INFLUENCE OF LATENT MOTOR ABILITIES ON PERFORMANCE IN JUDO

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Abstract:

The aim was to determine both the magnitude and the direction of the relations among certain motor abilities and performance in judo bouts performed in a standing position. Therefore, a sample of 122 of Zagreb's Faculty of Kinesiology sophomores was tested. A battery of 15 motor tests was used and these were the predictor variables. The sample of criterion variables consisted of two performance indicators: the number of victories and technical efficacy points. The investigation was aimed at verifying the hypothesis that performance and final success (victory) in judo standing position bouts strongly depends on the motor features of the contestants involved. Regression and factor analyses were used. The obtained results indicate that there is a relationship between the latent motor variables and both criteria evaluating performance in standing position bouts - the number of victories and technical efficacy points.

Key words: *bout, victory, technical efficacy, standing position*

Introduction

In judo, one of the very attractive combat sports, or martial arts, incessant and dynamic changes of the equilibrium in a dynamic system of two opposed judokas demand from fighters a high level of technical-tactical proficiency, an abundant repertoire of motor stereotype programmes and an ability to apply them, a higly developed ability to adjust them in an instant when needed in combat, and an ability to create ever new defensive, attacking and counter-attacking motor actions (Sterkowicz, Kiejda, & Blach, 1997; Sterkowicz & Maslej, 1998; Franchini, Sterkowicz, Meira, Gomes, &Tani, 2008; Sertić, 2004). However, any technical-tactical element, applied by either of the two competitors in order to overcome the other judoka, encounters his/her resistance of a variable magnitude during a bout lasting five minutes. When all the mentioned is taken into account, it becomes obvious that judokas need to have a high level of energy production to satisfy the energy demands of the bouts demands (Franchini, Takito, Kiss, & Sterkowicz, 2005; Sertić, Segedi, & Žvan, 2007). If we know that energy consumption depends on work intensity and duration, the type of work and on the amount of recruited muscles, then we can say that judokas perform hard physical work in both competition and training sessions with respective, quite high psychological strains. These strains become even bigger due to the possibility that a match can be concluded even before the regulation time. Therefore, a bout can be considered an actual psychological war (Filaire, Maso, Sagnol, Ferrand, & Lac, 2001), making energy consumption even greater.

Judo bouts are nowadays more dynamic than they were 20 or 30 years ago. Namely, the rules do not allow more than 5-10 seconds of the so called passive judo, a period of time during which neither of the contestants are actually active in trying to defeat the opponent. The umpire can assign penalties to the contestant who avoids action. Therefore, the judoists with only a defensive style of combat do not have many chances to win. Their fake or *pro forma* performed actions are not dangerous for their opponents; on the contrary, they are hazardous to the very judoka who performs them because of the disqualification threat.

Muscular exertion during a combat is of both the dynamic and the static nature, but the dynamic repeted exertions and explosive motions prevail (Little, 1991; Kubo, et al., 2006; Heitkamp, Mayer, Fleck, & Horstmann, 2002; Sertić, et al., 2007), therefore judoists must satisfy high motor and functional demands.

Judo as a sport is a specific model of kinesiological activity with high demands on the athletes' psychosomatic status. During training sessions and competitions almost all the psychosomatic subsystems of judokas function in the zones of submaximal and maximal efforts (Parmigiani, et al., 2006). Performance in judo is influenced, more or less, by all, or almost all anthropological dimensions; therefore, from the aspect of science, they should not only be determined, but also their magnitude and direction of relations with performance should also be revealed (Sertić & Lindi, 2003; Sertić, Segedi, & Budinšćak, 2006; Kuleš, 1996; Franchini, et al., 2008).

The goal of this research is to determine the magnitude and direction of the relations of certain motor abilities with performance in standing position judo bouts.

Methods

Sample of subjects

The population of subjects was defined as a cohort of regular full-time students of the Faculty of Kinesiology University of Zagreb. The sample of subjects consisted of 122 males, who were drawn from the population of sophomores, aged 19-21 years. Prior to the experiment they had not been involved in the training process of judo or any similar wrestling sport. Therefore, they can be described as novices in judo regarding their judo techniques proficiency and combat competition experience. The sample of subjects may be understood as a convenience non-random one, which is by its nature closest to the sample of athletes.

Sample of measuring instruments (variables)

Sample of predictor variables (motor variables)

To assess the motor abilities of the subjects in this research a battery of 15 motor tests was utilized. These tests are best in defining the latent dimensions of co-ordination, strength endurance of a dynamic type, power (explosive strength), speed and flexibility.

CO-ORDINATION ABILITIES were assessed using three measuring instruments:

- agility in the air (MKTOZ) (Metikoš , Hofman, Prot, Pintar, & Oreb, 1989) aimed at assessing co-ordination of the whole body (The subject sits on four medicine balls placed on the floor. Upon the measurer's signal, he/she performs a roll backwards, then a flying roll forwards over the medicine balls, turns quickly around and touches with his/her hands as quickly as possible, all four medicine balls. The result is expressed in seconds; the better subject is the one who has the better time, that is, who was faster – the reversely scaled variable.)
- long jump backwards (MRESDN) (Gredelj, Metikoš, Hošek, & Momirović, 1975), aimed at assessing the ability to reorganize a movement stereotype (The subject stands with his/her heels touching the starting line. The task is to perform two-legged a long jump backwards as far as possible. The distance is measured from the starting line to the mark of his/her toes. The task is performed three times. The average of three performances is the result and it is expressed in centimetres.), and
- moving in a figure eight with ducking (MAGOSS) (Metikoš, et al., 1989), aimed at assessing agility, that is, the ability to change direction and mode of moving quickly.

STRENGTH ENDURANCE OF A DYNAMIC TYPE was assessed by means of three measuring instruments:

- weighted sit-ups (MRCDTT) till exhaustion (Metikoš, et al., 1989); a subject had to perform as many sit-ups while holding a 20kg weight plate on his chest; aimed at assessing the strength endurance of the trunk;
- undergrip pull-ups (MRAZGP) (Metikoš, et al., 1989), assessing strength endurance of the shoulder girdle and arms;
- squats with weight (MRLPCT) (Metikoš, et al., 1989); assessing leg strength endurance; till exhaustion (the weight was relatively determined according to the subject's body weight ± 2 kg; the result was the number of repetitions made).

POWER (EXPLOSIVE STRENGTH) was assessed by means of three measuring instruments:

- sitting medicine ball toss for a distance (MFEBMS) (Metikoš, et al., 1989), a 1kg medicine ball was tossed from the subject's chest; assessing power of the shoulder girdle and arms; the distance achieved was expressed in decimetres;
- standing long jump (MFESDM) (Metikoš, et al., 1989), assessing leg power;
- 20m run from a standing start (MFE2OV) (Metikoš, et al., 1989), assessing leg power.

SPEED was assessed by the following tests:

- hand-tapping (MBFTAP) (Metikoš, et al., 1989), assessing speed of alternate movements of the strong hand;
- movements from the left to the right of the strong hand (MBPDRD), assessing speed of a simple movement performance by the strong hand, and
- forwards-backwards swinging of the dominant leg (MBPDNN), assessing speed of a simple movement performance by the dominant leg.

FLEXIBILITY was assessed by means of the following tests:

- shoulder circumduction (MFLISK) (Metikoš, et al., 1989), testing flexibility of shoulder joints;
- straddle seat forward bend (MFLPRR) (Metikoš, et al., 1989), tests flexibility of hips and groins;
- forward bend on a bench (MFLPRK) (Metikoš, et al., 1989), tests flexibility of the lumbar part of the trunk, one of the most fequently used tests for this purpose.

Sample of criterion variables (the number of victories and technical efficacy)

Performance evaluation procedures in a standing position judo bout

Performance in a standing position judo bout was defined by two criterion variables: the number of victories and technical efficacy points. The first criterion was the total of victories in five bouts, whereas the sum of technical efficacy points made the second criterion.

The first criterion variable, the *number of victories* (BRPOBJ), was obtained in a way that each winner in a bout received one point, whereas the loser did not receive any points (zero).The most quality subject in a group thus could achieve a maximum of five points (out of five bouts).

The second criterion variable, the *technical efficacy points* (BMAXB), obtained as the maximum (the largest) value of the assigned point for the action performed, that is, as a sum of the most valuable technical points assigned in each bout. The technical points were assigned and registered for both the winner and the loser in each bout for their most valuable combat action performed. For example, a bout won or lost - 1:0 (meaning, victory:defeat) and technical points 7:5 (meaning, the most valuable actions of throwing to both the winner and the loser, in this case, *waza-ari* - 7 points to the winner, and *yuko* - 5 points to the defeated contestant). The sum of all the technical points, won in both the bouts won and the bouts lost for the most valuable technical actions performed, was the second criterion. For example: 3 points for 3 victories and 44 technical points (3x10 points for *ippons* performed in the bouts won and 2x7 points for *waza-aris* performed in the bouts lost).

The subjects were divided into three weight categories: up to 73 kg, up to 81 kg, and up to 90 kg (according to the International Judo Federation rules).

Victory in a test bout (the test bout lasts three minutes), is achieved either by *ippon* (meaning the immediate termination of the bout and the victory assigned to the judoka who has performed the winning technique) or by the summation of the technical points assigned to the contestants. Technical or point efficacy of an individual was established by such a review of scores assigned for the technical elements performed during the bout.

The test bouts were refereed by the referees and judges of the national rank, categories from the first to the third.

Data processing methods

Multiple regression analysis was a basic method for establishing the relationships between motor space and judo bout standing performance.

All the predictor and criterion variables were subjected to standard descriptive analytical procedures for determining their basic statistical parameters.

The latent space was determined by factor analysis under the principal components model (Hotelling's methods).

The Guttman-Kaiser criterion was used to determine the significance of the principal components. Besides, the partial (% of variance) and cumulative (cumulative % of variance) contributions of particular factors to the total of the explained variance as well as communalities of variables (h^2) were utilized.

The final factor solution was obtained by means of the OBLIMIN oblique rotation. The matrices of parallel (a pattern matrix) and orthogonal (a structure matrix) loadings were computed.

Results

In Table 1 descriptive statistics of the predictor variables assessing motor abilities is presented: arithmetic means (Mean), standard deviations (SD), the minimum (MIN) and the maximum (MAX) score, as well as the asymmetry (skewness) and the curvature (kurtosis) of the distribution of the results.

The analysis of these descriptive statistical parameters displays the goodness of data fit, except for the variable *weighted squats* (MRLPCT). That small deviation from the normal distribution (the parameters of *skewness* and *kurtosis*) was probably caused by the limited maximum of repetitions, so all the subjects who had performed 35 or more squats received the result of 35. The rest of the variables were normally distributed and were included in the further analyses, together with the variable *weighted squats* (MRLPCT), due to its really small deviation.

In the sample of the Faculty of Kinesiology's students there were persons with various sport orientations and different motor dimensions profiles, which most probably contributed to a wide differentiation of motor abilities, evident in the low and frequently unusual relations between the motor abilities' tests.

Table 1. Descriptive parameters of motor variables

	Mean	MIN	MAX	SD	Skewness	Kurtosis
MBPDRD	5.61	3.29	7.83	.97	.07	-.48
MBPDNN	6.38	3.69	9.85	1.14	.38	-.08
MBFTAP	49.52	41.67	57.67	3.27	.10	-.41
MFLPRK	13.55	-10.87	27.10	7.41	-.79	.95
MFLISK	76.01	3.67	112.67	17.24	-.93	1.98
MFLPRR	59.75	28.67	80.00	10.87	-.31	-.04
MKTOZ	3.95	3.19	5.74	.39	.78	2.82
MRESDN	124.08	83.33	178.33	17.90	.47	.76
MAGOSS	18.82	16.83	21.10	.96	-.03	-.69
MRAZGP	10.26	2.00	20.00	3.15	.27	.19
MRCDTT	28.19	11.00	64.00	10.77	.96	1.15
MRLPCT	8.99	1.00	35.00	5.87	1.58	4.14
MFESDM	238.16	173.33	288.33	17.96	-.32	1.00
MFEBMS	8.04	4.73	12.00	1.23	0.06	0.51
MFE20V	3.24	2.91	3.76	0.15	0.43	0.82

Legend: MBPDRD-movements from the left to the right of the strong hand; MBPDNN-forwards-backwards swinging of the dominant leg; MBFTAP-hand-tapping; MFLPRK-forward bend on the bench; MFLISK-shoulder circuduction; MFLPRR-straddle seat forward bend; MKTOZ-agility in the air; MRESDN-long jump backward; MAGOSS-moving in a figure eight with ducking; MRAZGP-undergrip pull-ups; MRCDTT-weighted sit-ups; MRLPCT-squats with weight; MFESDM-standing long jump; MFEBMS-sitting medicine ball toss for a distance; MFE20V-20m run from a standing start

Hoteling's method of principal components, according to the Guttman-Kaiser criterion, resulted in the extraction of 5 principal components of the motor measure correlation matrix.

From Table 2 it is obvious that 58.9% (almost 60%) of the total variability was explained by the variability of motor space.

The number of the principal components corresponds to the hypothesis according to which the variables were selected. Five motor abilities were hypothesized: speed, co-ordination, flexibility, explosive strength and strength endurance of a dynamic type. Whether they would be suitable with regard to their contents is yet to be seen from the analysis of the oblimin factors obtained. The first principal component, which is supposed to represent general motor ability of the analysed space, bears a relatively small amount of information about the entire space because it explains only slightly more than 23% of the entire variability. The rest of four principal components bears even less amount of information – from the second to the fifth principal component the percentage of the explained variance is in a descending order from 10.9% to 7.3%.

Table 2. Eigenvalues and the amount of the explained variance of the correlation matrix of motor variables

Factor	Eigenvalue	% variance	cumulative % variance
1	3.50540	23.4	23.4
2	1.63517	10.9	34.3
3	1.38659	9.2	43.5
4	1.21612	8.1	51.6
5	1.09073	7.3	58.9

In Table 3 one can see the results of principal components' oblimin transformations: communalities, pattern, structure and factor correlations. There is a wide range of communalities from .39 to .81, where in four variables it was possible to explain less than 50% of their variability, whereas in 5 variables between 50 and 60% of their variability was explained. These values of communalities can be observed in all measures of *speed* and in one measure of *flexibility* (MFLISK .47), then in one measure of *explosive strength* (MFE20V .49). The lowest communality was registered for the measure of *co-ordination* (MAGOSS .39). Communalities of certain measures of *dynamic strength endurance* and *explosive strength* range from .60 to .70. The highest communalities were obtained in the group of *flexibility* measures (MFLPRR .72) and (MFLPRK .81).

A relatively small number of motor tests has relatively high loadings on the first isolated factor (pattern). It primarily regards the tests *hand-tapping* (MBFTAP) and *undergrip pull-ups* (MRAZGP), whereas the tests *standing long jump* (MFESDM; forwards) and *long jump backwards* (MRESDN) had considerably lower loadings on that dimension. A somewhat similar relation is expresed in the matrix of structure where the test *pull-ups*

Table 3. Factor analysis of motor variables

	Pattern					Structure					h^2
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
MBPDRD	.25	-.37	-.12	-.39	-.26	.35	-.44	-.23	-.43	-.39	.54
MBPDNN	-.05	.21	.02	.10	-.66	.08	.16	-.16	.10	-.62	.44
MBFTAP	.71	.27	.02	.03	.12	.67	.24	-.09	.05	-.00	.54
MFLPRK	-.00	-.14	-.92	.05	.15	.16	-.13	-.88	.06	-.13	.81
MFLISK	.21	-.21	.59	-.03	.19	.06	-.21	.60	-.06	.30	.47
MFLPRR	.13	.10	-.82	.01	.05	.27	.10	-.83	.04	-.21	.72
MKTOZ	.08	-.03	.18	-.04	.69	-.10	.02	.37	-.03	.72	.56
MRESDN	.45	-.08	-.04	-.15	-.46	.56	-.16	-.26	-.17	-.58	.57
MAGOSS	-.18	.33	.36	.12	.13	-.30	.37	.43	.14	.30	.39
MFESDM	.55	.04	-.03	-.08	-.48	.65	-.04	-.27	-.09	-.60	.66
MFEBMS	.18	.79	-.12	.08	-.11	.18	.78	-.18	.14	-.11	.69
MFE20V	.00	.24	-.08	.01	.65	-.13	.30	.11	.05	.65	.49
MRAZGP	.73	-.13	-.07	.19	.05	.73	-.16	-.20	.18	-.13	.59
MRCDTT	.22	.08	-.08	.75	-.13	.26	.12	-.18	.75	-.17	.66
MRLPCT	-.01	-.61	-.01	.61	-.07	.04	-.57	-.05	.56	-.11	.70

Legend: MBPDRD-movements from the left to the right of the strong hand; MBPDNN-forwards-backwards swinging of the dominant leg; MBFTAP-hand-tapping; MFLPRK-forward bend on the bench; MFLISK-shoulder circuduction; MFLPRR-straddle seat forward bend; MKTOZ-agility in the air; MRESDN-long jump backward; MAGOSS-moving in a figure eight with ducking; MRAZGP-undergrip pull-ups; MRCDTT-weighted sit-ups; MRLPCT-squats with weight; MFESDM-standing long jump; MFEBMS-sitting medicine ball toss for a distance; MFE20V-20m run from a standing start

retained the predominant magnitude of correlation, and *hand-tapping* established a somewhat lower relation to the same factor. It is interesting that the orthogonal loading of the test *standing long jump* (MFESDM) is almost equal to the variable *hand--tapping* (MBFTAP), whereas an above-average value was obtained for the orthogonal value of *long jump backwards* (MRESDN). These two motor tests had the parallel and orthogonal loadings of similar values on the fifth oblimin factor as well, whereas the tests *hand-tapping* (MBFTAP) and *undergip pull-ups* (MRAZGP) have high parallel and orthogonal loadings only on the first factor. Obviously, the latter tests contributed relevant information about the contents of the first factor, whereas the information obtained from the tests *standing long jump* and *long jump backwards* contributed to a far less extent to the explanation of the first latent dimension.

Due to the fact that in *pull-ups* manifestation, which predominantly determine the latent contents of this motor factor, the manifestation of relative dynamic strength endurance (repetitive power) is expressed, and the same ability has a significant influence on the scores in *hand-tapping*, especially in the last seconds of performance, it can be stated that in this dimension the information on relative dynamic strength endurance prevails.

However, the first factor also obtained quite considerable parallel and especially orthogonal loadings of the tests *standing long jump* and l*ong jump backwards*, in which *relative explosive strength ability* is manifested, we can be sure that the first oblimin factor bears information primarily on relative strength, which can be manifested as either a dynamic, repeated, or an explosive type of relatively simple motor patterns. **The first factor** can be named **relative strength/power**.

Positive high parallel (.79) and orthogonal (.78) loadings on the second factor were obtained for the variable *sitting medicine ball toss* (MFEBMS), whereas medium high parallel (-.61) and orthogonal (-.57) loading with the negative sign was obtained for the test *weighted squats* (MRLPCT). In the test *sitting medicine ball toss* explosive strength of an absolute type of the arms and shoulder girdle is manifested, whereas in the test *weighted squats* relative strength of a dynamic type is assessed. This bipolar factor differentiated between the subjects according to the body-topology-related power factors (arms and shoulder girdle vs legs), but also according to the action type (repeated vs explosive), where explosive strength was related to the topological factor of arms and shoulders, and the action factor *dynamic strength endurance* was related to the topological group of leg muscles. With great probability it can be assumed that this bipolar dimension was significantly influenced by certain morphological characteristics (Sertić, et al., 2007). Due to the fact that this factor is mostly influenced with these two variables, of the positive and the negative direction, which in their body topological structure include various extremities and assess various types of strength, the analysed factor divides the subjects into two different groups by their topological characteristics. It can be concluded that the **second oblimin factor** differs among persons with regard to the strength manifestation mode and type – absolute explosive strength and relative dynamic/repeated strength (strength endurance). It further distinguishes between the subjects who achieved good results in various types of explosive throws and the subjects who performed well in various kinds of relative-strength type squats. This bipolar factor can be described as the factor which distinguishes the abilities of subjects as the absolute explosive strength of a throwing type, on the one hand, and the relative dynamic strength endurance of a squat type. Therefore, it can be named the **topological factor**.

The third isolated factor can be interpreted as **flexibility**, due to the largest both parallel and orthogonal loadings of three variables aimed at assessing that motor ability: *forward bend on the bench* (MFLPRK), *shoulder circuduction* (MFLISK) and *straddle seat forward bend* (MFLPRR). The difference in signs corresponds to the interpretation of the tests. Forward bends have the opposite sign in relation to the test shoulder circumduction. Namely, in both former tests the better score is expressed as the higher value in centimetres, whereas in the latter tests the values are reversely scaled (the better result is expressed in lower values in centimetres).

Only two variables, assesssing *dynamic strength endurance*, established higher parallel and orthogonal loadings on the fourth factor. These were: *weighted sit-ups* (MRCDTT) and *weighted squats* (MRLPCT). Both tests are aimed at assessing dynamic strength endurance of an absolute type. Loadings of the mentioned tests are of the positive direction, whereas the other loadings are of zero value, except for the value of the test *movements from the left to the right of the strong hand* (MBPDRD), amounting to -.39, thus being significantly lower than the previous two. The fourth factor is a taxonomic dimension that describes the subgroup of the Faculty of Kinesiology's students with strong abdominal musculature (trunk flexors) and large muscle mass on their thighs. **The fourth factor** can be interpreted as the **absolute dynamic strength endurance**.

Five motor variables established higher parallel loadings in the matrix of pattern on the fifth isolated factor. These are in a descending order by the height of the loadings: one co-ordination variable – *agility in the air* (MKTOZ -.69); one speed variable – *forwards-backwards swinging of the dominant leg* (MBPDNN -.66); and one explosive power variable – *20m run* (MFE20V -. 65). Then come two variables: one assessing explosive power – *standing long jump* (MFESDM -. 48), and the other assessing co-ordination – *long jump backwards* (MRESDN -.46). An almost identical relationship of the orthogonal loadings on the fifth factor is obvious in the matrix of structure, with only one exception: the variables *20m run* (-.65) and *forwards-backwards swinging of the dominant leg* (-.62) changed places according to the height of the loading. Since the variables *standing long jump* and *long jump backwards* established significant loadings on the first factor as well, it is obvious that the tests *agility in the air*, *20m run* and *forwards-backwards swinging of the dominant leg* bear relevant information about the contents of this factor. The variable assessing body co-ordination (*agility in the air*), the ability pertaining to the group of complex motor abilities, had the highest loading on the fifth factor. The variable *20m run* was also a complex motor activity, assembled from a series of simple movement patterns which are, facilitated by excellent co-ordination, put together in a continuum of harmonious, quickly performed smooth movement patterns. The third variable that predominates over this factor is *forwards-backwards swinging of the dominant leg*, the ability pertaining to the group of simple motor tasks – it consists of a single simple movement which should be performed as fast as possible. The fourth and fifth standings by the magnitude of the parallel and orthogonal loadings on the fifth factor are reserved for the tests: *standing long jump* and *long jump backwards*, assessing power (explosive strength) and hypothetical factor of *co-ordination* (named the reorganization of motor movement stereotype/pattern), respectively. Since in the foundations of the manifestations of these very valuable results in both tests one can find the manifestation of explosive strength, which in turn depends to a great extent on intermuscular co-ordination, it can be said that these, only seemingly simple jumps, forwards or backwards alike, are in fact very complex motor tasks. Therefore, according to the variables, complexities of the motor tasks and their evaluation target, the fifth factor can be denoted as the **ability to perform complex motor tasks of a speed-explosive type**.

In Table 4 descriptive statistics of the criterion variables, assessing performance in a bout, is presented: arithmetic means (Mean), standard deviations (SD), minimum (MIN) and maximum (MAX) values as well as asymmetry (skewness) and curvature (kurtosis) of the distribution of results. It is obvious that no performance variable deviated significantly from the normal distribution. For the first criterion variable – *the number of victories* - the minimal result was zero, meaning that there were subjects who won no bout at all, whereas some accomplished the maximal result – five victories. Arithmetic mean is 2.48, meaning an average of two and a half victories per subject. The value of standard deviation reveals that most results ranged between one (1.05) and four victories (3.91). Such findings are comparable to certain predictions considering we were dealing with a group of older beginners in judo, where only a smaller number of subjects were expected to achieve either the maximum or the minimum (five victories or no victory).

The second criterion variable – technical efficacy points - is defined as the maximum value of the assigned point. It means that both contestants received points – both the winner and the defeated. The maximum value is the largest one possible to receive, whereas the minimum result (0) indicates there were subjects who failed to achieve any technical point for their actions in five bouts. The arithmetic mean value is somewhat higher than the half of the maximum value (27.49). Scores of most subjects are shifted to the higher values and range from 14.79 to 40.19 points. It indicates that most subjects managed to achieve some technical points, even in the lost bouts.

Table 4. Descriptive parameters of the criterion variables

Variables	Mean	SD	Kurtosis	Skewness	MIN	MAX
BRPOBJ	2.48	1.43	-.80	.9	0	5
BMAXB	27.49	12.70	-.57	.03	0	50

Legend: BRPOBJ-number of victories; BMAXB-technical efficiency points

Table 5. Relations of performance in standing position bouts, defined as the number of victories (BRPOBJ), to the latent motor variables

Criterion	R	R^2	F	p	df1	df2
BRPOBJ	.38	.14	3.90	.01	5	116

number of victories	B	SE B	BETA	T	p (BETA)
MOTFAC1	-.04	.13	-.03	-.29	.77
MOTFAC2	-.11	.12	-.07	-.85	.40
MOTFAC3	-.36	.13	-.25	-2.78	.01
MOTFAC4	.20	.12	.12	1.37	.17
MOTFAC5	-.27	.13	-.19	-2.06	.04

Legend: BRPOBJ - number of victories

Table 6. The relations of performance criterion in a standing judo bout, defined as the technical efficiency points, according to the criterion the maximum value of the assigned point (BMAXB), with latent motor variables

Criterion	R	R^2	F	p	df1	df2
BMAXB	.40	.16	4.40	.01	5	116

technical efficiency points	B	SE B	BETA	T	p (BETA)
MOTFAC1	-.60	1.12	-.03	-.53	.60
MOTFAC2	-.18	1.10	-.05	-.16	.87
MOTFAC3	-3.14	1.14	-.25	-2.75	.01
MOTFAC4	1.17	1.10	.11	1.08	.28
MOTFAC5	-3.13	1.15	-.21	-2.72	.01

Legend: BMAXB - technical efficiency points

Relations of performance in standing position judo bouts to the latent motor variables

In Table 5 the results of regression analysis are displayed by which the influence was determined of the group of predictor variables on the criterion performance in judo bouts performed in a standing position defined by the number of victories (BRPOBJ). In that the predictor group consisted of the five isolated factors of latent motor dimensions defined as: ***relative strength, topological factor, flexibility, absolute dynamic strength and the ability to perform complex motor tasks of a speed-explosive type***. Between the latent motor dimensions and performance in bouts performed in a standing position, defined as the number of victories, statistically significant association was established at the level of .01. Multiple correlation amounts to .38, explaining about 14% of the total variance of the first performance criterion.

Individual positive, statistically significant contribution to the explanation of the criterion variance performance in bouts performed in a standing position, defined as ***the number of victories***, was obtained for the following factors: ***flexibility*** and ***the ability to perform complex motor tasks of a speed--explosive type***. The factor interpreted as the ***ability to perform complex motor tasks of a speed-explosive type*** in fact represents co-ordination abilities of the subjects because the greatest contribution to that factor was obtained for the tests assessing co--ordination abilities.

The rest of three factors did not contribute statistically significantly to performance in a standing judo bout defined by the number of victories.

Table 6 shows the results of regression analysis by means of which the influence of the predictor group of the isolated latent motor dimensions on the criterion technical efficacy points in a bout performed in a standing position (BMAXB). Statistically significant association was established at the level of .01. The obtained multiple correlation of .40 explained about 16% of the total variance of technical efficiency in bouts performed in a standing position.

Individual statisticially significant contribution to the explanation of the criterion technical efficacy points (the maximum value of the assigned point for the action performed) were registered for the factors: ***flexibility*** (partial coefficient .25), and ***the ability to perform complex motor tasks of a speed-explosive type***, the partial coefficient of which amounts to .21. The association was established at the statistical significance level of .01. The rest of the three isolated motor factors did not have any significant contribution to the explanation of performance in judo bouts performed in a standing position.

Discussion and conclusion

Generally speaking, a low level of relations was obtained between latent motor dimensions and performance in a judo bout, defined with two criterion variables. On average, only 15% of variance of the criterion variables was explained by the influence of motor variables. The finding indicates that performance of experienced judokas must be under a considerable influence of other factors as well (Kalina, et al., 2005). That certainly imposes the necessity to proceed with investigations of the influence of other anthroplogical dimensions and other possible factors on performance in judo matches.

Factor of ***flexibility*** had a higher partial contribution to the explanation of the determined association. The ability to perform movements of great amplitude enhance efficacy in bouts so as to enable a quality technique performance in attack, defence, and counterattack. Here we regard primarily standing throwing techniques the efficiency of which depends on the quality of interferring with the oppponent's balance, for which flexibility of the shoulder region is most responsible, and the ability to reach the opponent's legs, which should be hooked, blocked, or swept, for which hip flexibility is most responsible. Hip flexibility is very important for various leg sweepings and trippings (for example, when executing throwings *uchi-mata*, *harai--goshi*, *tai-otoshi*, *soto-makikomi*) as well as in the performance of defensive moves (liftings, evasions, trippings and similar). Spine flexibility should also be accentuated as one of the very important throwing performance factors, consequently factors of bout performance in general. A flexible spine allows judoists, using rotations of the upper body to perform forward and backward bends, to establish closer, better body contacts with their opponents, thus achieving a better quality of a throw (*kake*).

If muscles are stiff and firm, flexibility of a joint system is reduced; movements are performed as coarse straightline patterns, very often intermittent and not continuous, quite opposite to what is required for successful actions aimed at getting the opponent off balance, at establishing proper body contact with him/her and at performing a throw (Franchini, et al., 2008; Sertić, et al., 2007; Sterkowicz & Maslej, 1998). The mentioned leads to a poor judo technique and it determines, to the highest degree, the performance in standing judo bouts. The analysis of the influence of flexibility on performance based on both criteria should include also the relationships between flexibility and co--ordination. A stiff and inflexible person is not able to perform well in various throwings (due to the specific joint structure, nonsynchronized actions of the agonist and antagonist muscles, pronounced musculature) in everchanging environmenal conditions of a combat.

The factor interpreted as ***flexibility*** influences performance in a judo bout in a way that it annuls the opponent's strong movements, enables the avoidance of body contact, and it allows movement performance with great amplitude and adequate behaviour on landing. Good flexibility helps in avoiding various leg attacks, in which *uke* annuls, blocks, or avoids the *tori's* attack by raising high the attacked leg.

The significant contribution of co-ordination abilities (the fifth factor) to the explanation of performance in a judo bout is not as high as expected with regard to the structural complexity of judo technical elements, their performance in an ever changing environment, and the total number of elements that are performed either in a standing position or on the mat, as well as with regard to the results in certain previous research (Lucić, 1988; Sertić, 1994, 1997; Sertić, et al., 2007). However, we should point out here that only three tests were used in this experiment to assess co-ordination abilities, and that was not enough to cover the broad space of co-ordination abilities which is usually covered by 7 factors of co-ordination abilities – co-ordination of arms, co-ordination of legs, total body co-ordination, co-ordination in rhythm, agility, reorganization of a motor stereotype, speed of performing complex motor tasks, and speed of adopting new motor tasks. However, the obtained partial relation should be considered more than satisfactory since only three tests were used. It is viable to presume that if more co-ordination tests had been used, a higher level of relations would have been obtained between co-ordination abilities and performance in judo standing bouts.

The influence of co-ordination abilities, primarily the ***ability to perform the complex motor tasks of a speed-explosive type***, on the performance criteria in judo bouts performed in a standing position can be explained by the high complexity of judo throws that must be performed with high speed and accuracy under the constantly changing environment conditions of a bout (Heitkamp, et al., 2002). It means the judoist must continuously adapt himself/herself to ever changing time-space conditions in relation to his/her opponent by adjusting his/her stances, movements, and technique performance in attack, defence and counterattack. Perception of how to act against the opponent and the application of a particular technique and direction to solve successfully a certain bout situation (Franchini, et al., 2008) are very important to the eventual outcome or efficacy in a bout. However, to perform a technique with the desired effectiveness, one needs a high level of co-ordination of the entire body. Also, these actions cannot be successful if not performed extremely swiftly. Speed interferes with the opponent's efficient defence, or makes it actually impossible. Therefore, it is obvious why speed and explosiveness in performance of complex motor tasks influence performance and success in judo.

Statistically significant connection of motor variables with the criterion of performance in a bout performed in a standing position was established in the latent space. The relation of latent motor dimensions with bout performance criteria (the number of victories and technical eficacy points) was determined by means of regression analysis. The coefficients of multiple correlation are statistically significant, and their levels are almost equal (the number of victories - R=.38; the maximum value of the assigned point - R=.40). On average, they explained 15% of performance-in-bout variance. Out of five isolated dimensions only two had a statistically significant individual contribution to the explanation of performance variance acccording to both criteria – these were ***flexibility*** and the ***ability to perform complex motor tasks of a speed--explosive type***.

The findings of this research, although obtained on the sample of sophomore student-athletes, can be useful for coaches in the process of training programming. Judo is a sport in which, according to the hypothetical equation of performance, maximal strength of the absolute type predominates. However, that strength must be specifically trained and employed in judo techniques execution. Judo technique is very complex and requires high speed, agility and quickness in application. Therefore, training contents must be focused on the development of the mentioned combination of motor abilities. In order to make technique as efficacious as possible, a high level of flexibility is also needed. The obtained results indicate that flexibility, a somewhat underrated ability in judo, must not be neglected by any means in sports preparation because its contribution to performance in a bout is considerable.

The obtained partial association of co-ordination abilities with the performance criteria should be regarded more than satisfactory due to the fact that only three tests were applied to asses this hypothetic motor dimension. A relatively low level of correlations between latent motor dimensions with the performance criteria and only 15% on average of the explained variance should undoubtedly be an impetus to design new research on the influence of motor dimensions on performance by implementing a greater number of more sophisticated tests. Also, other anthropological dimensions and success factors should be investigated when performance in judo is the research interest.

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UTJECAJ LATENTNIH MOTORIČKIH SPOSOBNOSTI NA USPJEH U JUDO BORBI

Sažetak

Uvod i cilj istraživanja

Neprestano mijenjanje situacija, njihova dinamičnost, tijekom borbe od boraca traži dobru usvojenost tehničko-taktičkih stereotipa koje primjenjuju, sposobnost trenutačne reorganizacije tih sterotipa te stalno stvaranje novih obrambenih, napadačkih i protunapadačkih programa djelovanja.

Činjenica da se tehnika juda u borbi primjenjuje uz konstantan protivnikov otpor te da svaka natjecateljska borba traje pet minuta, govori o velikoj energetskoj potrošnji judaša. Ako veličina energetske potrošnje judaša ovisi o trajanju i intenzitetu rada, karakteru tog rada te količini angažirane muskulature, onda judaš obavlja na natjecanju i treningu izuzetno težak rad praćen visokim stupnjem psihičkog naprezanja. Budući da prema pravilima natjecanja postoje i mogućnosti brzog završetka, u borbi se odvija pravi psihološki rat zbog kojega je potrošnja energije još i veća.

Na uspjeh u judaškoj borbi, odnosno općenito u judu, utječu manje ili više sve ili gotovo sve čovjekove dimenzije, pa ih je sa znanstvenog aspekta potrebno ne samo utvrditi, već i ukazati na veličinu i smjer njihove povezanosti s uspjehom.

Globalni je cilj ovog istraživanja utvrđivanje veličine i smjera relacija nekih motoričkih varijabli s uspjehom u borbi u stojećem stavu u judu.

Metode rada

Uzorak ispitanika definiran je kao skup redovnih studenata Kineziološkog fakulteta Sveučilišta u Zagrebu. Istraživanje je provedeno na uzorku od 122 ispitanika muškog spola,

Za procjenu motoričkih sposobnosti ispitanika u ovom istraživanju izabrano je 15 motoričkih testova koji najbolje definiraju latentne dimenzije koordinacije, repetitivne snage (snažne izdržljivosti ili izdržljivosti u snazi), eksplozivne snage, brzine i fleksibilnosti.

Uspjeh u borbi u stojećem stavu definiran je dvjema kriterijskim varijablama: *broj pobjeda* i *tehnička efikasnost*. Prema prvom kriteriju izračunat je broj sveukupnih pobjeda iz pet borbi, a prema drugom kriteriju sumirana je tehnička efikasnost u borbama temeljem bodova dodijeljenih (i pobjedniku i poraženomu) za izvedene akcije.

Sve prediktorske i kriterijske varijable bile su podvrgnute standardnim deskriptivnim postupcima za određivanje njihovih osnovnih statističkih parametara. Izračunate su: aritmetičke sredine (Mean), standardne devijacije (SD), najniži (MIN) i najviši (MAX) rezultati te koeficijenti asimetričnosti (Skewness) i spljoštenosti (Kurtosis) distribucije rezultata. Latentni prostor određen je faktorskom analizom pod modelom glavnih komponenata (Hotellingova metoda). Relacije između manifestnih i latentnih motoričkih varijabli s uspjehom u borbi u stojećam stavu utvrđene su regresijskom analizom.

Rezultati

Analiza deskriptivnih statističkih parametara varijabli za procjenu motoričkih sposobnosti otkriva da su motoričke varijable normalno distribuirane, osim varijable *čučnjevi s teretom* (MRLPCT).

Hotelingovom metodom glavnih komponenata, a prema G-K kriteriju, ekstrahirano je 5 značajnih glavnih komponenata matrice korelacija motoričkih mjera. Temeljem glavnih komponenata definirano je 5 statistički značajnih faktora.

Definirani i imenovani su na sljedeći način: prvi faktor je nazvan ***relativna snaga***, drugi oblimin faktor diferencira osobe prema načinu i tipu očitovanja snage, apsolutne eksplozivne i relativne repetitivne, pa ga se za potrebe interpretacije može nazvati ***topološki faktor***. Treći izolirani faktor može se bez većih poteškoća interpretirati kao ***fleksibilnost***, dok je četvrti faktor interpretiran kao ***apsolutna repetitivna snaga***, a peti kao ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozivnog tipa***.

Regresijskom analizom obrađen je utjecaj prediktorskog skupa na kriterij uspjeha u borbi u stojećem stavu definiranog brojem pobjeda (BRPOBJ), pri čemu je prediktorski skup činilo pet izoliranih faktora latentnih motoričkih dimenzija definiranih kao: ***relativna snaga, topološki faktor, fleksibilnost, apsolutna repetitivna snaga*** i ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozivnog tipa***. Između latentnih motoričkih dimenzija te uspjeha u borbama u stojećem stavu definiranog brojem pobjeda ostvarena je statistički značajna povezanost na razini od .01. Multipla korelacija iznosi .38, što objašnjava oko 14% ukupne varijance kriterija uspjeha u borbi u stojećem stavu definiranog ***brojem pobjeda***.

Pojedinačni pozitivan, statistički značajan doprinos objašnjenju varijance kriterija uspjeha u borbi u stojećem stavu definiranog kao ***broj pobjeda*** ostvaruju faktori imenovani kao ***fleksibilnost*** i ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozivnog tipa***.

Regresijskom analizom definiran je utjecaj prediktorskog skupa izoliranih latentnih motoričkih dimenzija na kriterij za procjenu tehničke efikasnosti u borbi u stojećem stavu prema kriteriju ***maksimalna vrijednost bodovane akcije*** (BMAXB). Iz tablice je vidljivo kako je ostvarena statistički značajna povezanost prediktorskog skupa i uspjeha u judo borbi u stojećem stavu definiranog tehničkom efikasnošću prema kriteriju maksimalna vrijednost bodovane akcije i to na razini od .01. Dobivenom multiplom korelacijom od .40 objašnjeno je oko 16% ukupne varijance za procjenu tehničke efikasnosti u borbi u stojećem stavu definirane prema kriteriju maksimalna vrijednost bodovane akcije.

Pojedinačni, statistički značajan doprinos objašnjenju varijance kriterija definiranog ***tehničkom efikasnošću*** prema kriteriju maksimalna vrijednost bodovane akcije ostvaruju faktori imenovani ***fleksibilnost***, čiji parcijalni koeficijent iznosi .25, i ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozivnog tipa***, čiji parcijalni koeficijent iznosi .21.

Rasprava i zaključak

Statistički značajna povezanost motoričkih varijabli s kriterijima uspjeha u borbi u stojećem stavu ostvarena je u latentnom prostoru.

Povezanost latentnih motoričkih dimenzija s uspjehom u borbi utvrđena je regresijskom analizom dva kriterija uspješnosti u borbi (broj pobjeda, tehnička efikasnost). Koeficijenti multiple korelacije statistički su značajni, a razine su gotovo identične (broj pobjeda - R=.38, maksimalna vrijednost bodovane akcije - R=.40), čime se objašnjava prosječno 15% varijance uspješnosti u borbi. Statistički značajan pojedinačni doprinos objašnjenju varijanci uspješnosti u borbi prema oba kriterija od pet izoliranih dimenzija imaju samo dvije, ***fleksibilnost*** i ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozivnog tipa***.

Utjecaj faktora ***fleksibilnosti*** na uspješnost u borbi objašnjava se zahtjevom da natjecatelj, i u napadu i u obrani, pri izvođenju tehničkih elemenata, izvodi pokrete velikih amplituda bez prevelike krutosti mišića.

Utjecaj faktora interpretiranoga kao ***sposobnost izvođenja složenih motoričkih zadataka brzinsko-eksplozinog tipa***, koji definiraju prvenstveno koordinacijski testovi, na uspješnost u borbi tumači se zahtjevom da se specifična složena gibanja u borbi izvode brzo. Drugim riječima, kvalitetno tehničko djelovanje natjecatelja u borbi, zbog složenosti judaške tehnike, nije moguće bez sposobnosti definirane tim faktorom koji je u biti po svojoj prirodi izrazito koordinacijski.

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