THE RELATIONS BETWEEN INDICATORS OF INTELLIGENCE AND MOTOR ABILITIES

Marjeta Kovač and Janko Strel

Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia

Original scientific paper
UDC: 159.9.07:796.012

Abstract:

The study analyses the relations between indicatory of motor abilities and fluid intelligence of 1859 girls, aged 10 to 18. To evaluate their motor abilities 26 tests were selected, covering all sub-spaces of motor abilities. To assess fluid intelligence the test TN-20 was selected. The relations between indicators of motor dimensions and fluid intelligence were studied by the multiple regression analysis.

The relations between the fluid intelligence indicators and the measurement procedures of evaluating agility, coordination of motion in rhythm, the speed of simple motor tasks, and flexibility are low, but statistically significant for younger subjects. The exercises with complicated motion structure, being new to the subjects, and supposedly to be successfully solved in the shortest possible time or in the optimum rhythm, demand a certain level of fluid intelligence. The capacity of the central nervous system to receive, control, adjust and elaborate different information is in the foreground.

The connection with the energy variables at the age of seventeen is surprising, and can be explained by a rational use of technique, which demands the involvement of the mechanism for tonus regulation. The motion performance of the subjects is surveyed and corrected by feedback information, comparing the data from the long term memory.

The findings partly enlighten our understanding of the relations between the motor and intellectual development of girls between 10 and 18 years of age.

Key words: motor abilities, intelligence, girls from 10 to 18 years

ZUSAMMENHÄNGE ZWISCHEN INTELLIGENZ UND MOTORISCHEN FÄHIGKEITEN

Zusammenfassung:

In dieser Arbeit werden die Zusammenhänge zwischen den motorischen Variablen und der Fluidintelligenz bei den 1859 Mädchen im Alter von 10 bis 18 Jahren analysiert. Um ihre motorische Fähigkeiten zu bewerten, wurden 26 Teste ausgewählt, die alle Unterbereiche der Motorik umfassen. Der TN-20 Test wurde zur Bewertung von Fluidintelligenz angewendet. Die Beziehungen zwischen motorischen Dimensionen und der Fluidintelligenz wurden mit Hilfe multipler Regressionsanalyse erforscht.

Die Korrelation zwischen der Fluidintelligenz und den Meßverfahren zur Bewertung von Gewandtheit, Koordination rhythmischer Bewegung, Schnelligkeit bei den einfachen motorischen Aufgaben und Flexibilität ist niedrig, aber für die jüngeren Mädchen statistisch bedeutend. Die Übungen mit komplizierter Bewegungsstruktur, die für die Geprüften neu waren und die möglichst schnell oder im optimalen Rhythmus von ihnen erfolgreich gelöst werden sollten, fordern ein gewisses Grad der Fluidintelligenz. Im Vordergrund steht die Fähigkeit des Zentralnervensystems, verschiedene Informationen zu empfangen, zu kontrollieren, zu adaptieren und zu verarbeiten.

Die Korrelation mit den Energievariablen bei den 17-jährigen ist überraschend und lässt sich als rationale Anwendung von Technik erklären, was den Einschluss der Mechanismen zur Tonusregulation verlangt. Die Ausführung der Bewegungen wurde beaufsichtigt und nach Feedbackinformation korrigiert, die abgespeicherten Gedächtnisdaten dabei vergleichend.

Die Befunde klären teilweise unsere Auffassung von den Zusammenhängen motorischer und intellektueller Entwicklung der Mädchen im Alter von 10 bis 18 Jahren auf.

Schlüsselwörter: motorische Fähigkeiten, Intelligenz, Mädchen im Alter von 10 bis 18 Jahren

Introduction

The objective of this research was to determine the relations between certain motor abilities and general intelligence of schoolgirls aged 10 to 18 years. The research was based on the motor model of Kurelić and colleagues (1975) and the Cattell-Horn theory of fluid and crystallised intelligence (Pogačnik, 1995). The model of Kurelić and colleagues (1975) is hierarchic and based on functional mechanisms responsible for latent motor abilities. There are four dimensions at the lower level: the mechanism for movement structuring, the mechanism for synergy automation and the regulation of tonus, the mechanism for regulation of excitation intensity, and the mechanism for regulation of the duration of excitation. There are two dimensions at the higher level: the mechanism for central regulation of movement and the mechanism for energy regulation. At the highest level the mechanism for regulation of movement is called the general factor of motor behaviour. The findings of different authors (Šturm, 1977; Gabrijelčić, 1977; Kurelić, Momirović and Šturm, 1979; Metikoš and colleagues, 1980; Strel, 1981; Pavlovič, 1982) have confirmed that the structure of motor abilities is organised hierarchically, and that it is primarily determined by two dimensions of wide range regulation. The processes of structuring, control and regulation of motor activities prevail in the first one, therefore it is supposed to depend on the mechanism of reception, analysis and implementation of information, whereas the energy regulation of movement prevails in the second one.

The research work in the area of motor behaviour in Slovenia is based on the model of Kurelić and colleagues (1975). For the purpose of research of school population the reduced models are used, which enable us to study the variables with the implementation of certain measurement procedures, which are used to observe the selected variables as closely as possible.

The Catell-Horn theory (Cattell 1963, 1971, Horn 1985; according to Pogačnik, 1995) claims that the primary mental abilities reflect basic psychological structures and processes. They represent those sources of differences among people which are subjected to the basic modules of intellect. All the abilities are correlated positively among themselves and are assembled into a wide range of abilities. At the highest level the neuro-physiological ability of information analysis, by Cattell called fluid intelligence Gf, and the experiences, called crystallised intelligence Gc, are substantial. To study the relations of motor abilities we have selected the fluid intelligence, which is relatively independent of upbringing and experiences and serves as a basis for numerous intellectual activities. It is reflected in the fast and effective resolving of mental problems and is highly correlated with the learning of new areas.

Both the fluid intelligence and the crystallised intelligence develop very fast from the time of an individual's birth to the age of maturity. However, the fluid intelligence develops as a consequence of biological growth of central nervous system, and the crystallised intelligence as a consequence of investment impact of Gf and the social environment on the education of a person. Gf is supposed to reach its peak at the age of 16, and starts to decline after the age of 30. Gc ends its development a bit later and it does not decline with age, in certain cases of primary mental abilities it even grows until later age (Pogačnik, 1995:74).

While the development of intelligence is relatively permanent (Pogačnik, 1995), the physical and motor status of children have changed significantly in the last 20 years (Šturm and Strel, 1985; Malina, 1991; Tanner, 1991; Przeweda, 1995; Conger and Galambos, 1997; Kondrič and Šajber Pincolič, 1997). We have assessed the content and the level of correlation for each age group, and we have, at the same time, studied the changes in the correlation in the process of growing up.

Because of the difference in the morphological and motor development, and the differences in the correlation between intelligence and motor abilities according to gender (Mohan and Bhatia, 1989; Strel and Žagar, 1993) we have taken only girls as the sample of the research work.

Methods

Subjects

The sample of 1859 schoolgirls of primary and secondary schools was stratified according to the regions, and selected ad hoc within the regions. The sample is representative for Slovenia, since the schools were selected from both the bigger and smaller centres, and among the secondary schools we have selected those which can be classified as schools with various types of education. Our research sample covers girls of primary schools who were of the age of 10, 11, 12, 13 and 14 years in the interval of +/- six months from 1 October 1993, and the girls of secondary schools who were of the age of 15, 16, 17 and 18 years in the interval of +/- six months from 1 October 1994, and were not excused from participating in the physical education classes for health reasons. Prior to that their parents had given a written consent for their participation in the research work.

Variables

Motor Abilities Tests

On the basis of the hypothetical model of Kurelić and colleagues (1975), the research works of Šturm (1970, 1977), and Strel and Šturm (1981) we have selected 26 tests to assess the motor abilities of the sample to be measured. The tests have hypothetically covered all the sub-spaces of motor system:

Table 1: Selected tests and their denominations

Selected tests	Denomination of tests	Selected tests	Denomination of tests
⊶ plate tapping 20 seconds	MTAP20*	⊶ hand drumming	MHDRUMM*
⊶ plate tapping 25 cycles	MTAP30*	⊶ hand and feet drumming	MHFDRUMM*
⊶ "1–foot tapping"	M1FTAP*	⊶ back arm twist	MBAT
⊶ standing long jump	MSLJ	⊶ bend forward on the bench	MBF
⊶ medicine ball put	MMBP	⊶ sit and reach	MSR
⊶ 60 m run	MR60*	⊶ stand on a low beam	MSLB
⊶ arm pull dynamometer	MDYNAM	⊶ flamingo balance	MFLAMIN
⊶ polygon backwards	MPBACK	⊶ sit-ups 20 seconds	MSU20*
⊶ climbing and descending	MCD	⊶ sit-ups 30 seconds	MSU30*
⊶ match juggling	MMJ*	⊶ sit-ups 60 seconds	MSU60*
⊶ figure of eight with low obstacle	M8OBS	⊶ bent arm hang	MBAHMAX*
⊶ running, rolling, crawling	MRRC	⊶ accelerating running	MACR*
⊶ running round three stands	MR3S	⊶ 600 m run	MR600**

** tests where subjects performed only one repetition*

The tests are described in the project research work of Strel and colleagues (1992). Because of the complexity and the extensiveness of the measurements the tested girls performed two repetitions of the energy less consuming tests. When elaborating the data, the second repetition was taken into consideration. The subjects performed the energy more demanding tests only once.

Intelligence Test

We have used the test of the set TN-20 (Pogačnik, 1994), which in the first place measures fluid intelligence. It contains also a bit of the perceptive and spatial component. It consists of 45 sets of special tasks increasing in difficulty. The time available is limited to 20 minutes; therefore the result is determined also by mental quickness. The tests have achieved satisfying measurement characteristics; they are practical for use, and relatively free of cultural influence (Pogačnik, 1994, 1995). Due to its measurement attributes the selected measuring procedure enables us to give quite a reliable assessment of fluid intelligence, and it is suitable to be used on the sample of school children in Slovenia.

Organisation and the Course of Measurements

The measurements of motor abilities and intelligence were carried out in the project "The analysis of development trends of motor abilities and morphological characteristics, and the relations of both with the psychological and sociological dimensions of Slovenian children and youth from 7 to 18 years of age in the Period from 1970 - 1983 - 1993" (by Strel and colleagues, 1992, 1996).

Data Analysis

We have analysed the relations between the indicators of fluid intelligence and the motor variables, the latter being mostly responsible for these relations at each age group, by means of the multiple regression analysis. The predictor system was represented by motor dimensions, expressed in manifest space, and the criterion variable was represented by the result of measuring the intelligence in its manifest form.

Results

The system of motor predictors is typically statistically (at the level of .05) related to the criteria of intelligence variables of children aged 10, 11, 12, 14, and 17 years. The proportion of the explained variance ranges between 20.4 % at the age of 10 up to 39.9% at the age of 17 years.

A smaller proportion of explained variance than expected at the age of 10 can be explained by the discovery that the performance of more co-ordination demanding tasks is, in that age period, under a bigger influence of endurance and explosive strength than the influence of the co-ordination of movement (Strel and Šturm, 1981, Simons and colleagues, 1990). Statistical insignificance of relations during the puberty age are probably a consequence of the great morphological changes and the deteriorated structure of numerous motor programmes, which, due to the biological and physiological changes, prevent a more successful realisation of the more demanding co-ordination tasks.

Table 2: The proportion of explained variance of criterion variable with the complex of predictor variables from the age of 10 to 18.

Age	N	RO	DELTA	F	SIGN F
10	223	.451	.204	1.742	.019
11	207	.582	.339	3.213	.000
12	221	.517	.267	2.090	.003
13	216	.435	.189	1.399	.109
14	205	.495	.245	1.887	.010
15	174	.495	.245	.735	.804
16	201	.565	.320	1.011	.470
17	212	.632	.399	1.916	.016
18	200	.490	.240	1.534	.063

Table 3: Statistically significant relations between motor abilities tests and intelligence test.

Age	Test	BETA	CORR	PARTIAL	T	SIGN T
10	MHDRUM	.363	.028	.175	4.435	.000
	M MTAP30	.249	.320	.316	2.368	.019
11	MHFDRUMM	.247	.334	.256	3.3822	.001
	M1FTAP	.237	.382	.219	2.8622	.005
	MHDRUMM	.192	.391	.185	2.409	.017
12	MHDRUMM	.250	.284	.227	2.844	.005
	MTAP20	.207	.236	.170	2.108	.037
	M1FTAP	-.204	.031	-.165	-2.047	.042
	MRRC	.201	.101	.164	2.034	.044
13	MPBACK	.224	.041	.195	2.477	.014
	MCD	-.228	.024	-.243	-2.279	.024
14	MBAT	-.162	-.214	-.170	-2.122	.035
	MSR	-.211	.033	-.166	-2.071	.040
	MBF	.198	.183	.157	1.959	.052
15	-					
16	MSLJ	.474	.277	.284	2.220	.030
17	MR600	.368	.121	.317	2.897	.005
		.249	.231	.231	2.057	.043
18	MR600	.243	.103	.177	2.015	.046

The relations with the variables, that can be hypothetically classified among the information components of movement, appear at younger age groups, and in the case of girls of 17 years of age the variables, hypothetically classified into the energy component of movement, are in the background.

Statistically significant relations appear with the measurement variables: the coordination of movement in rhythm and the speed of simple motor tasks at 10, 11 and 12 years, and with one of the agility tests at the age of 12 years. At the age of 14 the criterion variable is explained by the tests of flexibility, while at the age of 17 the test MSU60 and endurance test MR600 contributed to the explanation.

On the basis of a thorough analysis of the separate projections of predictors on the criterion we can assume that:

1. The tests MHDRUMM and MHFDRUMM, which are hypothetically ranked into the area of rhythmical performance of motion structures or rather into the wider complex of the coordination of movement (Strel and Novak, 1980; Strel, 1981), represent the typical motor tasks, where the subject is expected to carry out as many repetitions of a precisely determined sequence of movements with the upper or both the upper and lower limbs at the most optimum rhythm. The relation proves the findings of certain authors (Pavlovič, 1982; Momirović and Horga, 1982) about the relation between the intelligence and motor tasks performance of coordinated movement in rhythm. We can assume that the tasks with complicated structure, which are new to the participants and demand a more efficient performance in the shortest time possible at the optimal rhythm, require a certain level of intellectual potentials (fluid intelligence). Cortical centres, which receive, monitor, adjust and elaborate different information, are responsible for the successful resolution of motion problems.
2. The relation between the simple motor tasks execution and the intellectual abilities has also already been found several times before (Willson, Tunstall and Eysenk, 1971; Mejovšek, 1977; Jensen, 1982; Strel and Žagar, 1993; Planinšec, 1995). The capacity of fast performance of simple movements depends on the speed of the transmission of information to the motor centres, and on the adjusted regulation of simple motor tasks. Due to the demand for the highest possible number of repetitions, following each other in opposite directions, the result depends on the capacity of fast alternating inclusion of synergic and antagonist muscles, individual rhythm, and the parallel elaboration of information, on the one hand, or it may, on the other hand, depend on a certain level of the functioning of intellectual potentials for perception, analysis and correction of movement, which eventually represents the Cattell's fluid intelligence.
3. The variable MRRC represents the complex motor task, in which the subject is expected to perform, as fast as she can, certain movements prepared in advance, which differ in the position of the body, structure and direction of motion. The task is hypothetically classified into the area of agility (Šturm, 1970; Strel and Šturm, 1981). The relation is based on the Luria theory (1983), which says that in the case of a more complex composition of motion exercises, and precisely determined motion programmes, which should be carried out in the shortest time possible and in a limited space, the exercises should be done on the cortical level.
4. All three tests MBF, MSR and MBAT, demonstrate the representative measures of mobility. The relation between mobility and intelligence can be explained by the complicated adjustment of muscles tonus, which depends directly on the situation of the activation of the alpha motoneuron and the relations with the cortex through the pyramid and out-of-pyramid path (Pinter, 1996). It is likely that the subjects aged 14 years have faced some restrictive factors such as a non-relaxed mood at the time of the test performance, the reflex of extraction, and the changed morphological structure. Although the movement is carried out mostly at the adjustment level of higher positioned centres of the central nervous system, the negative influences cause negative projections of tests MSR and MBAT on the criterion variable. The processes taking place in the neuron networks are distributed parallelly: the intermingled connections cause several simultaneous processes, which could be encouraging or restrictive.

5. Test MR600 represents, in the case of the untrained population, the task of endurance, since the subjects remain in sub-maximal load from 2 to 5 minutes. The result depends on the bio-physiological capacities, on psycho-sociological status and the technique of running. As the exertion in the task performance never reaches the peak, the economic aspect of running becomes evident (Ušaj, 1996). Probably the technique of movement, and the intermuscular coordination in the untrained population become decisive factors, which effect the result more than any other factor, normally decisive in the well-trained athletes. A good intermuscular adjustment enables a better running technique, which consequently brings about a lower consumption of energy. In the intellectual processes, where the task should be solved over a longer period of time, we also meet the activation of the mechanism for the duration of excitation, and, the mechanism of successive processing is simultaneously recruited. The engagement of both mechanisms allow results to be achieved by coordination between the received and stored information. The relation can be explained by the same functional grounds, i.e. by the involvement of the same centres of the central nervous system.
6. In addition to the mechanism for the duration of excitation, which is decisive for the result in the test task MSU60, in the case of the untrained population, the mechanism for synergy and tonus regulation also participates in the successful accomplishment of a task. The explanation is similar to the one of test MR600. An appropriate intermuscular coordination, which prevents the appearance of exhaustion, has the same functional grounds as in the case of performing an intellectual task lasting for a longer period of time.

In the case of complex motion and unknown tasks we should also stress the role of motor learning. The acquisition of motor skills represents an intellectual task (Horga, 1993), since it depends on the set of processes for the elaboration of information in the central nervous system. Fitts and Posner (1967, after Horga, 1993) say that motion takes place in three phases (cognitive, associative and autonomous); in the initiation phase of learning an unknown task the cognitive processes are involved.

While performing the exercises, the subjects compare the information kept in their memory with the actual information, coming from sensor centres, primarily with the visual impulses and the impulses of muscles, sinews and joint receptors (Adams, 1976, after Horga, 1993). The movement performance can therefore be controlled on the basis of the feedback of information. According to the Schmidt theory of the open and closed loop system (Schmidt, 1991) the most important thing to be learned about the motion task is the establishment of the scheme in the motor memory: the recall scheme and the recognition scheme enable the inclusion of the general motor programmes responsible for the whole range of movement. The recall scheme makes it possible to modify movement according to the environment (it means an open loop – feed-forward), and the recognition scheme makes it possible to recognise and estimate motor activities on the basis of their sensor consequences (closed loop – feedback).

In the neuronic network we keep the conditions which are necessary to renew the motion pattern. Any previously kept pattern can be recalled by a similar impulse from outside. It is only important that the patterns that are more often reconstructed become clearer and clearer, and that the pattern can be reproduced from only a part of the motion pattern stored in the memory.

The level of simultaneous and consecutive comparison between the information and the quantity of information about different motor tasks kept in the memory are those elements which can confirm the probability of relations between the agility and intelligence of the 17-year-old subjects.

Conclusion

The principal aim of the research work has been to find out the relations between the motor abilities and the fluid intelligence of schoolgirls aged from 10 to 18 years.

We have determined a significant statistical correlation between the indicators of fluid intelligence and the range of motor variables in girls aged from 10 to 12 years and in the girls aged 14 and 17 years, whereas no significant statistical correlation has been found in girls aged of 13, 15, 16 and 18 years.

The results concerning the relations between the motor abilities and the fluid intelligence are partially surprising, since the majority of researchers think that in the process of growing up that relation starts to decline gradually. Although the development of fluid intelligence reaches its peak at the age of 16, the motor development is not yet completed at that age, which enables establishing certain relations, above all in the cases where the functioning is conditioned by the speed of the information transfer and by the synchronised operation of agonists and antagonists, as well as by the involvement of the information kept in the long term memory, and, finally, by the rational performance of movement.

The capacity of the central nervous system to receive, control, adjust and elaborate numerous and various pieces of information is in the background of solving the tasks with complicated motion structure, which is new to the tested girl and demands the quickest problem solving of in the shortest possible time and at optimal rhythm. The same capacity is important when solving the intellectual problems. The speed of the transformational processes, conditioning the human reactions in the intellectual and motor areas, depends on that capacity of the central nervous system. Also, the first phase of learning an unknown exercise requires inclusion of the cognitive processes. When performing the exercise the subjects also compared the information on the task they have stored in their memory, with the information of the movement coming from the sensor centres. Thus, girls could control and correct the performance of the movement on the basis of the feedback of information.

The relation between the motor variables of the speed of simple motion and the indicators of the intellectual capacities can be explained by the operational speed of the intellectual potentials for perception, analysis and correction of movement. Here we can agree with Mejovšek (1977), who states that when performing the tasks that do not involve problematic situations, the relation can be explained by the speed of the information transfer. Probably in the case of younger age categories the simple motion tasks to execute simple motions as quick as possible represent the problem solving challenge, and require the implementation of more complex intellectual capacities.

The discovered relation with the measures of mobility is surprising, since only Momirović and Horga (1982) have so far proved the relation between mobility and intelligence. Although the structure of movement, performed in all three tests, is very simple, it is evident that the success in executing exercises depends on the complex maintenance and adjustment of muscular tonus.

The explanation of the relations between two manifest variables of energy type (MR600 and MSU60) in the older subjects is not simple, probably because the same functional basis of both processes is involved. The economic aspect, which is subject to a good intermuscular adjustment, must be present also in the intellectual processes, where the task is to be solved over a longer period of time. The activation of the mechanism for the duration of excitation is needed. At the same time the mechanism of consecutive processing utilires previous by stored information and enables a better result from the coordination between the received and the stored information.

It should certainly be wise to compare the both sub-spaces on the sub-samples of 7, 8 and 9-year-old girls, since the relations between the separate measuring procedures would, according to the theoretical issues, be much higher. Following the obtained results concerning the relation between the indicators of fluid intelligence and the motor variables even after the age of 16, it would be also sensible to study the relation between the motor variables and the indicators of crystallised intelligence on a sample of secondary school girls. This seems specially important because the correlation between the fluid and crystallised intelligence ranges from 0.40 to 0.60 (Pogačnik, 1995).

This research work is one of the rare experiments: where the relations between the motor and intellectual abilities of girls from the pre–puberty period to the age of adolescence are studied and analysed, which is a fact that underlines the obtained results. The findings partly also enlighten the relation between the motor and the intellectual development of girls aged from 10 to 18 years. The results should contribute to a better understanding of their needs and in this way they might guide us to a more human treatment in the different phases of their development.

References

1. Conger, J. J., Galambos, N. L. (1997). *Adolescence and Youth. Psychological Development in a Changing World.* Addison-Wesley Longman, Inc.
2. Gabrijelić, M. (1977). *Manifest and Latent Dimensions of Top Athletes of Certain Collective Sports Games in Motoric, Cognitive and Conative Space.* (In Croatian). (Dissertation), Zagreb: Faculty of Physical Culture.
3. Horga, S. (1993). *The Psychology of Sport.* (In Croatian). Zagreb: Faculty of Physical Culture.
4. Jensen, A. R. (1982). Reaction time and psychometric g. In H. J. Eysenck (Ed.) *A model for intelligence,* (pp. 93-132*).* Prenger-Verlag.
5. Kondrič, M., Šajber Pincolič, D. (1997). *Analysis of the Development of Certain Physical Characteristics and Motor Abilities of Schoolboys and Schoolgirls in the Republic of Slovenia form 1988 to 1995.* (In Slovenian). (Master's thesis)*,* Ljubljana: Faculty of Sport.
6. Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, D., Viskić-Štalec, N. (1975). *Structure and Development of Morphological and Motor Dimesions of Youth.* (In Serbian). Beograd: Faculty of Physical Education, Institute for Scientific Research.
7. Kurelić, N., Momirović, K., Šturm, J. (1979). Structure of Motor Abilities and their Relations with other Dimensions of Personality. (In Croatian). *Kinesiology,* 9(1-2), 5-25.
8. Luria, A. R. (1983). *Basics of Neuropsychology.* (In Srebian). Beograd: Nolit.
9. Malina, R. M. (1991). Growth spurt, adolescent II. In Lerner, R. M., Petersen, A. C., Brooks-Gunn, J. (Eds.) *Encyclopedia of adolescence.* New York: Garland Publishing.
10. Mejovšek, M. (1977). Relations of Cognitive Abilities and Certain Measures of the Speed of Simple and Complex Motion. (In Croatian). *Kinesiology,* 7: 77-137.
11. Metikoš, D., Gredelj, M., Momirović, K. (1979). Structure of Motor Abilities. (In Croatian). *Kinesiology,* 9, 25-50.
12. Mohan, J., Bhatia, S. (1989). Intelligence, sex and psychomotor performance. *Indian Psychological Review,* 28, 34-35.
13. Momirović, K., Horga, S. (1982). Canon Relations of Hypothetical Dimensions Derived from the Measures of Cognitive and Motor Abilities. (In Croatian). *Kinesiology,* 14(5), 121-124.
14. Pavlovič, M. (1982). *Analysis of Relations between Cognitive and Coordinational Abilities of 11 years old Basketball Players.* (In Slovenian). Ljubljana: High School of Psysical Culture, Institute for Kinesiology.
15. Pinter, S. (1996). *Latent Structure of Movement Variables before the Partialisation and after Partialisation of Anthropometric Variables.* (In Slovenian). (Dissertation), Ljubljana: Faculty of Sport.
16. Planinšec, J. (1995). *Relations between Certain Motor and Cognitive Abilities of 5 year old Children.* (In Slovenian). (Masters thesis), Ljubljana: Faculty of Sport.
17. Pogačnik, V. (1994). *TN Test of Sets. Handbook.* (In Slovenian). Ljubljana: Productivity ltd. Centre for Psychodiagnostic means.
18. Pogačnik, V. (1995). *Comprehension of Intelligence.* (In Slovenian). Radovljica: Didakta.
19. Przeweda, R. (1995). Physical fitness in Polish children and youth. In *Physical Education and Sports of Children and Youth,* (pp. 218-221). Bratislava.
20. Schmidt, R. A. (1991). *Motor learning performance: from principles to practice.* Champaing: Human Kinetics Books.
21. Simons, J., Beunen, G. P., Renson, R., Claessens, A. L. M., Vanreusel, B., Lefevre, J. A. V. (1990). *Growth and Fitness of Flemish Girls. The Leuven Growth Study.* Champaign, Illinois: HKP Sport Science Monograph Series.
22. Strel, J., Novak, D. (1980). *Reliability and Structure of Coordination Tests of 11- year Schoolchildren.* (In Slovenian). Ljubljana: Faculty of Physical Culture, Institute for Kinesiology.
23. Strel, J., Šturm, J. (1981). *Reliability and Structure of Certain Motor Abilities and Morphological Characteristics of 6 and a half year old Schoolboys and Schoolgirls.* (In Slovenian). (Research work), Ljubljana: Faculty of Physical, Institute for Kinesiology.

24.Strel, J. (1981). *Analysis of Relations between Coordinational and Morphological Dimensions.* (In Slovenian). (Dissertation), Ljubljana: High School of Physical Culture.

25.Strel, J., Šturm, J., Štihec, J., Kovač, M., Tušak, M., Ambrožić, F., Leskošek, B. (1992). *The Analysis of Development Trends of Motor Abilities and Morphological Characteristics, and the Relations of both with Psychological and Sociological Dimensions of Slovenian Children and Youth from 7 to 18 in the Period from 1970 - 1983 - 1993.* (In Slovenian). (Project research), Ljubljana: Faculty of Sport, Institute for Kinesiology.

26.Strel, J., Žagar, D. (1993). The Relation between Motor Efficiency and Intelligence of Schoolboys and Schoolgirls. In *Second International Symposium Sport of the Young.* Ljubljana-Bled.

27.Strel, J. Šturm, J., Štihec, J., Kovač, M., Tušak, M., Ambrožić, F., Leskošek, B. (1996). *The Analysis of Development Trends of Motor Abilities and Morphological Characteristics, and the Relations of both with Psychological and Sociological Dimensions of Slovenian Children and Youth form 7 to 18 in the Period from 1970 - 1983 - 1993.* (In Slovenian). (Final report), Ljubljana: Faculty of Sport, Institute for Kinesiology.

28.Šturm, J. (1970). *Reliability and Factor Structure of 28 Tests of Motor Ability of 8 and 12 year old Schoolgirls and Schoolboys of Ljubljana Primary Schools.* (In Slovenian). Ljubljana: High School of Physical Culture.

29.Šturm, J. (1977). *Reliability of Motor Tests.* (In Slovenian). Ljubljana: High School of Physical Culture, Institute for Kinesiology.

30.Šturm, J., Strel, J. (1985). *Comparison of Certain Motor and Morphological Parameters in Primary Schools of Slovenia in the Period from 1970/71 - 83.* (In Slovenian). (Final repor), Ljubljana: Faculty of Physical Culture, Institute for Kinesiology.

31.Tanner, J. M. (1991). Growth spurt, adolescent I. In Lerner, R. M., Petersen, A. C., Brooks-Gunn, J. (Eds.) *Encyclopaedia of adolescence,* (pp. 419-424). New York: Garland Publishing.

32.Ušaj, A. (1996). *Short Overview of the Basic Sports Training.* (In Slovenian). Ljubljana: Faculty of Sport, Institute for Sport.

33.Willson, G. D., Tunstall, O. A., Eysenk, H. J. (1971). Individual differences in tapping performance as a function of time on the task. *Perceptual and Motor Skills,* 33, 361-369.

Received: March 31, 2000
Accepted: May 9, 2000

Correspondence to:
Marjeta Kovač, Ph.D.
Faculty of Sport, University of Ljubljana
Gortanova 22
1000 Ljubljana, Slovenia
Tel. +386 41 600 802
Fax: +386 61 327 792
E-mail: marjeta.kovac@mss.edus.si