EFFECTS OF DIFFERENT ASPECTS OF COORDINATION ON THE FIGHTING METHODS AND SPORT SKILL LEVEL IN CADET JUDO CONTESTANTS

Grzegorz Lech[1], Hrvoje Sertić[2], Stanisław Sterkowicz[1], Katarzyna Sterkowicz-Przybycień[1], Janusz Jaworski[1] and Robert Krawczyk[3]

[1]Institute of Sport, Faculty of Physical Education and Sport, University School of Physical Education, Cracow, Poland
[2]Faculty of Kinesiology, University of Zagreb, Croatia
[3]University School of Physical Education, Katowice, Poland

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Abstract:

The primary aim of this study was to determine the relationship between certain aspects of coordination, the time course of a bout and sport-related skill levels in cadet judoists. The study evaluated eight judokas with high sport skill levels. Based on the analysis of tournament matches (N=66), the authors determined the activity, effectiveness of actions and the level of achievement. Ten aspects of coordination were assessed by 28 indices. It was found that a high level of adaptive ability was a prerequisite for high levels of activity during phase I of a bout. Shorter durations of complex reaction time were correlated with higher effectiveness in both the phase I and throughout a bout. High level of visual-motor coordination was correlated with high effectiveness and its increase during phase II of a bout. Certain aspects of coordination seem to be necessary components of the technical and tactical coaching of cadets. However, they do not correlate directly with the level of achievement.

Key words: *martial arts, reaction time, psychomotor performance, motor skills, task performance, performance analysis*

Introduction

Over the past 30 years, researchers from different countries have demonstrated that one of the most important factors in the development of technical and tactical excellence in sports characterized by open movement structures (e.g. team games or combat sports) is well-developed coordination (Blume, 1978; Ljach, 1995; Sadowski, 2003; Starosta, 2003). High levels of coordination are prerequisites for effective learning of new technical skills and coordination determines how a judoka fights (Czajkowski, 2004). The more varied techniques required in a sport, the greater the importance of coordination (Starosta, 2003). A judoka has to perfect complementary throws with a single grip in order to use attacks in three to four directions and be effective during a bout (Calmet, Trezel, & Ahmaidi, 2006).

Judo is a sport characterized by numerous sport-specific techniques, i.e. by a large repertoire of technical elements and a variety of exercises practiced in exceptionally changing conditions. Furthermore, judoka's movements must be quick and precise enough to ensure the effectiveness of the fighting technique used. As a result, understood as a sport with the highest level of coordination complexity (Hirtz & Starosta, 1991; Starosta, 2006).

Despite the previously listed facts, researchers rarely investigate aspects of coordination in individuals who practice judo. Few studies in this area have focused on the effect of the sport on coordination levels (May, Baumann, Worms, Koring, & Aring, 2001; Drid, et al., 2009), changes in the selected aspects of coordination as a consequence of fatigue (Lima, Tortoza, Rosa, & Lopez-Martins, 2004) and the relationship with the sport's skill level (Hrysomallis, 2011).

To fully present the importance of coordination in this sport, it is necessary to demonstrate its relationship with the time course of bouts and to broaden understanding of its correlation with the sport skill level. Individual aspects of coordination might affect the course of the entire bout, as well as phase I and II; as a consequence, coordination may determine the contestants' level of sport achievement.

Interactions between multiple factors determining technical and tactical excellence, including reaction time, spatial orientation, visual-motor coordination and the ability to differentiate movements, have been identified in previous studies of adult judo contestants (Lech, Jaworski, & Krawczyk, 2007). A high correlation between the level of tournament-related achievement and speed, accuracy and precision of movements has also been demonstrated (Lech, et al., 2007).

In a group of junior judoists (Lech, Jaworski, Ljach, & Krawczyk, 2011), the activity of contestants during particular phases of bouts was correlated with their abilities to differentiate movements and speed, as well as with the accuracy and precision of movements, whereas the reaction time was correlated with the level of sport achievement.

Younger judoists are classified as cadets (15-16 years old). Some studies have demonstrated that superior performance in cadet tournaments significantly depended on cadet's strength and endurance conditioning (Krstulović, Sekulić, & Sertić, 2005). Boys at the age of cadet category have usually passed the progressive phase (peak height velocity) of ontogenetic development (Malina, Bouchard, & Bar-Or, 2004). Time structure of judo bouts performed by cadets was found to be specific when compared to other age categories (Miarka, et al., 2012). Thus, we assumed that coordination characteristics, which determine time structure of a bout and scores, might also differ from those observed in juniors and adult judoists.

The primary goal of the present study was to provide answers to the questions concerning the relationship between different aspects of coordination and fighting activity levels, effectiveness in a bout and the sport-related expertise of judo cadets.

Methods

Subject sample

The study evaluated eight male judokas in the following weight categories: under 60 kg (n=1), 73 kg (n=5), and under 81 kg (n=2), that is medium weight categories. Each judoka had won at least the fifth place in the national-level cadet tournaments. There were 18 athletes at this sport skill level in each tournament. The subjects Subjects were selected for the study based on their chronological age and training experience. Table 1 presents the characteristics of age, sports experience and basic parameters of somatic build in the study subjects.

Table 1. Age, experience and basic parameters of somatic build of the study participants (N=8)

Variables	Mean	Min.	Max.	SD
Age (years)	15.5	15	16	0.54
Body height (cm)	177.4	170	185	6.23
Body mass (kg)	71.7	56.5	82.4	7.48
Experience (years)	6.1	5.00	7.00	0.84
Lean body mass (kg)	65.2	52.4	72.8	6.31

Variables

Dependent variables included the indices that determine the fighting activity and effectiveness of actions performed by study participants. The activity index (AI) was calculated from the following formula: $AI=\Sigma A/NF$, where: ΣA is a total number of attacks, and NF is the number of bouts in which the contestant competed. The activity index calculated for phase I was AIFP, with AISP denoting bout phase II activity. Difference in the activity index (DAI) was also calculated to demonstrate the variability of activity during competition. It was calculated as follows: DAI=AIFP-AISP. The effectiveness index (EI) is an arithmetic mean of the scores for attacks (EIFP as calculated for phase I of a match and EISP for the phase II). The difference in the EI was calculated from the following formula: DEI=EIFP-EISP. Furthermore, the levels of sports achievements (LOA) were differentiated according to the following point scale:

- preliminary competitions: 1st place – 3 points, 2nd place – 2 points, 3rd place – 1 point, 5th place – 0.5 points;
- main round: 1st place – 7 points, 2nd – 5 points, 3rd place – 3.5 points, 5th place – 1.5 points, and 7th – 0.5 points.

The independent variables were the result of measuring different aspects of local-movement coordination. The contemporary classifications of coordination aspects were used here (Raczek, Mynarski, & Ljach, 2003; Starosta, 2006): kinaesthetic differentiation of movements (i.e. the precise perception of force, time and space when performing a motor activity); frequency of movements (which represents the ability of performing a maximum number of movements with the whole body or its parts at any given time); simple reaction time (to visual and auditory stimuli); selective reaction time (allows fast performance of a short-term action); rhythmization (allows one to perceive, reproduce and perform dynamic changes in movement within an ordered repeat cycle); speed, accuracy and precision of movement (i.e. muscle tremor in the hand) can be considered the harmonic vibrations that occur at the time of the test; motor adjustment (which allows for the implementation of an optimum program of action, as well as changes in this program if one has noticed or predicted the changes in the situation); spatial orientation, representing the ability to accurately assess the position of the body or its parts, as well as changes in this position with respect to a reference point; visual-motor coordination (which is regarded as a manifestation of receptor-motor coordination that consists of the harmonization of eye movements with the movement of the whole body or its parts); reaction to moving objects (which receptor-motor coordination, being highly dependent on reaction time); and balance (helps to maintain a stable body position or to maintain/to regain this state during or after completion of an activity) (a more detailed description in measurement protocols' description).

Experimental procedure

During elimination competitions in the lead-up to the Cadet Poland Cup (in Bytom, April 5-12, 2008, and in Głogów, April 26-27, 2008), tournament matches fought by the contestants were recorded (n=66). The athletes performed six to 12 bouts. AI indices for each athlete were computed per bout. Technical actions of individual contestants were evaluated with a computer-aided analysis of the bouts, which included an analysis of the selected matches of contestants who qualified for the main tournament. The actions awarded by points, as well as the part of a bout in which the technical action was carried out, were taken into consideration. The analysis also included ineffective actions not winning any points, as well as situations in which a contestant managed to interfere with the opponent's balance as an attempt to perform a throw (flying phase), which were also assigned a zero score. These actions require high energy expenditure and should not be neglected when analyzing fighting technique and tactics. In total, 121 technical actions were recorded. Two coaches and (champion class and the first class) with the combined judo experience of 72 years classified the events recorded during the bout.

Every bout was divided into the following two parts: phase I, represented by the first two minutes of a bout, and phase II, represented by the third and fourth minutes. Extra time (golden score), which occurred in four bouts, was included in the phase II of a bout.

The observations and the analysis of the videotaped judo bouts were carried out by two coaches with many years of experience. The objectivity of their observations, carried out during these tournaments, was very high. Inter-observer coefficients between the activity index (AI) and effectiveness index (EI) were .993, 95% CI=.968; .998 and .997, 95% CI=.988; .998, respectively. Similarly, the reliability determined by the intra-class correlation coefficients (ICC) of AI and EI indices was very high. Intra-observer reliability (ICC) values were .991, 95% CI=.970; .998 for AI and .996, 95% CI=.984; .999 for EI. ICC measures a relative homogeneity within groups in ratio to the total variation. The reliability ranging from .7 to .8 was debatable, with the values higher than .9 being high reliability (Vincent, 2005).

Investigations of different aspects of coordination (independent variables) relied on a set of tests with high reliability and validity that were proposed by Jaworski (Sterkowicz & Jaworski, 2006, 2012). The tests were carried out using a portable computer with a touch screen (Toshiba Satellite R15) with the following parameters: 1.7 GHz processor, Windows XP Tablet PC Edition 2005, 512 MB RAM, graphics card with 32-bit color depth (16 million colors), a 14.1'' LCD screen with 1024x768 pixel resolution, a computer mouse and a stylus pen. The tests were conducted in a secluded room that ensured silence for each individual tested.

Measurement procedures

- kinaesthetic differentiation: a subject predicted the time necessary for filling in the rectangle; the test outcome was the mean absolute deviation from the pattern, expressed in pixels;
- frequency of movements: within the time frame of 15 seconds (with a monitor positioned horizontally), a subject touched two squares alternately with a tablet pen; the result was expressed as the number of manual contacts;
- reaction time to visual or auditory stimuli: after the presentation of a stimulus, a subject was instructed to click the left button of a mouse as quickly as possible; the result was expressed in milliseconds;
- selective reaction time: depending on the stimulus (auditory or visual), a subject was instructed to click a button of a mouse as quickly as possible; left mouse button after exposure to auditory stimulus or right mouse button after exposure to visual stimulus;
- rhythmization: the subject was instructed to remember the rhythm presented by the computer and then to reproduce it; the result was expressed in milliseconds;
- speed, accuracy and precision of movements (labyrinth to the left; labyrinth to the right): the subject was instructed to drag a square with a tablet pen through a special maze as quickly as possible and to keep the number of mistakes to the minimum the result was expressed in seconds;
- differences in time of performance and the number of errors in the test evaluating speed, accuracy and precision of movements performed clockwise and counterclockwise considered as indices of motor adjustment ability;
- hand-eye coordination: a subject used a tablet pen to touch, as quickly as possible, a square generated by the program the result was expressed in seconds;
- spatial orientation: a subject used a tablet pen to change the sequence of two squares that were

displayed on the intersection of perpendicular lines change, as quickly as possible, the sequence the result was expressed in seconds;
- reaction to moving objects: when the test began, white squares on the screen started to fill with red, in random order. The subject was instructed to touch a grey square under the red square with the stylus pen as quickly as possible before another square filled with red.
- The subjects performed all coordination tests with the dominant hand.

The Flamingo Balance Test was also employed as an evaluation of balance according to the *Eurofit European Test Battery* (Committee of Experts on Sports Research, 1993). This test consisted of the following tasks: maintain balance for one minute while standing one-footed on a wooden beam (four cm in height and three cm in width) along its long axis and holding the foot of the other leg bent at the knee. In the beginning, the subject held the hand of a measurer. The test started the moment the subject released the hand of the assisting person. When the subject lost balance (i.e. let go his/her leg or touched the floor), the test was repeated within one minute. The score was represented by the number of attempts to stand on the beam for one minute maintaining the balance.

Statistical analysis

The STATISTICA PL v. 6.0 software package was employed for the analysis of the collected data. After distribution normality examination using the Shapiro-Wilk test, mean values (Mean), measures of variability (SD, V – coefficient of variation=[SD/M]·100%]) and Pearson's r correlation coefficients were calculated between a variety of coordination aspects and indices of the time course of a bout in relation to the phases I and II of a bout. The assessment of how well the correlations matched the empirical data was made using the coefficient of determination r_c (squared correlation coefficient).

Results

Very high levels of V were found for DEI (182%) and EISP (91.5%). High variability was demonstrated for indices of the course of a bout: AI (43.7%) and AIFP (53.0%), whereas a medium-level variation was observed for EI (23.2%) and EIFP (33.6%) (Table 2).

The analysis of the results obtained by the contestants in individual tests (Table 3) indicated that very high variability was observed for visual-motor coordination (parameter 21; V=76.9%), motor adjustment (parameter 18; V=72.9%) and the ability to differentiate movements (parameter 1; V=67.2%). Low variability was found for reaction time (parameters 3, 4, 6, 7 and 8), wherein the coefficient of variation ranged from 5.9% (parameter 6) to 7.5% (parameter 8), and visual-motor coordination (parameter 19, V=6%).

No significant correlation was found between the coordinated motor ability score and the level of achievement attained by the contestants.

The results obtained from the basic coordination ability tests correlated with a subset of bout-related indices (Table 4; Figures 1 to 12).

It was found during the interpretation of the value of the Pearson's r for the ability to differentiate movements that the test results for this elementary ability (parameter 1, kinaesthetic differentiation – anticipation, with anticipation understood as the ability to look forward and judge correctly what is going to happen next) showed a high significant positive correlation with the fighting activity levels of the contestants (AI; r_c=.53) (Figure 1), as well as with the fighting activity observed during phase I of the bouts (AIFP; r_c=.52) (Figure 2).

The minimum complex reaction time was associated with four indices of the time course of a bout. A markedly high positive correlation was found for this reaction time and the AI (Figure 3). These variables shared 56.3% of their variance.

A significant negative correlation was found between the minimum complex reaction time and the EI (r_c=.57) (Figure 4), EIFP (r_c=.53) (Figure 5) and the DEI (r_c=.64) (Figure 6). Furthermore, rhythmization (parameter 12) was negatively correlated with EI (r_c=.64) (Figure 7).

A significant strong negative correlation was also detected for the relationship between the difference in the time spent performing the tests, including labyrinth to the left, labyrinth to the right (parameter 17) and AIFP (Figure 8). These variables shared 63% of their variance. The visual-motor coordination error frequency (parameter 20) corre-

Table 2. Characteristics of the indices that determine activity, effectiveness and the level of achievement of the study participants (N=8)

Variables	Mean	Min.	Max.	SD
AI	1.7	0.6	2.6	0.76
AIFP	1.2	0.4	2.4	0.61
AISP	0.9	0.3	2.0	0.59
DAI	0.6	0.6	1.2	0.42
EI	4.5	3.3	6.3	1.05
EIFP	5.3	3.3	8.5	1.76
EISP	3.0	0.0	7.0	2.72
DEI	2.3	-3.0	8.5	4.20
LOA	2.9	0.0	9.0	3.01

Legend: AI - activity index; AIFP - activity during the first part of a bout; AISP - activity during the second part of a bout; DAI - difference in the activity index; EI - effectiveness index; EIFP - effectiveness during the first part of a bout; EISP - effectiveness during the second part of a bout; DEI - difference in the effectiveness index; LOA - level of achievement

Table 3. Parameters for the determination of different aspects of coordination in the study participants (N=8)

Test	No.	Parameter/Measurement unit	Mean	Min.	Max.	V (%)
Ability to differentiate movements	1	Kinaesthetic differentiation – anticipation / pixel	33.6	5	66	67.2
Frequency of movements	2	**Hand movements frequency (tapping) / n**	45	37	53	12.2
	3	Minimum reaction time (visual stimulus) / ms	227.5	210	250	7.0
	4	Mean reaction time (visual stimulus) / ms	248	225	271	6.5
	5	Maximum reaction time (visual stimulus) / ms	273.75	240	320	9.1
	6	Minimum reaction time (auditory stimulus) / ms	191.25	180	210	5.9
	7	Mean reaction time (auditory stimulus) / ms	206.38	191	235	7.3
	8	Maximum reaction time (auditory stimulus) / ms	222.5	210	260	7.5
	9	Minimum complex reaction time / ms	260	220	300	10.1
	10	Mean complex reaction time / ms	386.25	323	432	11.0
Reaction time	11	Maximum complex reaction time / ms	590	460	780	21.0
Rhythmization ability	12	Movement rhythmization / ms	166.5	50	297	41.3
	13	Labyrinth to the left / s	52.1	43	59	10.0
	14	Labyrinth to the right / s	46.3	38	58	15.6
Speed, accuracy and precision of movements	15	Labyrinth to the left / mistakes n	18.6	10	27	29.1
	16	Labyrinth to the right / mistakes n	15	7	27	45.6
	17	Difference between the direction to the right and to the left / s	9.6	5	15	31.4
Motor adjustment	18	Difference between the direction to the right and to the left / mistakes n	7.9	2	18	72.9
	19	Optional / s	81.6	76	91	6.0
	20	Forced / errors n	77.6	45	95	22.2
	21	**Forced / correct n**	22.4	5	55	76.9
	22	Eye-hand coordination / s	76.5	63	100	15.9
Visual-motor coordination	23	Eye-hand coordination / mistakes n	18.8	6	24	30.8
	24	Optional / s	62.1	53	73	11.2
Spatial orientation	25	Optional /errors n	2	0	5	70.7
	26	**Forced / correct n**	20.5	10	39	42.2
Reaction to moving objects	27	Forced / errors n	29.5	11	40	29.3
Balance	28	Number of attempts to stand on the beam / n	9.9	5	17	35.6

Legend: The stimuli were bolded/higher values of indices to facilitate accuracy of the results.

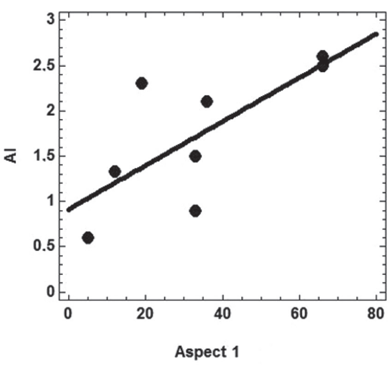

Figure 1. Kinaesthetic differentiation – anticipation / pixel versus activity index (AI).

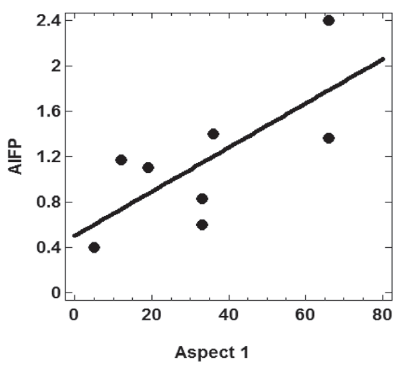

Figure 2. Kinaesthetic differentiation – anticipation / pixel versus activity during the first part of a bout (AIFP).

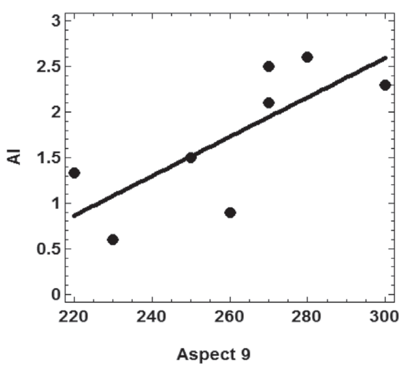

Figure 3. Minimum complex reaction time / ms versus activity index (AI).

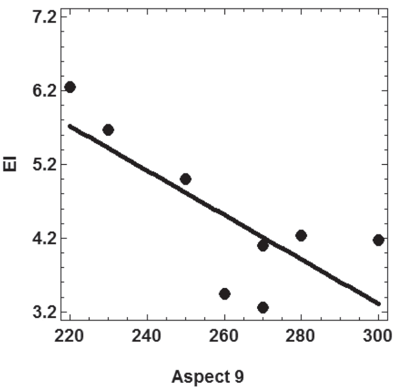

Figure 4. Minimum complex reaction time / ms versus effectiveness index (EI).

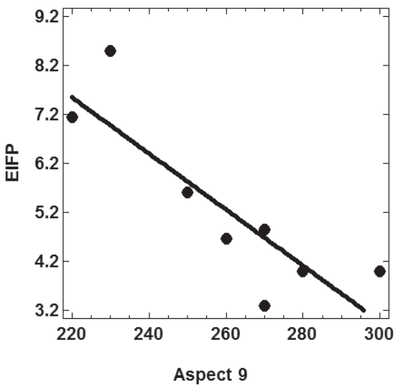

Figure 5. Minimum complex reaction time / ms versus effectiveness during the first part of a bout (EIFP).

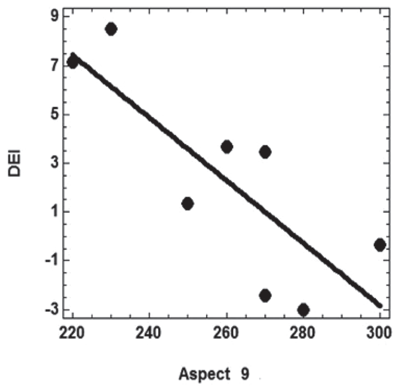

Figure 6. Minimum complex reaction time / ms versus difference in the effectiveness index (DEI).

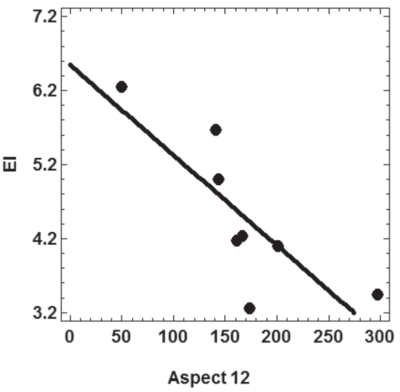

Figure 7. Movement rhythmization / ms versus effectiveness index (EI).

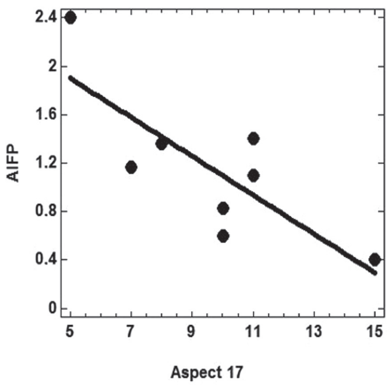

Figure 8. Difference between the direction to the right and to the left / s versus activity during the first part of a bout (AIFP).

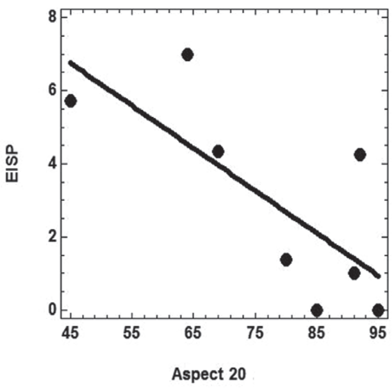

Figure 9. Visual-motor coordination. Forced / errors n versus effectiveness during the second part of a bout (EISP).

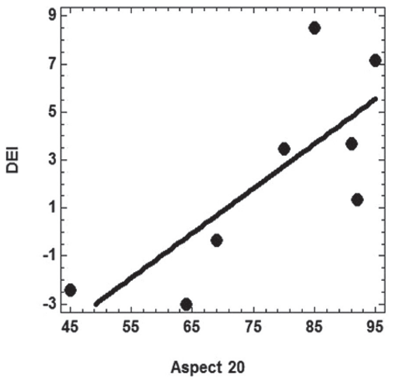

Figure 10. Visual-motor coordination. Forced / errors n versus difference in the effectiveness index (DEI).

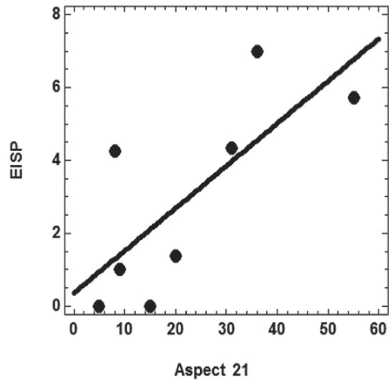

Figure 11. Visual-motor coordination. Forced / correct n versus effectiveness during the second part of a bout (EISP).

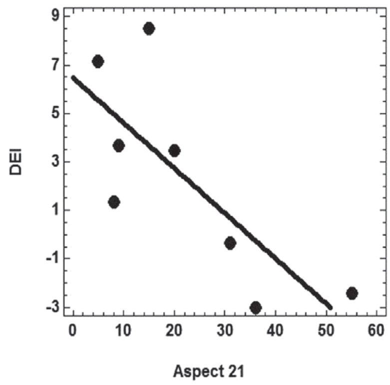

Figure 12. Visual-motor coordination. Forced / errors n versus difference in the effectiveness index (DEI).

lated negatively with EISP (r_c=.53) (Figure 9), and positively with DEI (r_c=.58) (Figure 10).

A significant correlation was observed between the number of proper reactions during the test (parameter 21) and EISP (Figure 11) and DEI (Figure 12). Regarding the effectiveness in phase II of the bouts, this correlation was strong and positive, and it explained 55% of the total variability for this index. In contrast, the number of proper reactions in the DEI test was negatively correlated (r_c=.58).

Table 4. Statistically significant (p<.05) values of Pearson's correlation coefficients calculated between the coordination test results, the indices varying in relation to the time course of a bout and the level of achievement in the studied group of contestants (N=8)

Correlation coefficients	r(X,Y)	r_c	*t*	p
Kinaesthetic differentiation – anticipation / pixel AI	.728	.530	2.601	.041
Kinaesthetic differentiation – anticipation / pixel AIFP	.720	.518	2.538	.044
Minimum complex reaction time / ms AI	.750	.563	2.778	.032
Minimum complex reaction time / ms **EI**	**-.755**	**.570**	**-2.821**	**.030**
Minimum complex reaction time / ms **EIFP**	**-.852**	**.726**	**-3.991**	**.007**
Minimum complex reaction time / ms DEI	-.802	.643	-3.284	.017
Movement rhythmization / ms **EI**	**.801**	**.641**	**-3.272**	**.017**
Difference between the direction to the right and to the left / s **AIFP**	**-.790**	**.624**	**-3.157**	**.020**
Visual-motor coordination. Forced / errors n **EISP**	**-.740**	**.548**	**-2.698**	**.036**
Visual-motor coordination. Forced / errors n **DEI**	**.764**	**.584**	**2.904**	**.027**
Visual-motor coordination. Forced / correct n **EISP**	**.740**	**.548**	**2.698**	**.036**
Visual-motor coordination. Forced / correct n **DEI**	**-.764**	**.584**	**-2.904**	**.027**

Legend: Favourable correlations are bolded (better results in coordination test were associated with a favourable value of the index determining the fighting method).
AI - activity index; AIFP - activity during the first part of a bout; EI - effectiveness index; EIFP - effectiveness during the first part of a bout; EISP - effectiveness during the second part of a bout; DEI - difference in the effectiveness index.

Discussion and conclusions

Sports performance of judo contestants, apart from specific psychological predisposition profiles, depends on a combination of technical skills, which include levels of coordination, strength, speed and endurance, and tactical skills that perform an overriding function with respect to the previously mentioned physical features and technical skills (Lech & Sterkowicz, 2004). Superior performances in cadet tournaments significantly depend on strength and endurance conditioning (Krstulović, et al., 2005). Therefore, the degree of technical and tactical excellence of judo contestants might be determined, up to a point, by their levels of coordination. Although favorable correlations were found between a subset of coordination parameters and indices of technical and tactical excellence, our study has demonstrated that the level of cadet achievement was not directly connected with the level of coordination.

The reaction time was correlated with the effectiveness of actions during a bout, especially during phase I. Given the strength of these correlations, it can be concluded that high effectiveness of athletes with superior reaction times in phase I of a bout is likely to influence correlation between this particular aspect of coordination and effectiveness throughout a bout. This interpretation is also supported by the lack of correlation between reaction time and the effectiveness of actions in phase II of a bout (including extra time). These observations are intriguing, given a previous study demonstrating that post-exercise fatigue following the use of a bicycle ergometer (Guiziani, et al., 2006) or a judo bout (Lima, et al., 2004) causes an elongation of reaction time. The fatigue caused by the bout, as evidenced by the prolonged reaction time, seems to facilitate a reduction in the influence of this coordination aspect on the effectiveness of subsequent actions.

Movement rhythmization was associated with the effectiveness of actions. This relationship can be confirmed by the existence of the 'rhythm of a bout', which signals the individualized repetition of technical and tactical actions during certain periods of a match. Therefore, with a more distinct rhythm of a bout (i.e. a higher level of rhythmization), the effectiveness of actions is likely to increase.

Motor adjustment was correlated with fighting activity in phase I of the bouts. This aspect of coordination allows for the realization of an optimum plan of action, as well as for the adjustment of the plan if environmental changes have been noticed or anticipated. Therefore, the athletes with elevated levels of this ability were most likely superior at recognizing the situations that were conducive to attack performance. After the recognition of the situation (in phase II of the bouts, including extra time), the effect of this type of coordination on the fighting activity levels was reduced.

The indices that defined visual and motor coordination correlated with the effectiveness measures in phase II of the bouts (including the extra time), as well as with increased effectiveness during this phase of a match. It is difficult to provide an unequivocal explanation for these relationships. It is, however, feasible to conclude that the reduced effect of the reaction time on the effectiveness of fighting actions is likely compensated by visual-motor coordination.

The current findings and those obtained in the studies of adults (Lech, et al., 2007) and junior athletes (Lech, et al., 2011) demonstrated that the ability to react fast as measured with time reaction tests was found to be of great importance. In the groups of adults and cadets these indices correlated with the properties of the course of a bout, whereas in junior athletes they correlated with the level of achievement.

Supporting information that reinforces the importance of this aspect of coordination in combat sports is also provided by the results obtained in a group of fencers, with the advanced fencers demonstrating shorter reaction times compared to the beginners (Wiliams & Walmsley, 2000).

Despite the high significant correlations reported, the findings of the present study should be approached with due caution. Any interpretation must take into account unique characteristics of a particular population, as well as the type of tests. The number of study participants (N=8), however, was a limiting factor in considering the homogeneity in terms of age, experience, body mass and sports quality level. With respect to these types of tests, it should be emphasized that they are performed under non-judo-specific conditions and actions. In other words, one could argue that the measurements concerned *general* rather than *special* coordination.

Favorable and statistically significant correlations were found between the following:

1) Activity level of the contestants and their ability to adapt (activity in phase I of a bout, expressed as the differences in time measured during the labyrinth to the right and labyrinth to the left tests).
2) Effectiveness of actions and
   - minimum complex reaction time (effectiveness in phase I and in the whole bout)
   - visual-motor coordination (number of errors and correct reactions during the test of visual-motor coordination, correlated with the effectiveness of fighting actions in phase II of a bout and increased effectiveness during the latter part of a match).
3) No correlations were found between the level of coordination abilities and sport level in the studied group of athletes.

It is notable that training for individual age groups should be aimed at achieving an individually tailored optimal level of motor abilities eventually displayed by adult athletes. Thus, the particular focus should be on the development of spatial orientation, the ability to adapt movements and reaction time. In particular, many of these exercises should be developed in younger school ages (before the observed growth spurt in body height), as this is a period of life that is very sensitive in terms of coordination development. The studies have confirmed that, even without intentional influence on the formation of some aspects of coordination, training at this age yields measurable effects. The contestants who have started training in this period of their development are more likely to perform actions with a complex movement structure (e.g. throws with body turn) and to use their own inertia during actions; importantly, they are more likely to exhibit higher sport skills' levels by the time they reach adult status (Lech & Sterkowicz, 2004).

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UČINCI RAZLIČITIH ASPEKATA KOORDINACIJE NA NAČIN BORENJA I RAZINU SPORTSKE VJEŠTINE KADETSKIH JUDO NATJECATELJA

Primarni cilj ovog istraživanja bio je utvrditi povezanost između pojedinih aspekata koordinacije, tijeka borbe i razine specifičnih motoričkih znanja u judaša kadetskog uzrasta. U istraživanju je testirano osam tehnički visokokvalitetnih judaša. Na temelju analize turnirskih borbi (N=66), autori su utvrdili aktivnost, učinkovitost akcija te razinu uspjeha sportaša. Deset aspekata koordinacije bilo je procijenjeno pomoću 28 pokazatelja. Utvrđeno je da je visoka razina sposobnosti adaptacije preduvjet za visoku razinu aktivnosti tijekom prve polovice judo borbe. Kraće vrijeme kompleksne reakcije bilo je u korelaciji s višom razinom učinkovitosti u prvom dijelu borbe, ali i tijekom cijele borbe. Visoka razina vizualno-motoričke koordinacije predstavlja preduvjet za visoku razinu učinkovitosti u borbi, a razina koordinacije povećavala se tijekom drugog dijela borbe. Čini se da su određeni aspekti koordinacije komponente potrebne za tehničko-taktičko usavršavanje kadeta. Ipak, aspekti koordinacije nisu izravno povezani s razinom uspjeha na natjecanju.

Ključne riječi: *borilački sportovi, vrijeme reakcije, psihomotorička izvedba, motorička znanja, izvedba zadatka, analiza izvedbe*

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Correspondence to:
Grzegorz Lech, Ph.D.
Institute of Sport,
Faculty of Physical Education and Sport
University School of Physical Education, Cracow
Al. Jana Pawła II 78, 31-571 Cracow, Poland
Phone: 48 12 683 12 86
Fax: +48 12 683 11 21
E-mail: glech@poczta.wp.pl