RELATIONS OF LATENT ANTHROPOMETRIC DIMENSIONS TO SUCCESS IN JUDO BOUT

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Abstract. The global objective of this research was determining the relations between anthropometric variables with success in judo bout. The research was conducted on a sample of 122 subjects. The sample of variables consisted of 18 anthropometric measures, out of which three latent dimensions were isolated by the use of factor analysis. Three latent dimensions (factors) represent a set of predictive variables. Criterion is defined as a success in judo bout and it is represented by two criteria variables; number of wins and technical efficiency in judo bout. To test the relations of latent anthropometric variables with success in the bout the regression analysis was used. Statistically significant but low connections were found between anthropometric variables and the two criteria. As only the factor volume and mass of the body partially contribute to the explanation of criteria, one can conclude that the active muscle mass is in the background of achieved connection.

Key words: morphology, score, victory, technical efficiency

Introduction

In terms of structural analysis judo is a combat sport that, like other martial arts, belongs in the group of polystructural sports in which acyclic movements are dominating. The final bout result can be expressed as a binary variable; win or loss (Kuleš 1990). All technical elements in the bout can be applied only with the correct time execution of all its phases and the use of all psychological and physical potential of the individual. Constantly changing, dynamic situation during the bout requires good acquisition of technical and tactical stereotypes, the ability of the current reorganization of these stereotypes and constant creation of new defensive and offensive motor programs. The fact that each judo technique is performed in a direct conflict with the opponent and with the constant opponents' resistance, during a five minute bout, evidences the large energy consumption of the competitors. As the amount of the energy consumption depends on the duration, intensity of work, nature of work and the amount of the muscles involved, one can say that judokas during the competition and training perform extremely hard work with a high degree of physical and psychological stress. To achieve top results in sport, long-term training is

necessary. High quality sports result depends on a number of skills and qualities that must interact in a particular way. For all these reasons, we can say that many years of judo training certainly change the psychosomatic status of the athletes and already established relationships between the dimensions and the elements of psychomotor status of sportsmen. That is why one can talk about models of successful contestants created during the extensive training and competition. However, due to the fact that competitors in judo are classified into weight categories, for each weight category, theoretically and practically, a different model of successful judoka exists. In senior judo bout there are seven weight categories and, as some studies showed (Almansba et al. 2008; Franchini et al. 2008), within each category the hierarchical structure of efficiency of throwing techniques is different. The logical assumption is that the difference is caused by different anthropological dimensions of judoka. The aim of the research is to determine the impact and relations of some anthropometric variables with success in judo bout.

Material and methods

Conducted research has been approved by an ethic committee and all data were collected according to the laws of the country in which the work took place.

Sample of subjects

The sample of subjects consisted of 122 male students of the Faculty of Kinesiology, University of Zagreb between the ages of 19 and 21. Till the beginning of the experimental procedure subjects had never been involved in judo training or similar wrestling sports. All subjects, according to the level of knowledge of judo techniques and experience in fighting, can be characterized as judoka beginners.

Predictor set of variables

To estimate the volume and mass of the body six measures are selected: the circumference of the upper leg (OPSNAT), lower leg circumference (OPSPOT), upper arm circumference in contraction (OPSNAD-F), extended upper arm circumference (OPSNAD-O), forearm circumference (OPSPOD) and body weight (MASTIJ). To estimate the longitudinal dimensionality of the skeleton four measures are selected: body height (VISTIJ), leg length (DUZNOG), arm length (DUZRUK) and shoulder width (BIAKRAS). For the assessment of body fat five measures were selected: upper arm skinfold (NABNAD), forearm skinfold (NABPOD), calf skinfold (NABPOT), skinfolds on the back (NABLEĐ) and the skinfolds on the abdomen (NABTRB).

Transversal dimensionality of the body is determined by three measures: the diameter of the elbow (DIJLAK), knee diameter (DIJKOL) and width of the pelvis (BIKRIS). All measurements were taken on the right side of the body and also all measurements were taken in the morning.

Criterion set of variables

The success in judo bout in standing position is defined by two criterion variables:
– number of wins (BRPOBJ),
– technical points in judo bout (BPRAV).

The result in the first criterion variable was calculated by the number of overall wins from five bouts. The result in the second criterion variable represents the sum of all technical points achieved in five bouts.

The first criterion variable, number of wins (BRPOBJ), was obtained in the way that every win in the bout is awarded with one point. The highest quality respondent in the group was able to achieve five points from five bouts.

The second criterion variable, technical points in judo bout (BPRAV), was obtained in the way that only the winner was awarded with the technical points. Only one, the most valuable, action point was taken into consideration. The judoka that lost the bout recorded zero points. The scoring was awarded according to the official rules of judo bout. Second criterion is therefore expressed as the sum of the most valuable technical points achieved in victories. Maximum possible value of the sum of the points according to the criterion technical points in judo bout (BPRAV) was 50 technical points.

Technical points were achieved only in the standing position (by application of techniques of throws) and the bout was conducted by national rank referees.

Competition rules

Basing on the actual weight categories, subjects were divided into three weight classes: up to 73 kg, 81 kg and up to 90 kg.

Pairs of contestants within a category were determined by chance. The bout lasted for three minutes. Each participant took part in five bouts. The victory is achieved as ippon (immediate cease of bout), or with the technical points at the end of the battle. Technical points or efficiency of an individual is determined on the basis of quality of performed technical elements of judo – according to judo bout rules.

Methods of data processing

Basic statistical parameters were calculated: mean (AS), standard deviation (SD), minimum (MIN) and maximum (MAX), the results for the coefficients of asymmetry (skewness) and flatness (kurtosis).

The latent space is determined by factor analysis under the model of the main components, and by using OBLIMIN rotation.

Multiple regression analysis was chosen as the primary method of connecting anthropometric area with success in judo fight.

Results and discussion

A detailed analysis of the descriptive statistical parameters (Table 1) of anthropometric variables showed that they do not deviate significantly from a normal distribution, except for the variable upper leg circumference (OPSNAT). The comparison of central and dispersion parameters with the results of previous research on the student population of the University of Zagreb and the previous generation of the Faculty of Kinesiology (Medved et al. 1992a; Mišigoj-Duraković 1995; Mišigoj-Duraković et al. 1998) reveals that the sample in this study has a higher body weight than the other students at the University of Zagreb and the previous generations of Faculty of Kinesiology students.

The sample of students, who participated in the survey, compared with the Faculty of Kinesiology students and other students of the University of Zagreb in the research of Medved et al. (1992b) and Mišigoj-Durakovic et al. (1998), is also somewhat heavier and has a higher value of transverse dimensions, circumferences and skinfolds, while the height and diameter of the elbow and knee are not different.

Table 1. Descriptive parameters of anthropometric variables

VARIABLES	Mean	Minimum	Maximum	Standard deviation	Skewness	Kurtosis
MASTIJ	76.31	56.80	104.80	8.44	0.52	0.46
VISTIJ	180.70	163.30	201.30	6.84	0.18	0.04
DUZNOG	101.40	90.30	115.00	5.17	0.14	–0.12
DUZRUK	78.79	71.10	86.90	3.25	0.00	–0.25
BIAKRAS	41.75	34.00	45.40	1.73	–0.56	2.31
BIKRIS	28.79	24.70	33.40	1.68	0.19	0.11
DIJLAK	7.09	6.50	7.80	0.32	0.03	–0.52
DIJKOL	9.74	8.70	11.00	0.42	–0.07	0.07
OPSNAD-O	30.57	26.10	38.50	2.06	0.72	1.54
OPSNAD-F	33.93	29.00	40.10	2.07	0.39	0.24
OPSPOD	27.65	24.80	31.20	1.37	0.35	–0.02
OPSNAT	56.82	35.50	67.90	3.92	–1.14	6.38
OPSPOT	38.17	33.10	45.90	2.07	0.37	0.93
NABLEĐ	9.48	6.00	17.47	2.34	1.24	1.60
NABNAD	9.05	3.83	19.87	2.88	1.03	1.39
NABPOD	5.85	3.00	10.17	1.42	0.74	0.35
NABTRB	11.90	4.83	31.77	5.61	1.30	1.43
NABPOT	7.07	3.40	16.23	2.36	1.03	1.54

For more precise interpretation of the connection of predictor (anthropometric) variables with the criteria (success in bout and technical efficiency) a sample of eighteen variables was reduced to a smaller number of latent anthropometric dimensions

Eighteen anthropometric variables were reduced to three significant latent dimensions which explained 72,5% of the overall variance.

Basing on the obtained values and the total percentage of explained variance, it can be concluded that the three obtained latent dimensions exhaustively describe the anthropometric space (Table 2).

Table 2. Eigenvalues and explained variance of correlation matrix of anthropometric measures

Factor	Eigenvalue	% variance	Cumulative % var.
1	8.02076	44.6	44.6
2	3.49498	19.4	64.0
3	1.54161	8.6	72.5

Table 3 shows the results of OBLIMIN transformation of the main components. Communality (h2) of factors is generally satisfactory.

The variables of volume and mass of the body (OPSNAD -O, OPSNAT ,OPSNAD -F ,OPSPOD and OPSPOT) and measures of body weight (MASTIJ) have he biggest parallel and orthogonal projection to the first extracted factor. This factor can be called the volume and mass of the body (ANTFAC1).

The second factor can also be interpreted without major difficulties, since the biggest projections with it are found in the variables of skinfolds (NABLEĐ, NABNAD, NABPOD , NABPOT , NABTRB). This factor can be interpreted as a subcutaneous adipose tissue of the body (ANTFAC2).

The four measures of longitudinal dimension of the body: body height (VISTIJ), leg length (DUZNOG), arm length (DUZRUK) and shoulder width (BIAKRAS) have the biggest projections on the third extracted factor. Slightly lower, but still satisfactory projections on the same factor have two measures of transversal dimensionality of the skeleton (BIKRIS, DIJKOL). The third factor can be called - longitudinal and transversal dimensions of the body (ANTFAC3).

Table 3. Factor analysis results for anthropometric variables

	ANTFAC1	ANTFAC2	ANTFAC3
MASTIJ	0.86	0.45	0.77
VISTIJ	0.41	0.06	0.90
DUZNOG	0.40	0.14	0.91
DUZRUK	0.33	−0.02	0.90
BIAKRAS	0.40	0.10	0.69
BIKRIS	0.31	0.12	0.76
DIJKOL	0.43	0.42	0.54
DIJLAK	0.65	0.34	0.54
OPSNAD-O	0.92	0.44	0.32
OPSNAT	0.77	0.58	0.54
OPSNAD-F	0.87	0.36	0.31
OPSPOD	0.89	0.30	0.51
OPSPOT	0.78	0.26	0.41
NABLEĐ	0.48	0.80	0.00
NABNAD	0.29	0.91	0.09
NABPOD	0.39	0.88	0.17
NABPOT	0.24	0.85	0.13
NABTRB	0.48	0.84	0.05

Table 4. Correlations between factors

	ANTFAC1	ANTFAC2	ANTFAC3
ANTFAC1	1.00		
ANTFAC2	0.41*	1.00	
ANTFAC3	0.44*	0.13	1.00

* significant coreelation on the level of p < 0.01.

The correlation matrix of isolated latent dimensions (factors) (Table 4) revealed two significant connections. The first is the connection between the first factor (volume and mass of the body) and the second factor (subcutaneous adipose tissue of the body), and also between the first factor and the third factor (volume and mass of the body and longitudinal and transversal dimensionality). A statistically significant relationship was not established between the second and the third factor (subcutaneous adipose tissue and longitudinal and transversal dimensionality).

In previous studies (Kuleš 1996) links between these latent dimensions were a little bit higher. High correlations between the factors volume and body mass and subcutaneous adipose tissue can be explained with a significant influence of subcutaneous adipose tissue in the volume and mass of the body. The correlation of volume and body mass and the factor interpreted as longitudinal and transversal dimensionality is also logical and can be explained by the fact that taller people with longer limbs, with larger transverse measures and increased body weight have greater circular dimension. The absence of significant correlation between subcutaneous adipose tissue factor and longitudinal and transversal dimension factor can be explained by the specific structure of the body of athletes, where pronounced longitudinal dimensions of the body are not followed by increased amount of subcutaneous fat.

Table 5. Descriptive parameters of the criterion variables

Variable	Mean	Standard deviation	Kurtosis	Skewness	Minimum	Maximum
BRPOBJ	2.48	1.43	−0.80	0.90	0	5
BPRAV	23.64	14.42	−0.80	0.18	0	50

The analysis of Table 5 reveals that none of the variables for assessing the performance of the bout does not deviate significantly from the normal distribution with regard to the parameters of asymmetry (skewness) and flatness (kurtosis). For the first criterion variable – number of wins – the minimum score is zero, which means that some subjects did not win in any fight, while some obtained the maximum score of five wins. Also, according to the second criterion variable, the number of points in judo bout, some subjects managed to achieve maximum value of the technical points, but, again, there were those who did not win in any of the fight and did not achieve a single technical point.

Relations between latent anthropometric dimensions (predictors) with success in judo bout variables (criterion)

To confirm the hypothesis about the relationship of latent anthropometric dimensions with success in the bout, a regression analysis was conducted. Hypotheses set out in this paper were based on and emphasize the connection between the anthropometric latent space, as previous studies have reported the connection of manifest anthropometric variables with success and technical efficiency in the bout (Sertić 1994; Sertić 1997; Sertić and Vuleta 1997).

Table 6. Relations of success in standing judo bout, defined with number of wins (BRPOBJ), and latent anthropometric dimensions

Criterion	R	R^2	F	p	df1	df2
BRPOBJ	0.26*	0.07	2.77	0.04	3	118

* level of significance $p < 0.05$.

BRPOBJ	B	SE B	BETA	T	p (BETA)
ANTFAC1	0.41	0.15	0.29	2.68	0.01**
ANTFAC2	−0.21	0.14	−0.15	−1.49	0.14
ANTFAC3	−0.03	0.14	−0.02	−0.24	0.81

** level of significance $p < 0.01$.

Table 6 shows the connection between the criterion variable number of wins with the predictor set of latent anthropometric dimensions (R = 0.26) under the significance level of 0.05. The predictor set can explain only 6.8% of the total variance of the criterion variable number of wins (BRPOBJ).

Such a low percentage of explanations of success in the bout is expected considering the previous studies. Judo is so diverse that every judoka, according to personal morphological characteristics, can choose a highly effective technique (Tokui waza) which will help them to win bouts with judokas of similar morphological structure. For this reason, anthropometric dimensions, or at least the impact of body mass, obviously are not a limiting factor for selection to judo sport, as is the case of some other sports (eg. basketball, sumo) where success is clearly defined by the anthropometric dimensions of height and weight.

To limit the influence of morphological status, judokas are competing in weight categories in which judokas share similar morphological characteristics. Extremely large number of throwing techniques and possible combinations provide opportunities for people of different body sizes to choose a technique that, according to their anthropometric dimensions, will be the most suitable for them. Adopting a certain basic form of the technique and adjusting it to the physical status of judoka, ensures maximum efficiency regardless of the morphological characteristics of opponents.

By detailed analysis of Table 6, we find that only the first latent dimension, the volume and mass of the body, achieved a statistically significant connection with success in bout by the criterion number of wins. Since this factor is defined primarily by volume, and then the weight of the body, it is possible to conclude that the difference in muscle mass is in the background of generated connections. If muscle mass is primarily responsible for the success in the fight, then it can be explained by the need to use the strength from the beginning of the bout (grip for kimono, unbalancing, establishing contacts, lifting the opponents and a series of defensive action, such as pushing, blocking, fixation and certain other positions).

Table 7. Relations of success in judo bout, defined with technical points (BPRAV), and latent anthropometric dimensions

Kriterij	R	R^2	F	p	df1	df2
BPRAV	0.25*	0.06	2.70	0.04	3	118

* level of significance $p < 0.05$.

BPRAV	B	SE B	BETA	T	p (BETA)
ANTFAC1	4.14	1.56	0.29	2.66	0.01**
ANTFAC2	−1.87	1.41	−0.13	−1.33	0.19
ANTFAC3	−0.33	1.43	−0.02	−0.23	0.82

** level of significance $p < 0.01$.

Table 7 shows the connection between the latent anthropometric dimensions to the criteria defined by the technical points in judo bout (BPRAV) (R = 0.25) under the significance level of 0.05. Predictor set explain only, a modest 6.3% of the total variance of the criterion variables. The size and the significance of the obtained connections are similar to the connection between the latent anthropometric dimensions and the first criterion – number of wins, which is normal; if one takes into account that these two criteria variables are nearly collinear (their mutual correlation is 0.99). It is clear that the technical efficiency of individual very little depends on the anthropometrical

dimensions A wide selection of techniques , based on a number of principles, which can be adjusted so that, for example, lower competitor can easily throw a high competitor and vice versa, using the advantages (features) of their body structure, allows each judoka, regardless of personal morphological characteristics, the selection of highly effective throwing technique (Tokui waza), with which one can achieve the technical points in the bout. Each judoka, with Tokui waza selected according to his anthropometric characteristics, can efficiently throw opponents of different physical structure. From this we can again conclude, as well as for the criteria of number of wins, the anthropometric characteristics as not a limiting factor for selecting and effectively performing techniques or throws neither for orientation nor selection in this sport.

The statistically significant connection of only the first latent dimension with criteria can be interpreted identically as in the first criteria - number of wins. So if muscle mass is responsible for the technical efficiency in a judo bout, then it can be explained that the achieved technical point in a bout depends also on the strength. As it is written in judo rules; ippon is awarded if the competitor "with control throws the other contestant largely on his back with considerable power and speed" (IJF Referee Rules 2014). Since the result in this criterion includes only the highest scored action, and only by the winner of the bout, previous explanation of the impact of volume and muscle mass, to the score of throwing technique is only logical. Basing on the information from previous interpretations it can be concluded that stronger judokas received higher scores for techniques done by a certain, higher, amount of force. Powerful subjects, due to the impact of volume and mass of the body, defeat their opponents by using techniques in which, in critical moments, they could apply more power. Connection of factor of volume and mass of the body with the criteria variables wins and points in the bout can indicate that statement. It is obvious, also, that the performance of more technical actions or getting the higher scores do not depend too much on anthropometric characteristics, but on some other features and capabilities, knowledge and the acquisition of techniques.

Conclusions

The aim of this study was to determine the impact and relations of some anthropometric variables with success in judo bout. Research was conducted on a sample of 122 students of Faculty of Kinesiology University of Zagreb, who underwent testing with 18 anthropometric variables that were the basis for defining three latent anthropometric dimensions (predictor set of variables). The success in judo bout in standing position was defined with two criterion variables: number of wins and technical points in judo bout. Subjects were divided into three weight classes: up to 73 kg, 81 kg and up to 90 kg and each participant had five bouts. Relations between latent anthropometric variables with success in the bout were determined by regression analysis. Statistically significant but low connections were found between anthropometric variables and the two criteria (the number of wins multiple correlation R = 0.26; and technical points multiple correlation R = 0.25). As only the first factor (volume and mass of the body) partially contributes to the explanation of criteria, one can conclude that the active muscle mass is in the background of achieved connection. Muscle mass predominantly determines the size of the applied force, which predominantly determines the success of the bout. Of course, aligning judoka per category reduces the variability of muscle mass of contestants which is the reaso nwhy the volume and body mass explain only a part of the variance of criteria success in bout and technical efficiency. It can be assumed that the rest of the variance of criteria is defined by the technical excellence of each judoka. Judokas choose for themselves the best ones form a large number of techniques according to their morphological characteristics and preferences. Certainly, the combination of affinity and favourable anthropometric characteristics for the throw or group throws result in a faster mastery of technique,

training to automation and better and more efficient use of throwing techniques in situational conditions during the judo bout in the competition. One can conclude that anthropometric dimensions are not a limiting factor for selection in judo or for selection of a favourable technique, but still represent a respectable factor that also affects the success in competitive judo sport (especially the super heavyweight category).

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