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Coordination motor abilities of judo contestants at different age

Stanisław Sterkowicz[1], Grzegorz Lech[1], Janusz Jaworski[2], Tadeusz Ambroży[3]

[1] Department of Theory and Methodology of Combat Sports, University School of Physical Education, Krakow
[2] Department of Kinesiology, University School of Physical Education, Krakow
[3] Department of Theory and Methodology of Gymnastics, University School of Physical Education, Krakow

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Summary

Introduction. Judo is generally considered as a sport which combines strength and endurance. In this sport, with predominance of open movement habits, an important role is played by coordination abilities. The main aim of the present study is to carry out a comparative analysis of the indices of coordination motor abilities (CMA) among judo contestants at different age.

Material and methods. The study group was comprised of 25 judo contestants during the competitive season (7 seniors, 10 juniors and 8 cadets). A series of computer tests were carried out in order to evaluate kinaesthetic differentiation of movements, simple reaction time, complex reaction time, spatial orientation, visual-motor coordination, rhythmization, speed, accuracy and precision of movements, ability to adapt movements, eye-hand coordination. The study also tested global movement coordination (Starosta's test) and balance (Flamingo test). Significance of differences was assessed by means of one-way ANOVA ($p<0.05$). In intergroup comparisons, the levels obtained in seniors were adopted as reference values.

Results. The factor of experience (age category and sport experience) has an overwhelming effect on the sense of balance, which is the highest in seniors, medium in juniors and the lowest in cadets. The category of juniors exhibits the most of beneficial differences in terms of global motor coordination compared to cadets, minimal complex reaction time compared to seniors, spatial orientation and indexes of reaction to moving objects. Seniors are characterized by longer minimal complex reaction time compared to juniors and stagnant results in the test of global motor coordination, spatial orientation and reaction to moving objects.

Conclusions. The tests which differentiate between age categories should be taken into consideration in monitoring of the preparation of judo contestants.

Introduction

Results of judo competition represent a combination of a variety of factors, connected with both natural aptitudes as current body abilities [1]. A vital (and multi-faceted) element is the ability of performing efficient movements of the body while controlling balance and ensuring quick and precise reactions to unexpected attack of the opponent. Combined with a variety of requirements, this control over movement represents the essence of a global motor coordination [2,3]. Attempts to find judo-specific coordination motor abilities (CMA) reveal that a considerable place in this structure is taken by: balance, reaction time and spatial orientation. Ability to control balance helps maintain a stable body position (static balance) or maintaining/regaining this state (dynamic balance) during or after completion of an activity. Judo is a sport that requires a high level of dynamic balance [4]. The main criteria of optimum level of the ability discussed are the elements determined by a number of factors in body build and function of the nervous system, such as precision, speed, purposefulness and resourcefulness that ensure maintaining or regaining the stability [5]. The most intensive development of balance control is observed at the age of from 7 to 12 years [6], but an improvement of 11.9% [7] is also observed in boys aged 15 to 17 years. The best age for development of balance abilities is from 9 to 14 years [8]. Abilities of spatial orientation and kinaesthetic differentiation are based primarily on orientation and kinaesthetic information of the process of controlling movements, with the decisive role played by sensory functions. Furthermore, the ability of quick reaction is a property which is characterized by more complex sensory functions and complicated executive motor operations [9]. A complex reaction assumes making a choice out of a selection of several available patterns which are closely related to particular stimuli. In judo fight, these decisions are actually made throughout the fight. Reaction time is determined by speed aptitudes, which can be effectively developed in the period of human life between 11 and 15 years of age, whereas at the age of 16, a gradual regress in this ability is observed [10,11].

The aim of the present study is to evaluate the level of coordination motor abilities (CMA) with respect to the age of judo contestants.

Material and methods

The study group was comprised of 25 judo contestants during a competitive period, who expressed their interest and consent to participate in coordination motor abilities testing. The group included 7 seniors, 10 juniors and 8 cadets. The contestants had scored at least fifth place in national-level tournaments. The characteristics of age, training experience and physical growth indices of the judoists are presented in Table 1.

All the CMA tests were carried out according to the testing procedure. Tools used in the tests were: in global movement coordination (GMC) test – coordination meter [3]; in balance test – special beam [12] in the case of recording of 27 measures and indices of CMA - a tablet with touch screen and author's test battery proposed by Jaworski. A detailed description of computer tests was presented in a study by Sterkowicz and Jaworski [13]. In general, the coefficients of reliability (ICC 3,1) in the author's test battery computed based on the test-retest results ranged from 0.60 to 0.93 [13,14]. Therefore, the computer tests used were characterized by adequate reliability for this type of measurement tools [15-17].

In the present cross-sectional study, the main factor was age category (S – seniors, J – juniors, C – cadets), whereas the set of dependent variables was comprised of 29 measures and indices of CMA which were evaluated in terms of normality of distribution with Shapiro-Wilk test. In the case of consistency of the empirical and normal distribution of the dependent variable, the significance of the differences between the means was measured using one-way ANOVA while the the differences between pairs were compared by LSD multiple range test. If the assumptions for normality of distribution were not met, a Kruskal-Wallis test (W) was used whereas the comparison between the pairs of means was made with non-parametric U test. The significance level during verification of the hypotheses concerning the differences, in Shapiro-Wilk test and between pairs of comparison between means was set at $p<0.05$. Furthermore, the differences between the groups C and S and J and S were expressed in percentage terms, while the values in group S was adopted as a model.

Results

Part of mean results obtained from CMA tests exhibited a typical hierarchy, with the best performance observed in seniors, followed by junior and the worst one found in cadets (see Tab. 2). The effect of comparison of the mean results of the balance tests (No. 1, Table 2) was statistically significant (see Tab. 3). Similar arrangement of the means (see Tab. 2) was also found for the number of mistakes during labyrinth-to-the-left test (No. 17, Table 2) and the differences in mistakes between the directions to the right and to the left (No. 20) and the number of the mistakes in spatial orientation attempt (free mode) (No. 27). An opposite arrangement, with the worst results demonstrated by seniors were observed in minimum (No. 5) and mean (No. 6) reaction time to visual stimulus and mean (No. 9) and maximum (No. 10) reaction time to auditory stimulus. The results of other tests exhibited also other arrangements of mean values.

Tables 3 presented the results of comparison of these tests of coordination motor abilities where means differed between age categories of judoists. The factor of age category significantly affected six out of 29 CMA indices with their level determined with percentage differences in the results obtained in the C and J groups as compared with the level found in seniors (Fig. 1).

Significant differences in balance test (No. 1) were found between the means from groups S and C, and between J and C (multiple range test). In GMC test, the best results were found in juniors, who differed significantly from cadets. Comparison of the results obtained by seniors and juniors and between seniors and cadets did not show any significant differences. Complex reaction time (minimum time in the test series) exhibited a significant advantage of the J group over S group. These differences were not revealed between the pairs of comparisons S-C and J-C. Furthermore, significantly better results in the reactions to moving objects were found in juniors compared to cadets.

Discussion

We found that the factor of experience (age category and training experience) did not affect the sense of balance which was the highest in seniors, average in juniors and the lowest in cadets. In the category of juniors, the least favourable differences were found with respect to cadets. They concerned

Table 1. The general characteristic of seniors, juniors and cadets

Variable	Seniors (n=7)			Juniors (n=10)			Cadets (n=8)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Age (years)	21.6	20	23	17.5	16	18	15.5	15	16
Training (years)	12.4	9.0	14.0	8.4	7.0	11.0	6.1	5.0	7.0
Body height (cm)	180.4	170.0	187.0	180.4	173.0	186.0	177.4	170.0	185.0
Body mass (kg)	82.2	70.9	92.9	85.8	72.0	101.2	71.7	56.5	82.4
LBM* (kg)	74.2	65.4	82.1	72.1	64.4	79.0	65.2	52.4	72.8

* - lean body mass

Table 2. The statistical characteristic of examined coordination motor abilities in group of seniors, juniors and cadets

Variable (measure unit)	Seniors		Juniors		Cadets	
	Mean	SD	Mean	SD	Mean	SD
1.Balance (n)	5.57	1.71	6.80	3.46	9.87	3.52
2. Global movement coordination GMC (^{o})	555.71	278.09	595.10	266.08	303.37	270.67
3. Kinaesthetic differentiation (pixels)	29.57	9.74	36.80	13.89	33.75	22.69
4. Movement frequency (n)	47.71	6.57	43.20	7.70	45.00	5.48
5. Minimum reaction time to visual stimulus (ms)	237.14	11.12	233.00	15.67	227.50	15.81
6. Mean reaction time to visual stimulus (ms)	254.42	10.50	247.00	21.43	248.00	16.14
7. Maximum reaction time to visual stimulus (ms)	282.85	19.75	270.00	35.59	273.75	25.04
8. Minimum reaction time to auditory stimulus (ms)	194.28	18.12	196.00	17.13	191.25	11.26
9. Mean reaction time to auditory stimulus (ms)	216.42	26.46	212.00	23.07	206.37	15.04
10. Maximum reaction time to auditory stimulus (ms)	244.28	27.60	234.00	32.73	222.50	16.69
11. Minimum complex reaction time (ms)	291.42	26.72	250.00	24.04	260.00	26.19
12. Mean complex reaction time (ms)	401.42	54.54	362.10	35.84	386.25	42.49
13. Maximum complex reaction time (ms)	548.57	114.80	521.00	72.95	590.00	124.10
14. Rhythmization (ms)	131.71	82.23	93.00	54.74	166.50	68.73
15. Labyrinth to the left (s)	52.14	11.18	46.00	7.45	52.12	5.19
16. Labyrinth to the right (s)	45.28	9.28	40.80	8.66	46.25	7.21
17. Labyrinth to the left/mistakes (n)	11.28	7.43	11.80	6.58	18.62	5.42
18. Labyrinth to the right/mistakes (n)	12.42	5.96	8.80	5.07	15.00	6.85
19. Difference between the direction to the right and to the left (adaptation) (s)	8.57	6.90	5.60	4.25	9.62	3.02
20. Difference between the direction to the right and to the left (adaptation) (n)	5.14	3.38	6.20	3.61	7.87	5.74
21. Visual motor coordination Free mode (s)	74.57	4.72	74.40	10.22	81.62	4.90
22. Visual motor coordination Constraint mode/ mistakes (n)	78.71	13.32	69.00	21.99	77.62	17.20
23. Visual motor coordination Constraint mode/correct (n)	21.28	13.33	31.00	21.99	22.37	17.20
24. Eye-hand coordination (s)	74.00	9.30	69.10	14.53	76.50	12.20
25. Eye-hand coordination /mistakes (n)	15.00	12.79	19.00	13.17	18.75	5.78
26. Spatial orientation Free mode (s)	58.57	4.07	54.30	5.87	62.12	6.96
27. Spatial orientation Free mode/mistakes (n)	1.14	1.21	1.60	1.17	2.00	1.41
28. Reaction to moving objects Constraint mode/correct (n)	23.00	11.84	32.90	9.34	20.50	8.65
29. Reaction to moving objects Constraint mode/mistakes(n)	27.00	11.84	17.10	9.34	29.50	8.65

Table 3. The significant differences in the level of coordination motor abilities depending on the factor of age group

VARIABLE (measure unit)	Significance of differences	Significance of differences between groups
Balance (n)	F=3.94 p=0.035	S<C, J<C
Global movement coordination GMC (^{o})	W=8.21 p=0.017	J>C
Minimum complex reaction time (ms)	F=5.65 p=0.011	S>J
Spatial orientation Free mode (s)	F=4.04 p=0.032	J<C
Reaction to moving objects Constraint mode/correct (n)	F=3.99 p=0.033	J>C
Reaction to moving objects Constraint mode/mistakes(n)	F=3.99 p=0.033	J<C

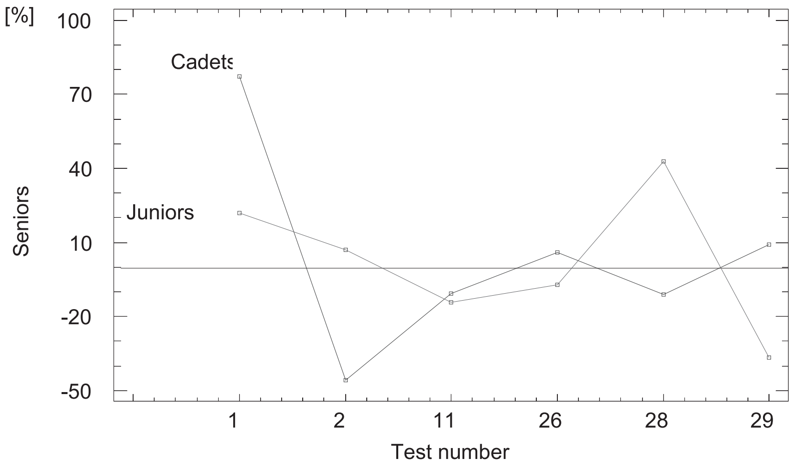

Fig. 1. Percentage differences between average results obtained in the tests performed by cadets and juniors compared to the group of seniors: 1 – balance, 2 – global movement coordination GMC, 11 – minimum complex reaction time, 26 – Spatial orientation; Free mode/mistakes (n), 28 – Reaction to moving objects; Constraint mode/correct (n), 29 – Reaction to moving objects; Constraint mode/mistakes (n)

global motor coordination, spatial orientation and reaction to moving objects. When compared with juniors, seniors were characterized by longer reaction time and stagnation of the results obtained from the test of global motor coordination, spatial orientation and reaction to moving objects.

In judo, the main purpose of the fight is to throw the opponent out of balance and causing him fall. Therefore, the fundamental importance is from maintaining the dynamic balance [18]. Typically, judo fight occurs in vertical position [19]. Therefore, balance is of essential importance, especially when using Ashi-waza techniques (throws performed while standing on one leg), which are a group of techniques used in the fight [1,20]. It can be expected that with many years of training, the stimuli that affect balance analysis system improve this ability in judo contestants. The observed relationships between the means, with a hierarchy that depends on age categories, could have been caused by the selection process, with the individuals with better balance exhibiting aptitude for senior category. Balance abilities in the untrained boys develop particularly at the age of 7 to 12 years [6,21]. The best results in the static balance tests (higher number of attempts to stand on the beam is regarded as worse result) were found in seniors, followed by juniors and the worst results were observed in cadets. Against the untrained subjects [12], the results obtained by cadets were located at the level of 88th centile, whereas in juniors, this value was 76th centile. A significant improvement in balance was observed after 6 and 12 months of training in the group of judokas. However, no significant improvements in tapping and reaction time to visual and auditory stimuli were observed [22].

Depending on the sport skill level, the mean from global motor coordination (GMC) ranged from 768° (2nd class athletes) to 889° (national and international class champion). Seniors obtained considerably better results (857°) than juniors (769°) and younger juniors (801°) [3]. In the present study, the athletes exhibited a considerably lower level of GMC. This was likely to have been caused by higher volume of exercises of strength and endurance character, which contributed to obtaining these results.

According to sport theorists, complex reaction time improves with experience, which corresponds to age and years of training. In our study, we found the worst reaction time in seniors, while it was considerably worse in juniors. It should be emphasized that these relationships might be determined by the developmental factors and the methods of selection since the progress in the reaction time is the most noticeable at the age of juniors and, after 16 years of age, a gradual decline in certain speed parameters is observed [23].

Spatial orientation is defined as a psychical activity which is closely related to perception and realization of the spatial body location. As we demonstrated, it was similar in seniors and juniors, who solved test assignments on the computer in a considerably shorter time. Analysis of the temporal structure of the randomly selected fights recorded during the National Qualification Tournament indicated that 23.9% of the time of the fight was a preparatory phase, when a judoka moves without holding the opponent. In seniors, this specific activity, which preceded direct contact and fighting while holding the opponent in order to perform a throw, was shorter (12-13% of the time of the fight on average) [24]. A considerable part of judo fight (ca. 18%) occurs without contact with the opponent. This is when the judoka evaluates the distance as they want to select the type of grip. Contemporary fighting regulations limit this choice to the upper body and the related parts of judo uniform. Although we found a significant difference between the age categories, the adequate reaction to moving objects is essential, regardless of the age, as it determines the use of the grip that allows for unbalancing an opponent.

On the other hand, the opponent attempts to do the same. Therefore, judo theory has developed the concept of fighting for grip, which is considered to be one of the technical and tactical skills [25]. In this phase of the judo fight, the efficacy of visual analyser is of much importance. However, it has been recently demonstrated that the results of balance tests with eyes open were similar in judokas and the untrained subjects. The same unipedal stance test with eyes open showed that the athletes reached significantly better results compared to the untrained subjects. This caused that many years of judo training was beneficial for improvement in postural balance [26]. The muscle stretch reflex during postural task leads to less destabilizing movements and improved balance ability [27].

A factor analysis revealed a varied contribution of coordination and fitness motor abilities to the results of the fights of 122 male subjects at the age of 19 to 20 years [28]. Among 15 motor abilities tested, four were grouped in the factor 1 (relative strength, power), which explained 23% of the variance. These included the number of chin-ups with supinated grip (shoulder girdle and arm endurance with the load of 0.73), time of hand tapping (movement frequency, 0.71), standing long jump distance (power in lower limbs, 0.55) and standing long jump backwards (ability of re-organizing motor stereotypes). This factor included both motor effects of coordination and fitness abilities. In explanation of the number of wins, the greatest and the most significant contribution was found for the factors of agility and ability to perform explosive (speed-related) movement tasks, which, according to the authors [28], 'actually represents a level of coordination motor abilities.

In our study, which was of the cross-sectional characters, we used a CMA test battery which is more comprehensive than presented in [28]. The study considered the relationships between age category and CMAs in judo contestants. When attempting to explain the results obtained in the study, we took into consideration the mutual relationships between the level of CMAs and judo training [1,26,28]. The differences observed between the age groups might have been also caused by natural patterns of growth observed throughout the ontogenesis in boys. Explanation of the separate effect of training factor and the age necessitates planning a scheduled experiment.

Conclusions

1. Considerable differences in CMA observed between age categories are the effect of sports training and they result from the ontogenetic development.
2. The tests with the results that differentiate between age categories, with particular focus on global movement coordination and minimum complex reaction time should be taken into consideration when monitoring of preparation of judo contestants.

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Address for correspondence:
Prof. dr hab. Stanisław Sterkowicz
Katedra Teorii i Metodyki Sportu
al. Jana Pawła II 78, 31-571 Krakow, Poland
phone: (+48 12) 683-11-33, e-mail: wtsterko@cyf-kr.edu.pl

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