**0.03**	**0.37**	**0.03**
R = 0.75	$R^2 = 0.57$		P = 0.00		Adjusted $R^2 = 0.45$	

In Table 4. can be noted that the system of morphological variables is significantly related to the criterion (Oi-Zuki) (P=0.00). The value of the multi-correlation coefficient was relatively high (R=0.77), which described 60% of the common variability (observing the adjusted values of the coefficient of determination, this variation is slightly lower, 50%). Observing the values of the partial coefficient of correlation for the variables body height and muscles mass, the amount of muscles is seen to have increased in relation to Pearson's coefficient of correlation and other statistically significant (ppart≤0.01) coefficients. It is assumed that the remaining variables reduced the speed and efficiency of the movement of the arms during the arm movement in the forward direction with tall karateka and those with a higher total amount of muscle (Table 4). Taking into account the values of the partial coefficient of correlation for the body mass, the correlation is found to be negative (rpart=-0.47) and statistically significant (ppart=0.03).

Table 4. Influence of morphological characteristics on Oi-Zuki in karate athletes (N=25)

Variable	r	p	r_{part}	p_{part}	Beta	p_{β}
Body height (cm)	**0.38**	**0.03**	**0.64**	**0.00**	**0.87**	**0.00**
Body mass (kg)	0.08	0.35	**-0.47**	**0.03**	**-0.56**	**0.03**
Fat mass (%)	**0.39**	**0.03**	0.37	0.10	0.28	0,10
Muscle mass (%)	**0.52**	**0.00**	**0.55**	**0.01**	**0.46**	**0.01**
Overall body water (%)	-0.09	0.32	0.30	0.19	0.21	0.19
R = 0.77	R^2 = 0.60		P = 0.00		Adjusted R^2 = 0.50	

The results from Table 5. in Mawashi – Geri show that there is no influence of the system of predictor variables on the above criterion (P=0.06). The value of the multi-correlation coefficient R=0.64, which explained 41% of the common variability of the predictor system and criteria. Taking into account the adjusted values of the coefficient of determination with respect to the small sample of the respondents, considerably less values of the common variability (from 26%) are observed. Even though the variable body height has a significant impact on this foot kick ($p<0.05$).

Table 5. Impact of morphological characteristics on Mawashi-Geri in karate athletes (N=25)

Variable	r	p	r_{part}	p_{part}	Beta	p_{β}
Body height (cm)	0.40	**0.02**	0.55	0.01	0.86	0.01
Body mass (kg)	0.16	0.23	-0.37	0.10	-0.51	0.10
Fat mass (%)	0.28	0.09	0.35	0.13	0.31	0.13
Muscle mass (%)	0.16	0.22	0.16	0.50	0.13	0.50
Overall body water (%)	0.12	0.28	0.39	0.08	0.35	0.08
R = 0.64	R^2 = 0.41		P = 0.06		Adjusted R^2 = 0.26	

Interpretation of results in Table 6 indicates that there is influence of the system of predictor variables on the Mae-Geri criterion (P=0.01) at the value of the multiple correlation coefficient R=0.71, which explains 50% of the common variability (or 37% through the adjusted correlation coefficient). Observing muscle mass show a significant effect on the criterion (p_{β}=0.00). If the Pearson coefficient values are also taken into account, it can be assumed that karateka with higher body height, body mass, and muscle mass achieved, significantly ($p\leq0.05$) better results in mae-geri. By observing the partial correlation coefficient of the muscle mass (rpart = 0.61), it can be seen that the coefficient increased with respect to the Pearson coefficient and remained statistically significant (ppart = 0.00), so it can be assumed that other predictor variables only reduced the better performance of the test in karateka with a higher amount of muscle, and that it has the greatest predictive effect on the rapid performance of this test on a given sample of participants.

Table 6. Influence of morphological characteristics on Mae-Geri in karate athletes (N=25)

Variable	r	p	r_{part}	p_{part}	Beta	p_{β}
Body height (cm)	**0.43**	**0.02**	0.32	0.16	0.40	0.16
Body mass (kg)	**0.36**	**0.04**	0.12	0.60	0.14	0.60
Fat mass (%)	0.16	0.22	-0.07	0.75	-0.06	0.75
Muscle mass (%)	**0.49**	**0.01**	0.61	**0.00**	**0.60**	**0.00**
Overall body water (%)	-0.04	0.42	0.24	0.29	0.19	0.29
R = 0.71	R^2 = 0.50		P = 0.01		Adjusted R^2 = 0.37	

Discussion

The present study examined the influence and correlation between morphological characteristics and specific motor skills of junior age karate athletes. The major findings of this study were that morphological characteristics effect on specific motor skills in karate athletes from Loznica, of junior age.

The variability of the results ranged from 50% in the Mae-Geri criteria to 60% in the Oi-Zuki criteria. This relatively high percentage of commonly described variance points to the great role of anthropometric parameter; parameters of the body composition in effective, fast, precise and powerful execution of strokes with hands and feet. Based on the standardized Beta coefficient, the positive effect of body height and muscle mass, and the negative influence of body mass that were statistically significant ($p_{\beta} \leq 0.05$). On the basis of the stated data, it can be assumed that Oi-Zuki will be best performed by karateka with higher body height, lower body mass and a higher percentage of muscle. The justification of the results, should be sought in the properly learned technique of performing this specific motor skill and in their body composition. According to Gloc, Plewa, & Nowak (2012) karate athletes showed harmonious construction body and low-fat percentage. In Mae-Geri, it can be assumed that karate athletes with higher body height, body mass, and muscle mass achieved, significantly ($p \leq 0.05$) better results than other karate athletes. Muscles mass pointed to the very important role in the performance of fast and efficient kicking (Mae-Geri). Analyzed Gyaku-Zuki the results suggest that taller karateka with a higher percentage of muscle mass and overall body water had better results. It was interesting that the variable fat mass, had a positive effect on this criterion, which can be explained by varying body weight in karateka. Although fat mass is also changing, that phenomena have not adversely affected the speed and efficiency of the rapid arm forward stroke. Top profiled karateka with a slightly higher percentage of fat can be found in Japan (Imamura et al., 1997) and Poland where karateka have 16.8% (Sterkowicz-Przybycień, 2010), which does not greatly affect their combat effectiveness. The category of muscular strength tests and the speed that was investigated here through specific motor tests focuses on muscle groups so that they can produce force and speed of movement.

Of all the predicted variables analyzed, body height had the greatest impact on the expression of hand and foot strokes and the reasons for such results should be sought in the very technique of performing the movement and speed of movement in this group of karate athletes. It has been well established that karate practice requires by explosive, intermittent, and quick movements performed either by the upper or lower part of the athlete's body (Chaabene, et al., 2015).

The results of the research confirm the set research hypothesis, as well as the results of some previous research Abdel-Baser (2010) which found that, in addition to the technique, the longitudinal dimension of the skeleton (Body height) plays an important role in sporting performance in karate.

The remaining percentage can be attributed to the effects of other characteristics and abilities that were not part of this predictor system on the criteria examined. Such results indicate that the predicator variables largely determine the performance of hand and leg strokes in karate.

Despite many befits observed in this study there are a few limitations. Firstly, we have investigated only male karate athletes, while female karate athletes were not included. Secondly, we analyzed influence body composition parameters and some anthropometrics parameters (body height and body mass) without other parameters (skinfold, body mass index, circumference). Thirdly, we analyzed all karate athletes regardless of whether they belong to kata or kumite. Future studies should consider influence morphological characteristics depending on whether they belong kata or kumite. Also, for future studies it would be interesting to examine the impact of morphological characteristics on the frequency of strokes in a combat in kumite.

In conclusion, the present study showed influence of morphological characteristics on specific motor skills in karate athletes junior age. The obtained results can contribute to the improvement of the physical characteristics of karateists, with an emphasis on body mass building. The results of the research draw attention to the need for further correction of body material and further planning of training work.

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