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Biomotor Systems in Elite Junior Judoists

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A B S T R A C T

The aim of the study was to assess the impact of motor abilities and morphological characteristics on junior judoka performance. A set of 14 morphological parameters and a set of 14 motor tests as predictor variables, and 3 variables evaluating judo performance as criteria were applied in a sample of 40 judoists aged 17 years ±6 months. Three factors were isolated by factor analysis in morphological area: factor of muscle mass and bone volume (muscle and bone mass – mesoectomorphy), factor of longitudinal skeleton dimensionality, and factor of subcutaneous adipose tissue (endomorphy). Four factors were isolated by factor analysis in motor area: factor of coordination and strength (regulated force), factor of movement frequency (speed), factor of muscular and cardiovascular endurance (endurance), and factor of tonus regulation and synergy regulation (flexibility/balance). Canonical correlation analysis between latent morphological and motor variables, and variables for assessment of competitive performance of junior judoists yielded two linear combinations, i.e. two pairs of canonical factors. Correlation in the first pair of canonical factors was underlain by the favorable impact of coordination/strength, speed, flexibility and balance, along with above-average muscle mass and bone volume, and above-average skeleton longitudinality on performance in judo. Correlation in the second pair of canonical factors was based on positive determination of above-average endurance along with moderate coordination/strength and speed, and below-average muscle mass and bone volume and skeleton longitudinality upon judo performance as expressed by the fight winning score.

***Key words**: elite judo, morphological and motor structures, fighting efficiency*

Introduction

Studies based on structural and biomechanical judo analysis[1–4] suggest that three motor-functional abilities, i.e. strength, coordination and aerobic-anaerobic endurance, may be crucial for judo performance. During judo fight, all strength types (i.e. maximal, repetitive, explosive and static strength) are employed, thus stronger judoists being at an advantage over their opponents of comparable technical skills. It is desirable that total body mass is predominated by muscle tissue. An excess of subcutaneous adipose tissue implies greater total body mass, leading to a higher category, which generally diminishes the chances for success at contest.

As current judo regulations impose a very high fight dynamics (the mean heart rate in fight is about 180 beats *per* minute), hard work performance is expected from judoists on training and at contest, which requires great psychophysical strain. This in turn entails an increased nervous and muscular adaptation to training load, resulting in muscle hypertrophy, bone-ligament changes, cardiac muscle hypertrophy, and an increase in all vital function capacities[5].

Gualdi-Russo and Graziani (1993)[6] estimated morphological status in Italian elite judoists. They performed somatotyping according to Heath-Carter scale in 1593 male and female athletes from various sports. A predominance of the mesomorphic (muscle) component over endomorphic and ectomorphic components was found in gymnasts, rowers and judoists in particular. Krawcyzk et al. (1997)[7] conducted a large study determining Heath-Carter somatotypes in a sample of 300 athletes (66 of them judoists) from various sports (volleyball, rowing, wrestling, boxing, judo and karate). Like the Italian authors above, they also recorded a very high mesomorphic component in judoka, where muscle component was most pronounced, immediately following wrestlers. The mean somatotype in judoists was endomorphy 2.84, mesomorphy 6.07 and ectomorphy 1.51.

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Relations among morphological, motor-functional and technical variables in elite judoists were observed by Franchini et al. (2001a)[1]. They analyzed the number of attacks by a particular technique in fight and correlated it with the morphological and motor-functional characteristics. Their results indicated the judoists with a lower proportion of adipose tissue and high anaerobic capacity to have a higher rate of attempted use of various techniques in fight. They also conclude that arm techniques are more energy demanding than leg techniques.

Takeuchi et al. (1999)[4] point to the role of basic physical preparation in judoists. They report on a higher level of basic motor abilities in the judoists of higher contest performance. Major differences between judoists of different quality were recorded on static strength testing in favor of higher quality judoists, according to weight categories. Monteiro et al. (2001)[3] conducted a similar study in 18 judoists divided into two groups according to success at international contests. They used a battery of tests to assess morphological features, and basic and specific motor abilities. Statistically significant differences between the two groups were obtained in tests of specific endurance, forearm grabbing strength, and flexibility.

Significant differences between elite and non-elite fighters in specific judo-fitness test for endurance assessment were confirmed by Franchini et al. (2001b)[2]. These authors also found significant between-group differences in some morphological measures, e.g., contracted triceps circumference and forearm circumference were significantly greater in elite judoists. In addition, elite judoists had higher stature relative to leg length.

Jagiello et al. (2004)[8] investigated strength development in children and adolescents engaged in judo. The aim of the study was to compare the development of various strength types between the children without sports engagement and those on active judo training. Study results revealed significant differences in strength endurance between the children and adolescents engaged in judo training, and a control group without such a sports engagement. The older the children and the longer their engagement in judo training, the higher was the level of difference significance.

The main aim of the present study was to assess the impact of motor abilities and morphological characteristics on junior judoist performance. In order to recognize particular phases in acquiring comprehensive information on the biomotor systems in junior elite judoists, the following partial aims were set in line with the main one:

- to determine latent structure of the (a) morphological status and (b) motor abilities in a sample of currently top Croatian junior elite judoists; and
- to determine the association of latent morphological characteristics and motor abilities with the junior judoist performance as expressed by the manifest variables of fight efficiency.

Subjects and Methods

Subject sample

Study sample included 40 junior judoists, mean age 17 years ±6 months. Testing was performed in all seven regular judo junior weight categories (<60, 66, 73, 81, 90, 100 and >100 kg), attending a camp organized by the Croatian Judo Association (CJA) in Split. As judoists from all regions of Croatia attended the camp, the sample could be considered representative and relevant for the study objectives. The subjects had been actively training judo for 4 to 10 years, and none of them had a category lower than blue belt.

Variable sample

The set of variables used on assessment of morphological characteristics included 14 standard anthropometric measures evaluating the following four anthropometric dimensions[9–13]:

- longitudinal skeleton dimensionality: body height, leg length, arm length, and biacromial breadth;
- transverse skeleton dimensionality: bitrochanter breadth, wrist breadth, and femur breadth;
- body mass and volume: body weight, forearm girth, calf girth, and chest girth; and
- subcutaneous adipose tissue: triceps skinfold, subscapular skinfold, and abdominal skinfold.

The relevant basic motor abilities of junior judoists were evaluated by use of 14 standard motor tests. Twelve of these tests were previously used on several occasions[9, 14–16], only the 6-min run was now used instead of 3-min run, and two new tests were introduced, i.e. push-ups and 60-m run. The following tests were chosen for:

- assessment of coordination: backward polygon and floor agility;
- assessment of flexibility and equilibrium: sit and reach flexibility test and astride standing on equilibrium bench (bench standing);
- assessment of movement frequency: hand tapping and foot tapping;
- assessment of explosive strength: small ball throw, standing long jump, 20-m run, and 60-m run;
- assessment of repetitive strength: trunk lifting with legs bent (sit-ups) and push-ups; and
- assessment of muscle and aerobic endurance: hang with elbows bent (bent arm hang) and 6-min run.

All junior judoists had previously participated in three criterion contests (according to CJA regulations), one of these being Croatia Championship. The contest performance of the study subjects was evaluated by three criterion variables, as follows:

- ranking score – score sum from three contests (ranking at each of the three criterion contests was allocated respective score: 5 points for first place, 4 points for second place, 3 points for third place, 2 points for fifth place, and 1 point for lower places. Points from all

three contests were summed up, yielding a score range of 3 to 15 points in all study subjects);

- number of wins – sum of wins from three contests (as a varying number of contestants were present in different weight categories, reaching finals or winning was determined by a variable number of fights. So, in some weight categories a series of three wins were required to win the contest, whereas in others the respective figure amounted to six wins. Therefore, another criterion variable of contest performance, i.e. total number of wins at three contests, had to be defined); and
- technical score – total technical points from three contests (the third criterion variable of contest performance included total score of all technical points from all three contests for each individual judoist. At judo contests, a fighter wins with one of the four possible results expressed in technical points, i.e. 3:0, 5:0, 7:0 or 10:0. Even score is not anticipated by judo rules).

By use of these three criterion variables, the possibility of error on assessing the real contest efficiency of study subjects was minimized.

The study was expected to produce model values of anthropometric and motor status of elite junior judoists. The results obtained in the study will be useful in upgrading objective selection of junior judoists as well as in subsequent monitoring their performance.

Statistical analysis

The following statistical methods were used on data analysis: factor analysis to determine factor structure in the samples of morphological variables and motor variables (calculations: V1… – significant varimax factors according to Guttman-Kaiser criterion of $\lambda>1$; Lambda – characteristic values; Variance % – percentage of variance explained by each latent dimension); and canonical correlation analysis to determine relations between latent morphological and motor variables, and the set of variables for assessment of contest performance (CAN – structure of canonical variable; Can R – canonical coefficient of correlation; Can R^2 – coefficient of canonical determination; p – level of significance).

Results and Discussion

Table 1 shows results of factor analysis (varimax rotation) of the variables assessing morphological characteristics of junior judoists, where V1, V2 and V3 = significant varimax factors according to Guttman-Kaiser criterion ($\lambda>1$); Lambda = characteristic values; and Variance % = percentage of variance explained by each latent dimension. Factor analysis isolated three dimensions which taken together explained 82% of total variability of the system observed.

As illustrated in Table 1, the measures of body mass and volume, and of transverse skeleton dimensionality elicited highest projection upon the first varimax factor (V1). Two presumably independent latent dimensions were observed to have integrated into a single factor. This integration can be explained as follows. Large and massive bone surfaces generally are more tightly connected with muscle tendons and ligaments. In addition to reducing the potential lesions, these bonds enable work with greater external load in athletes, which eventually leads to better musculature development. This process is of a cause-and-effect character, i.e. muscles as well as the bone-ligament and tendon apparatus are strengthened by training. In other words, the judoists with greater

TABLE 1
DESCRIPTIVE STATISTICS (X±SD) AND RESULTS OF FACTOR ANALYSIS (VARIMAX ROTATION) OF VARIABLES ASSESSING MORPHOLOGICAL CHARACTERISTICS OF JUNIOR JUDOISTS

Variable	X±SD	V 1	V 2	V 3
Stature	180.60±7.08	0.37	0.86	0.13
Leg length	103.51±5.22	0.00	0.95	0.10
Total arm length	81.14±4.20	0.18	0.92	0.12
Biacromial breadth	40.69±2.27	0.49	0.08	0.54
Bitrochanter breadth	28.50±1.98	0.69	0.47	0.07
Wrist breadth	5.87±0.33	0.83	0.26	0.02
Femur breadth	9.97±0.52	0.67	0.54	0.35
Body mass	76.91±13.29	0.80	0.32	0.43
Forearm girth	95.81±7.26	0.72	0.16	0.50
Calf girth	27.33±2.09	0.89	–0.06	0.28
Chest girth	37.12±3.36	0.80	0.08	0.45
Triceps skinfold	7.57±2.05	–0.04	0.32	0.82
Subscapular skinfold	8.42±2.12	0.43	0.00	0.84
Abdomen skinfold	8.22±3.07	0.36	0.07	0.83
Lambda		4.91	3.33	3.24
Variance %		35.07	23.79	23.14

V – significant varimax factors, Lambda – characteristic values, Variance % – percentage of variance explained by a particular factor

TABLE 2
DESCRIPTIVE STATISTICS (X±SD) AND RESULTS OF FACTOR ANALYSIS (VARIMAX ROTATION) OF VARIABLES ASSESSING MOTOR ABILITIES IN JUNIOR JUDOISTS

Variable	X±SD	V 1	V 2	V 3	V 4
Polygon backward#	8.05±1.21	–0.77	–0.12	–0.34	–0.03
Floor agility#	9.16±1.40	–0.71	0.05	–0.46	–0.27
Bench standing	8.64±1.99	0.06	0.31	0.17	0.85
Sit and reach	72.98±11.21	0.04	0.00	–0.04	0.95
Hand tapping	39.28±3.91	0.09	0.88	0.17	0.29
Foot tapping	44.23±4.53	0.27	0.63	0.54	0.06
Ball throw	41.66±7.57	0.38	0.68	0.26	0.11
Standing long jump	252.58±15.63	0.72	0.32	0.11	0.29
20-m run#	3.28±0.16	–0.70	–0.59	0.15	0.06
60-m run#	8.41±0.50	–0.73	–0.55	0.11	0.07
Sit-ups	55.95±7.93	0.65	0.14	0.05	–0.01
Push-ups	41.48±11.68	0.72	0.10	0.35	–0.02
Bent arm hang	53.71±16.36	0.23	0.11	0.81	0.11
6-min run	1487.1±127.0	0.07	0.13	0.81	–0.01
Lambda		3.86	2.44	2.24	1.90
Variance %		27.57	17.43	16.00	13.57

#variable with opposite metric orientation, V – significant varimax factors, Lambda – characteristic values, Variance % – percentage of variance explained by a particular factor

transverse skeleton dimensionality measures had superior musculature development. Thus, the first varimax factor could be described as a factor of muscle mass and bone volume (muscle and bone mass).

The second varimax factor (V2) was mostly defined by the variables of longitudinal skeleton dimensionality, and could thus be described as a dimension of longitudinal skeleton dimensionality.

All skinfold variables showed significant projection upon the third varimax factor (V3). As these are ballast mass measures, the third varimax factor could be described as a dimension of subcutaneous adipose tissue.

Table 2 presents results of factor analysis (varimax rotation) of the variables assessing motor abilities of junior judoists, where V1, V2, V3 and V4 are significant varimax factors. As the four dimensions taken together explained 75% of total variability of the system observed, it was concluded that the variables chosen to describe motor abilities of junior judoists were properly selected.

The variables assessing coordination, explosive strength of the jump and sprint type, and relative repetitive strength of the trunk, arms and shoulder girdle elicited highest projection upon the first varimax factor (V1). Therefore, the first varimax factor could be described as a factor of coordination and strength (coordination/ strength). Other studies[1–4] indicate that strength and coordination of motor ability have greatest impact on the performance in judo fights. In the present study, the highest quality judoists must have stood out from other study subjects on strength and coordination testing, resulting in the respective structure of the first varimax factor.

The variables assessing movement frequency and explosive strength of throwing type showed significant correlation with the second varimax factor (V2). The result of small ball (weighing 200 g) distant throw was predominantly determined by the speed of movement. Considering the second varimax factor structure, it could be described as a factor of movement frequency (speed).

The third varimax factor (V3) was primarily defined by high projections of the variables assessing aerobic endurance and strength endurance. The hang with elbows bent test requiring the longest possible isotonic contraction and cardiovascular endurance test showed correlation with the third varimax factor. The correlation of these two variables is justified, thus the third varimax factor could be described as a dimension of isotonic muscle and cardiovascular endurance (endurance).

The variables of astride trunk bending and astride standing on equilibrium bench showed significant projection upon the fourth varimax factor (V4), which could therefore be described as a factor of tonus and synergy regulation (flexibility/equilibrium).

Table 3 shows results of canonical correlation analysis of latent morphological and motor variables, and variables assessing contest performance of junior judoists. The results obtained by canonical correlation analysis indicated the correlation of latent morphological characteristics and motor abilities with criterion variables of judo performance to be defined by high coefficients of correlation, yielding two linear combinations, i.e. two pairs of canonical factors.

There was a significant correlation ($p<0.001$) of the first pair of canonical factors with a high canonical correlation coefficient of 0.88, explaining 77% of the system variance. The first canonical factor of the predictor set of variables was predominantly defined by the very high

projection of the morphological latent variable of muscular and skeletal body mass, motor latent variables of coordination and strength, tonus regulation and synergy regulation, and movement frequency at one pole, and of longitudinal skeleton dimensionality at the opposite pole.

The structure of the canonical factor of the criterion set of variables was characterized by very high positive projection of all three criterion variables, i.e. number of technical points, followed by the number of ranking points and number of wins. These results indicate that the high values of primarily muscle mass and bone volume had a favorable effect on judo performance, generally expressed as total ranking at three contests and number of technical points collected from all three contests. It is concluded that the high values of coordination, strength and movement speed as well as of flexibility, equilibrium and movement frequency exerted favorable impact upon contest results of junior judoists.

The results obtained suggested that the high values of longitudinal dimensionality had unfavorable effect on judo performance, primarily expressed as the number of technical points from three contests. Favorable impact on judo performance was recorded in those junior judoists with high values of muscle mass and bone volume (muscle and bone mass). The judoists with lower longitudinal measures had a shorter stature than their opponents in the same weight category, facilitating them to assume a favorable position on applying throwing techniques (below the opponent's gravity center). On the other hand, on defense from the opponent's action, shorter judoists had greater dynamic stability because their gravity center was lower.

As judo is a very demanding sports activity, weight lifting plays a major role in training process. The methods of work and the volume of load used in training definitely influence the judoist morphological characteristics, as demonstrated by Gualdi-Russo and Graziani (1993)[6], and Krawczyk et al. (1997)[7]. These authors showed elite judoists to be at the top of mesomorphic somatotypes in sports hierarchy. Thus, it is quite logical that performance in the study sample of junior judoists, in the area of morphological characteristics, was primarily dependent on the proportion of muscle-bone mass in total body mass.

Other studies[1–4] suggest that performance in judo is predominantly influenced by the motor abilities of strength and coordination. Elite judoka achieved significantly better results in the tests assessing strength and coordination than other subjects. Junior judoists with greater explosive strength were able to more quickly and properly draw the opponent off balance. Also, they could more readily apply the technique of judo throw (the final phase of opponent throwing in particular). Most probably they were more successful in defense from the hold catch, counter-throwing, and breaking the opponent's catch off. All these were the potential reasons for their superior performance at all three contests.

Another two latent motor variables, i.e. factors showed significant positive correlation with the criteria of judo performance used in the study. These factors were tonus and synergy regulation, and movement frequency (speed). Those junior judoists who could more readily apply a technique or a combination of throwing techniques had the best chances to surprise or outwit the opponent, and thus to successfully apply the throwing technique. The importance of movement frequency in judo also manifests in defense by timely avoiding the opponent's actions.

The second pair of canonical factors with canonical correlation coefficient of 0.83 explained 69% of the system variance. In the morphological-motor area, the second canonical factor was defined with rather high, significant and positive factor projections for assessment of muscular and cardiovascular endurance, and moderate projections of the coordination/strength and speed factors, along with negative projections of morphological factors, the factor responsible for the muscle and bone mass volume in particular. In the area of situation efficiency, the second canonical dimension was defined by quite a high, significant and positive projection of the criterion variable of the number of wins, and to a lesser extent by the number of technical points and number of ranking points. The correlation of the second pair of canonical factors was underlain by positive determination of judo performance as expressed by the number of wins by the above-average endurance, along with below-average muscle mass and bone volume and skeleton longitudinality. This linear combination favors the judoists with such a morphological-motor system where motor abilities are more pronounced, with a predominance of endurance over muscle mass and bone volume development. The opposite pole is occupied by judoists with above-average development of muscle mass and bone volume and inadequately developed motor abilities, especially muscular and aerobic endurance, exerting an unfavorable effect on efficient judo performance.

Conclusion

Acquiring relevant information on the impact of morphological characteristics and motor abilities on performance in Croatian elite junior judoists was primarily limited by the small sample of study subjects. Therefore, latent variables were formed by use of factor analysis in the series of morphological variables and motor variables. Then, relations of latent morphological and latent motor variables as an integral set of predictor variables with the set of variables assessing performance in judo as a criterion were determined by use of canonical correlation analysis. Using this methodology, the morphological-motor mechanisms determining performance in junior judoists were identified.

Study results showed properly developed muscular and skeletal mass, i.e. mesoectomorphy, to be the predominant morphological characteristic of junior judoists (Table 1), whereas general motor efficiency was found to be defined by the first varimax factor (Table 2), which integrated coordination and (explosive and repetitive) strength factors. In the first canonical linear combina-

TABLE 3
RESULTS OF CANONICAL CORRELATION ANALYSIS BETWEEN LATENT VARIABLES OF MORPHOLOGICAL AND MOTOR AREAS AND VARIABLES OF FIGHT PERFORMANCE IN JUNIOR JUDOISTS

Variable	CAN 1	CAN 2
Muscle and bone mass	–0.72	–0.58
Skeleton longitudinality	0.89	–0.31
Adipose tissue	–0.22	–0.16
Coordination/Strength	–0.61	0.25
Speed	–0.38	0.21
Endurance	–0.05	0.62
Flexibility/Equilibrium	–0.49	0.05
Ranking points	–0.79	0.44
Number of wins	–0.68	0.71
Technical points	–0.80	0.58
Can R	0.88*	0.83*
Can R^2	0.77*	0.69*

*$p<0.001$, CAN – canonical variable, Can R – canonical correlation, Can R^2 – coefficient of canonical determination

tion, the muscle-skeletal mass from the group of morphological factors and coordination/strength from the group of motor factors were those that predominantly determined performance in judo (Table 3). In this linear combination, the factor of tonus and synergy regulation and the factor of movement frequency (speed) also had significant effect on the manifest criterion variables. In junior judoists, tonus regulation and synergy regulation manifested in developed motor abilities of flexibility and equilibrium, which facilitated application of all judo techniques, both in upright position and on the floor. The factor of movement frequency manifested in the speed of applying particular technique and/or a combination of techniques. The speed of reaction and movement frequency are important, especially in kick sports such as boxing and karate[17]. Motor abilities of movement speed, equilibrium and flexibility precede the development of the factors of strength and motor coordination[18]. Judo training significantly influences the development of flexibility and equilibrium as early as in 7-year-old boys[19], indicating that these abilities determine judo performance in the beginners. Judo training has no major influence on the development of psychomotor speed[19], because this ability is mostly genetically determined. As the achievement of superior results in judo greatly depends on psychomotor speed, it should be included in the primary selection criteria.

In the first linear combination, the factor of muscular and cardiovascular endurance was neutral relative to the criteria of judo performance, indicating the judoists characterized by this linear combination to have a satisfactory developmental level of motor abilities defining this factor, without major differences. However, the second linear combination of predictor and criterion sets of variables shows the importance of muscular and cardiovascular endurance for achievement of top results in judo. In this linear combination, muscular and cardiovascular endurance is opposed to muscle and skeletal mass. Accordingly, the judoists of outstanding endurance have below-average muscle and skeletal mass but are characterized by moderate above-average coordination/strength and speed, allowing them to achieve a higher win score at contests. These obviously include the judoists on intensive judo training for years, which has resulted in the formation of an appropriate morphological structure relying on the quality rather than quantity of muscular tissue. This in turn facilitates them the use of specific motor abilities and specific motor skills in judo. Therefore, training processes focused on strength development should be based on specific, situation operators-exercises while avoiding weight lifting exercises which simply increase muscle mass.

An increasing number of anthropologic system predictors relevant for judo performance have been included in the formation of elite judoists. Resolving the tasks and situations in judo fight is a complex issue that is closely related to the development of basic and specific motor abilities, as follows:

- phase one – approximately at age 7–9 years: development of psychomotor speed, equilibrium and flexibility;
- phase two – approximately at age 10–12 years: development of coordination and (explosive and repetitive) strength factors, ensuring proper learning and acquiring specific motor knowledge;
- phase three – approximately at age 13–15 years: integration of all these basic motor abilities for efficient use of judo techniques in series and combinations; and
- phase four – approximately at age 16–18: development of muscle and aerobic endurance, built upon the development of motor abilities attained in previous phases, eventually ensuring achievement of top results in judo.

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BIOMOTORIČKI SKLOPOVI ELITNIH JUDAŠA JUNIORA

S A Ž E T A K

Cilj ovoga istraživanja je bio utvrditi utjecaj motoričkih sposobnosti i morfoloških osobina na uspješnost u judu kod juniora. U tu svrhu na uzorku od 40 judaša starosne dobi od 17 godina ±6 mjeseci primijenjen je skup od 14 morfoloških mjera i skup od 14 motoričkih testova kao varijabli prediktora i 3 varijable za procjenu uspjeha u judu kao kriterija. Faktorskom analizom u morfološkom prostoru izolirana su 3 faktora: faktor mišićne i koštane mase (MezoEktomorfija), faktor longitudinalne dimenzionalnosti skeleta, te faktor potkožnog masnog tkiva (Endomorfija). Faktorskom analizom u motoričkom prostoru izolirana su 4 faktora: faktor koordinacije i snage (regulirana sila), faktor brzine frekvencije pokreta (Brzina), faktor mišićne i kardiovaskularne izdržljivosti (Izdržljivost) i faktor regulacije tonusa i sinergijske regulacije (Fleksibilnost/Ravnoteža). Kanonička korelacijska analiza između latentnih morfoloških i motoričkih varijabli i varijabli za procjenu natjecateljske uspješnosti judaša juniora je utvrdila dvije linearne kombinacije, tj. dva para kanoničkih faktora. U osnovi povezanosti prvog para kanoničkih faktora je pozitivni utjecaj koordinacije/snage, brzine, fleksibilnosti i ravnoteže, uz iznadprosječnu mišićnu i koštanu masu i ispodprosječnu longitudinalnost skeleta, na uspjeh u judu. U osnovi povezanosti drugog para kanoničkih faktora je pozitivna determiniranost iznadprosječne izdržljivosti uz umjerenu koordinaciju/snagu i brzinu, a ispodprosječne mišićne i koštane mase i longitudinalnosti skeleta, na uspjeh u judo borbi izražen brojem pobjeda.