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Original empirical article

RELATIONS BETWEEN INTELLECTUAL AND MOTOR ABILITIES IN YOUNGER SCHOOLCHILDREN

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Abstract. *The assessment of motor abilities by using a battery of 7 motor tests along with assessment of the intellectual abilities by Raven's colored progressive matrices was carried out on a sample of 976 boys and girls, 7 to 10 years of age, elementary school children from Vojvodina. The univariate and multivariate analysis of variance showed that there are statistically significant gender differences in the individual variables and the entire system of applied motor variables alike. There are no statistically significant gender-related differences in the entire age group examined by Raven's colored progressive matrices. After conducting a factor analysis in all age groups, two significant factors were found: the first one which was the general motor ability factor and the second one which had significant projections on the variable for intelligence assessment, whilst in certain age groups it was related to motor variables for the assessment of flexibility and speed of alternative movements. Factors of inter-correlation matrices showed high and positive correlations of obtained factors in all age groups of both genders.*

Key words: *Raven's colored progressive matrices, children, factor analysis.*

INTRODUCTION

The age when they start school is exceptionally sensitive period for development of children's motor abilities, especially when we talk about learning and adopting the exten-

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sive repertoire of motor skills. It is vitally important not to miss this period, i.e. the advantages that it has in forming the foundation of motor skills. For the development of the child in this period, and even at a younger age, choosing appropriate movement activities is of great importance. Through movement and moving, the child explores its abilities, understands himself/herself and the environment, communicates with others.

According to Tubić (2009), one of the factors of success in the broadest sense is undoubtedly the intellectual functioning of a person, even though it explains only about 25% of the variability of the cause of this achievement, that is, represents only one of the factors that affect this achievement, ranging from school or sports ones to those verified by life itself. Intellectual functioning is still viewed as a key to explaining achievement in all sorts of activities, including a part of motor functioning. For this reason it is not surprising that many kinesiology studies are partly concerned with cognitive abilities, i.e. intellectual abilities, most often treated as their representatives in psychological literature.

The greatest and statistically significant correlations with the factor of general intelligence are obtained in motor variables whose structure is characterized by predominant coordination, balance, speed of alternative movements and explosive strength, than in motor tasks consisting of unusual movement structures, where maximum speed is required along with the correct performance of the task. Other motor abilities do not have statistically significant relations to intelligence (Ismail, Kane & Kirkendal, 1976; Mejovšek, 1977; Ismail & Gruber, 1967, Momirović et al, 1979, according to: Popović 2010).

THE METHOD

The participants

The sample of participants consisted of boys and girls, 7 to 10 years of age from the elementary schools in the region of Vojvodina (Bačka Palanka, Sombor, Novi Sad, Sremska Mitrovica and Zrenjanin). There were 976 participants in total (Table 1). Data were collected for the scientific research project "Anthropological status and physical activity of Vojvodina population", which was implemented by the Faculty of Sports and Physical Education in Novi Sad, and financed by the Provincial Secretariat for Science and Technological Development.

Table 1. The structure of participants based on gender and age.

Gender	7		8		9		10		Total	
	N	%	N	%	N	%	N	%	N	%
Boys	161	48.3	116	56.9	121	53.8	121	56.5	519	53.2
Girls	172	51.7	88	43.1	104	46.2	93	43.5	457	46.8
Total	333	100	204	100	225	100	214	100	976	100

N - number of participants; % - percentage of participants

Sample of measuring instruments

The sample of motor tests consisted of the following:

- For the estimation of coordination: 1) the obstacle course backwards test
- For the estimation of the frequency of movement: 2) the hand tapping test
- For the estimation of flexibility: 3) the seated straddle stretch test
- For the estimation of explosive strength: 4) the standing broad jump test and 5) the 20 m dash test

- For the estimation of repetitive strength of the trunk: 6) the sit-ups test
- For the estimation of the static strength of the arms and shoulder: 7) the bent-arm hang test.

The measuring of the motor abilities of children was conducted according to the recommendations of Bala, Stojanović and Stojanović (2007).

To test their intellectual abilities, Raven's colored progressive matrices (RCPM) were used. RCPM is one of the most commonly used tests for examining the intelligence of preschool and younger school-age children, and it also represents one of the standard non-verbal tests for the assessment of the g-factor or fluid intelligence.

Data analysis

The collected data were processed using the statistical package SPSS 15.0. Basic descriptive parameters were calculated for all of the variables. The differences between the boys and girls were first analyzed in the intellectual and motor variables by applying a multivariate and univariate analysis of variance (MANOVA, ANOVA). The structure of the intellectual and motor space for every age and either gender of the children was established using a factor analysis. The correlation matrix was factorized by the procedure of principal components. The criteria for the separation of significant factors were the KG-criteria. Significant principal components were afterwards rotated in a promax solution.

THE RESULTS

Differences in the motor and intellectual space between the boys and girls 7-10 years of age are shown in Tables 2, 3, 4 and 5.

Table 2. Differences in the motor and intellectual variables of the boys and girls 7 years of age.

Variable	Gender	M	Sd	Min	Max	F	P
Dash 20 m (0.1s)	Boys	44.38	4.96	38	70	24.52	0.00
	Girls	50.24	5.48	41	93		
Obstacle course backwards (0.1s)	Boys	235.15	93.62	99	543	19.65	0.00
	Girls	281.19	94.89	116	676		
Arm plate tapping (freq.)	Boys	18.40	3.42	9	31	2.18	0.14
	Girls	17.88	2.99	8	27		
Seated straddle stretch (cm)	Boys	38.76	7.89	15	60	36.13	0.00
	Girls	43.95	7.80	22	65		
Standing broad jump (cm)	Boys	125.72	17.93	76	168	21.74	0.00
	Girls	116.53	18.18	50	160		
Bent-arm hang (0.1s)	Boys	178.28	159.15	0	851	0.33	0.56
	Girls	168.24	150.45	0	1200		
Sit-ups (freq.)	Boys	25.28	9.96	3	50	0.15	0.69
	Girls	25.67	9.07	0	44		
RCPM (point)	Boys	24.28	5.65	7	35	0.05	0.80
	Girls	24.43	5.66	10	36		
F=13.77 P= 0.00							

Legend: M - mean; SD - standard deviation; Min - minimum score; Max - maximum score; f – f-test; p - level of statistic significance of f-test; F - F-test; P – level of statistic significance of F-test

Table 3. Differences in the motor and intellectual variables of the boys and girls 8 years of age.

Variable	Gender	M	Sd	Min	Max	F	P
Dash 20 m (0.1s)	Boys	44.38	3.53	38	57	16.11	0.00
	Girls	46.52	4.04	37	63		
Obstacle course backwards (0.1s)	Boys	225.79	92.02	113	695	6.36	0.01
	Girls	259.23	95.55	104	687		
Arm plate tapping (freq.)	Boys	19.37	3.67	7	28	0.11	0.73
	Girls	19.20	3.26	8	29		
Seated straddle stretch (cm)	Boys	40.84	8.41	18	67	30.41	0.00
	Girls	47.09	7.41	30	64		
Standing broad jump (cm)	Boys	135.64	19.75	82	182	22.62	0.00
	Girls	121.64	22.07	65	177		
Bent-arm hang (0.1s)	Boys	212.92	191.72	0	777	0.08	0.92
	Girls	210.51	183.64	0	835		
Sit-ups (freq.)	Boys	29.67	7.32	12	46	1.99	0.16
	Girls	28.08	8.71	1	46		
RCPM (point)	Boys	26.67	5.68	8	36	1.67	0.19
	Girls	27,68	5.28	5	36		

F=10.26 P= 0.00

Table 4. Differences in the motor and intellectual variables of boys and girls 9 years of age.

Variable	Gender	M	Sd	Min	Max	F	P
Dash 20 m (0.1s)	Boys	44.35	3.72	37	58	10.47	0.01
	Girls	45.20	3.94	37	53		
Obstacle course backwards	Boys	196.01	61.12	101	396	17.48	0.00
(0.1s)	Girls	237.94	88.45	92	670		
Arm plate tapping (freq.)	Boys	20.82	3.45	12	29	3.45	0.06
	Girls	21.71	3.75	15	34		
Seated straddle stretch (cm)	Boys	44.86	7.55	25	61	19.98	0.00
	Girls	49.90	9.36	26	76		
Standing broad jump (cm)	Boys	144.36	20.03	102	207	24.02	0.00
	Girls	131.11	20.45	85	182		
Bent-arm hang (0.1s)	Boys	284.68	244.00	0	1200	17.49	0.00
	Girls	170.68	143.42	0	623		
Sit-ups (freq.)	Boys	32.22	7.36	10	52	4.37	0.03
	Girls	30.03	8.36	3	47		
RCPM (point)	Boys	28.10	5.72	11	36	1.67	0.91
	Girls	28.02	6.05	2	36		

F=11.04 P= 0.00

Table 5. Differences in the motor and intellectual variables of boys and girls 10 years of age.

Variable	Gender	M	Sd	Min	Max	F	P
Dash 20 m (0.1s)	Boys	41.34	3.44	32	52	11.93	0.00
	Girls	42.98	3.40	35	54		
Obstacle course backwards (0.1s)	Boys	179.62	55.21	101	397	6.96	0.01
	Girls	200.77	60.86	107	370		
Arm plate tapping (freq.)	Boys	22.95	4.00	13	32	3.03	0.08
	Girls	23.89	3.74	16	34		
Seated straddle stretch (cm)	Boys	43.97	8.08	21	64	47.54	0.00
	Girls	52.30	9.44	30	72		
Standing broad jump (cm)	Boys	150.21	19.25	100	204	9.09	0.00
	Girls	142.25	18.69	98	180		
Bent-arm hang (0.1s)	Boys	284.04	221.77	0	1200	11.93	0.00
	Girls	192.05	144.01	0	777		
Sit-ups (freq.)	Boys	35.56	7.22	18	51	0.03	0.86
	Girls	35.49	7.08	13	52		
RCPM (point)	Boys	29.83	5.13	12	36	0.79	0.37
	Girls	29.16	5.75	10	36		

F=13.41 P= 0.00

The multivariate analysis of variance proved the existence of statistically significant differences between the analyzed groups of all the age groups.

A further analysis of the results of the participants indicates that there are statistically significant differences in the individual variables in terms of four variables, of all the age groups: the 20 m dash, Obstacle course backwards, Seated straddle stretch, and Standing broad jump. It can also be concluded that the variable Bent-arm hang implies statistically significant differences between the participants of the age of 9 and 10, whereas the variable Sit-ups has statistically significant differences only for the participants aged 10.

A significant and stable advantage during the entire observation period was determined in favor of the girls for the variable Seated straddle stretch, whose goal is the measurement of flexibility. During the entire studied period the boys had a significant and stable advantage in the variables the 20 m dash, Obstacle course backwards and Standing broad jump, whose goal was the measurement of speed, explosive strength and coordination (in addition of the coordination of the entire body, it also assesses the ability of reorganization of movement stereotypes). It is interesting that only for the Arm plate tapping variable, which assessed the speed of alternative movements, there were no statistically significant differences between boys and girls of any age group.

In terms of the intellectual abilities during the entire study period, there were no statistically significant differences determined between the boys and girls in this sample of participants.

By applying a factor analysis on the group of boys of 7 years of age, two significant principal components were isolated, that explained 49.38% of the common variability, the first of which explained 35.12%, while the second one explained 14.26%. In the group of girls 7 years of age, two significant main components were isolated, that explained 48.59% of the common variability, the first of which explained 35.19%, while the second one explained 13.40%.

By rotating the principal components in a parsimonious position (promax), simple solutions were attained, on the basis of which their pattern and structure can be defined. They were named on the basis of the size of pattern matrix (Table 6).

Table 6. The pattern (a) and corelations (r) of the isolated factors of boys and girls (7 and 8 years of age).

Variable	7 age				8 age			
	Boys		Girls		Boys		Girls	
	A1	A2	A1	A2	A1	A2	A1	A2
Dash 20 m	-0.77	0.09	-0.70	-0.13	-0.70	-0.15	-0.78	-0.03
Obstacle course backwards	-0.65	-0.19	-0.65	-0.21	-0.76	-0.10	-0.76	-0.11
Arm plate tapping	0.40	0.25	0.26	0.58	0.45	0.32	0.40	0.49
Seated straddle stretch	0.02	0.70	0.15	0.25	0.53	-0.50	0.61	-0.56
Standing broad jump	0.88	-0.03	0.78	0.15	0.80	0.19	0.85	0.02
Bent-arm hang	0.59	-0.08	0.62	-0.55	0.73	-0.13	0.56	-0.01
Sit-ups	0.66	-0.06	0.62	0.00	0.13	0.67	0.75	0.09
RCPM	-0.07	0.75	-0.00	-0.71	-0.00	0.68	0.08	0.80
	r = 0.16		r = 0.28		r = 0.31		r = 0.25	

The highest parallel projections on the first factor of the boys and girls were found in all of the analyzed motor variables, except for the variable of pliability assessment. The single factor in which flexibility as a special motor skill was the only factor singled out was already obtained in several studies with this sample of motor tests (Bala, Nićin and Popović, 1997; Popović, 2010; etc.). It is clear that the first factor assesses motor space and can be named the GENERAL MOTOR FACTOR. On the second factor in boys and girls alike, the highest projections were those of motor variables for the assessment of flexibility and the RCPM variable for the assessment of the general intelligence factor. The second factor can be named the FACTOR OF INTELLIGENCE AND FLEXIBILITY.

The inter-correlation of the factors shows a relatively high and positive correlation of the two aforementioned factors at the level of statistical significance of p=0.02 for the boys and p=0.00 for the girls, which imposes the conclusion about the integral functioning of boys and girls.

By applying the factor analysis on the group of boys that are 8 years of age, two significant principal components were isolated, which explained 51.45% of the common variability, the first of which explained 37.93%, while the second one explained 13.52%. In the group of girls that are 8 years of age, two significant main components were also isolated, that explained 57.72% of the common variability (44.22% and 13.50%).

The highest parallel projections on the first factor for the boys were found in all of the analyzed motor variables, except the Sit-ups variable. It is clear that the first factor assesses motor space, so it can be named THE GENERAL MOTOR FACTOR. On the second factor, the motor variable for the assessment of repetitive strength of the trunk and the RCPM variable for the assessment of the general intelligence factor showed the highest projections. The second factor can be named THE GENERAL INTELLIGENCE AND THE FACTOR OF REPETITIVE STRENGTH OF THE TRUNK.

The highest parallel projections on the first factor for the girls 8 years of age were found in all motor variables, except Arm plate tapping. As in previous studies, especially ones involving a sample of girls, the isolated motor factor was obtained which contained

the Arm plate tapping variable in addition to the already mentioned variable for flexibility assessment (Bala & Popović, 2007). It is clear that the first factor which assesses motor space can be named THE GENERAL MOTOR FACTOR. On the second factor the highest projections were those of the motor variables for the assessment of speed of alternative hand movements and the RCPM variable for the assessment of intelligence. The second factor can be named THE GENERAL INTELLIGENCE AND ALTERNATIVE MOVEMENT SPEED FACTOR. The inter-correlation of the factors shows a statistically significant and positive correlation of factors in both genders.

By applying a factor analysis on the group of boys that are 9 years of age, two significant principal components were isolated, that explained 51.13% of the common variability, the first of which explained 37.44%, while the second one explained 13.69%. In the group of girls that are 9 years of age, two significant main components were isolated, that explained 56.27% of the common variability (41.00% and 15.27%) (Table 7).

Table 7. Pattern (a) and the correlations (r) of the isolated factors of boys and girls (9 and 10 years of age).

Variable	9 age				10 age			
	Boys		Girls		Boys		Girls	
	A1	A2	A1	A2	A1	A2	A1	A2
Dash 20 m	-0.67	-0.16	-0.80	-0.06	-0.75	0.11	-0.58	-0.20
Obstacle course backwards	-0.79	-0.05	-0.70	-0.15	-0.51	-0.42	-0.63	-0.33
Arm plate tapping	0.14	0.56	0.19	0.69	0.28	0.37	0.12	0.73
Seated straddle stretch	0.27	-0.06	0.36	-0.36	0.08	0.52	0.00	0.69
Standing broad jump	0.88	-0.01	0.82	0.08	0.77	0.21	0.77	-0.05
Bent-arm hang	0.75	-0.10	0.82	-0.45	0.69	-0.05	0.88	-0.40
Sit-ups	0.30	0.50	0.55	0.26	0.43	0.31	0.45	0.24
RCPM	-0.27	0.90	-0.13	0.76	-0.43	0.83	-0.17	0.58
	r = 0.36		r = 0.27		r = 0.25		r = 0.41	

The highest parallel projections on the first factor in both genders were found in all of the motor variables, except Arm plate tapping, whilst for the boys the Sit-ups variable also projected more on the second factor. The first factor can be named THE GENERAL MOTOR FACTOR. On the second factor the highest projections were found for the motor variable for the assessment of alternative hand movement speed, as well as the variable for the assessment of the general intelligence factor (RCPM). The second factor can be named THE INTELLIGENCE, ALTERNATIVE HAND MOVEMENT SPEED AND REPETITIVE STRENGTH OF THE TRUNK. The inter-correlation of the factors shows a statistically significant and positive correlation of the two factors for both genders.

By applying a factor analysis on the group of boys 10 years of age, two significant principal components were isolated, that explained 48.28% of the common variability (33.26% and 15.02%).

In girls 10 years of age, two significant principal components were also isolated that explained 50, 94% of the common variability (36, 99% and 13, 95%) (Table 7).

The highest parallel projections on the first factor in both genders were found in all of the motor variables except Arm plate tapping and the Seated straddle stretch. This confirms that flexibility does not essentially belong to the motor abilities, as well as that its nature is uncertain (Bala et al., 1997; Bala & Popović, 2007). The first factor can be

named THE GENERAL MOTOR FACTOR. On the second factor the highest projections were found in the variable for the assessment of alternative hand movement speed, the variable for the assessment of general intelligence, as well as the variable of flexibility assessment. The second factor can be named THE INTELLIGENCE, FLEXIBILITY AND ALTERNATIVE MOVEMENT SPEED FACTOR. The inter-correlation of factors shows a statistically significant and positive correlation between the two factors in both genders.

DISCUSSION

On the basis of the results of the factor analysis for all the age groups, it is clear and it can generally be concluded that the first factor refers to the general motor factor, but in terms of the second factor the expected results were not obtained (Bala et al., 1997 and Popović, 2010). This mainly refers to the correlation of intelligence and flexibility for the ages of 7 to 10 in both genders. Accordingly, the author believes that this confirms the doubtful relatedness of body flexibility and motor space and finds it increasingly justified that the variable Seated straddle stretch should be defined as an anatomical characteristic. As expected, the Arm plate tapping variable had a significant correlation with the variable RCPM, because Arm plate tapping originally represents a test of ability for synergistic regulation, and at a younger age it is mostly an indicator of hand coordination, which is a quite complicated movement at a younger age, so the connection of this variable with intelligence is not surprising, which was also confirmed earlier in the research of Mejovšek (1977).

The matrices of the inter-correlation factors have shown high and positive correlations of the obtained factors for all ages in both genders at the level of statistical significance of p=0.01, which only imposes the conclusion about the integral functioning of boys and girls at this age. This means that children of better intellectual abilities are better and more efficient in solving motor problems and tasks that are set before them, especially if they are under the significant influence of the movement structuring mechanism and excitation intensity regulation mechanism. Ismail's theory of integral development could once again be confirmed (Ismail, 1984), according to which there is a connection between the motor and intellectual area. According to this theory, the motor and intellectual functioning of the body does not represent discrete or whole types of development, but rather "organic unity" between these areas, i.e. it is of a general type, (Ismail & Gruber, 1971; Bala, 1981, according to: Popović 2010), which means that in this age there are still no differentiated motor abilities (the children react with his-her entire body and entire motor skills). Besides, an important feature of preschool and even younger school-age children is a marked and striking integrability of development, wherein the domains of children's development (physical, motor cognitive, etc.) are closely related. Development in one domain affects the development in others.

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RELACIJE INTELEKTUALNIH I MOTORIČKIH SPOSOBNOSTI MLAĐE ŠKOLSKE DECE

Franja Fratrić, Dejan Orlić, Badža Vukašin, Milan Nešić, Kosta Goranović, Ivana Bojić

Na uzorku od 976 ispitanika, dečaka i devojčica uzrasta od 7 do 10 godina, učenika osnovnih škola Vojvodine, izvršena je procena motoričkih sposobnosti primenom baterije od 7 motoričkih testova i procena intelektualnih sposobnosti primenom testa Ravenove progresivne matrice u boji. Univarijatnom i multivarijatnom analizom varijanse utvrđeno je da postoje statistički značajne razlike po polu na svim uzrastima, kako u pojedinačnim tako i u sistemu primenjeni motoričkih varijabli. U testu inteligencije Ravenove progresivne matrice u boji nije bilo statistički značajnih razlika u oba pola na celom ispitivanom uzrastu. Nakon primene faktorske analize na svim uzrastima, dobijena su dva značajna faktora, od kojih je prvi u svim uzrastima predstavljao generalni motorički faktor, dok je na drugom faktoru značajne projekcije imala varijabla za procenu inteligencije, dok su joj se na pojedinim uzrastima pridruživale i motoričke varijable za procenu gipkosti i brzine alternativnih pokreta. Matrice interkorelacije faktora pokazale su visoke i pozitivne korelacija dobijenih faktora na svim uzrastima kod oba pola.

Ključne reči: *Ravenove progresivne matrice u boji, deca, faktorska analiza.*