NEXUS BETWEEN MANIFEST MOTOR INDICATORS AND FLUID INTELLIGENCE IN PREPUBERTAL BOYS

Jurij Planinšec

Faculty of Education, University of Maribor, Slovenia
and Science and Research Centre of Koper, Institute of Kinesiology, University of Primorska, Slovenia

Submitted in October, 2005

The purpose of this study was to investigate the correlation between manifest motor indicators and the fluid intelligence of boys. The sample comprised 550 boys aged 10 to 14. A battery of 26 tests was used for measuring motor performance. Intelligence testing was implemented with the test TN-20. A multiple regression analysis indicated that association between motor variables and fluid intelligence exists. The closest connection was the one between fluid intelligence and motor tasks which demand the coordination of movement in rhythm and the speed of movement. The associations between motor performance and fluid intelligence were age dependent: in 12 year old boys the connection between motor variables and fluid intelligence is the highest, followed by 14 year old boys, where it is a little lower; the connection is the lowest in 10 year old boys. The results suggest that developmental changes have a significant influence on the relations between motor performance and fluid intelligence.

Keywords: Motor performance, physical fitness, fluid intelligence, connection, boys.

INTRODUCTION

Motor abilities are shown in interaction with other psychosomatic dimensions, so they can be correctly interpreted only on the basis of knowledge about such connections. A better understanding of the principles of human development requires the study of motor dimensions and their relations with other psychosomatic dimensions, since in the course of development changes occur in the individual dimensions as well as in the relations between them. A more detailed analysis of the connections between motor dimensions and intelligence is reasonable for children and adolescents who are in the phase of dynamic development. The age period between 10 and 14 is characterised by great variability and instability of several human dimensions as well as relations among them, which results in the instability of development processes (Gallahue & Ozmun, 1998).

Some studies have analysed connections between various motor variables and intelligence (Carretta & Ree, 1997; Mejovšek, 1977; Mohan & Bhatia, 1989; Momirović & Horga, 1982; Momirović, Hošek, & Gredelj, 1987; Planinšec, 2002; Planinšec & Pišot, 2003; Tirre & Raouf, 1998). These studies have proved the existence of two important factors which are significant for the connection between motor performance and intelligence. In cases where the motor task does not include problem situations, the connection is dependent on the speed of the information flow in the nervous system, while in cases where the motor task is complex on the information level, the nexus is dependent on the intellectual activity used in solving the motor problem situations. There are interesting conclusions that the correlation coefficients among tests for measuring the motor coordination are almost equally significant as compared with the correlation coefficients of these tests with intelligence tests (Momirović et al., 1987). However, the ability of motor coordination is not simply one of the manifestations of general intellectual ability, but a result of several abilities (Tirre & Raouf, 1998). Carretta and Ree (1997) have established that the nexus between high-order cognitive factors and psychomotor factors are higher than between low order factors. Nijenhuis and Van de Flier (2002) established that perceptual-motor ability tests overlap with the general intelligence factor. The interdependence of motor abilities and the intellectual skills of children has been studied by Bonifacci (2004). According to motor efficiency she divided children into groups with low, average and above average motor abilities. She concludes that there are important differences in the abilities of visual-motor integration between the low-average and above-average group while there were no differences among children concerning their perceptual skills.

Only a few studies up to now have treated the development changes of relations between motor performance and intelligence (Cole & Harris, 1992; Eggert & Shuck, 1978; Thomas & Chissom, 1972; Zimmer, 1981). Their studies show a positive correlation between motor performance and intelligence. It is medium high in the pre-school period and decreases in older children, with the ability of the coordination of movement having the strongest connection with intelligence. Cole and Harris (1992) have established that the relations between the intelligence quotient and the motor quotient are unstable, as they change significantly with age.

The above mentioned studies show significant differences with regard to the samples of participants, the selection of tests and the methods of data processing, which makes the comparison among them rather difficult. In comparison with the above mentioned research, our research mainly uses different motor and intelligence tests.

The main aim of this study is to analyse the connection between the manifest motor indicators and fluid intelligence of boys aged 10 to 14 years. It intends to establish whether the relations among motor performance and intelligence change with age and which motor variables show the strongest connection with the fluid intelligence in difference age periods.

MATERIALS AND METHODS

Participants

The participants were 550 healthy boys, of whom 195 are aged 10.2 years (SD = 0.32), 160 are aged 12.3 years (SD = 0.29) and 195 are aged 14.3 years (SD = 0.34). The selection of boys for sample was random. The participants come from different parts of Slovenia.

Variables

Motor tests. For the assessment of motor performance a battery of 26 tests (Strel, 1996) was used; eight tests are from Eurofit test battery (1993). The motor tests belong to the following indicators of motor performance: *speed of movement* (hand tapping; hand tapping 25 cycles; foot tapping); *strength* (standing broad jump; put the medicine ball; 60 m run; hand grip; sit-ups 20; sit-ups 30; sit-ups 60; bent arm hang); *agility* (running around three stands; running around two stands with obstacles; running, rolling, crawling); *motor coordination* (drumming with the hands; drumming with the hands and feet; polygon backwards; climbing and descending; match juggling); *flexibility* (forward bow; back arm twist; sit and reach); *balance* (standing on a low beam; flamingo balance); *endurance* (600 m run; endurance shuttle run). The motor tests have been applied on a population of Slovenian children (Kovač & Strel, 2000; Strel, 1996; Šturm, 1980) and are thus appropriate for application on the selected sample. In existing studies, motor tests were of acceptable reliability.

Intelligence test. The assessment of intelligence was carried out with the test TN-20 (Pogačnik, 1994). The test is intended for measuring fluid intelligence, i. e. for the testing of the general neurophysiological capacity of the central nervous system for information processing. It is non-verbal and culture free. The test consists of 45 tasks, which increase in difficulty. Since there is a 20 minute time limit for the test, it can be labeled as a speed test. The test has satisfactory measurement characteristics and is thus appropriate for application on the selected sample (Pogačnik, 1994). Pogačnik (1995) determines a high correlation of this test with other tests for the assessment of intelligence.

Procedure

The measurements of motor abilities and intelligence were always carried out before noon in especially prepared areas. Each participant completed all the tests in two hours. The measurements were carried out by qualified experts. First, the participants performed an intelligence test followed by measurements of motor performance. All participants were well informed about the course of measurements and they received precise instructions for each task before performing it. The whole course of testing was coordinated and supervised by the measurements leader while a special leader was responsible for the motor and psychological complex of the measurements. Children and their parents agreed to participate in this research. Written consent was obtained from the children's parents.

Analyses

The data were processed with the program SPSS 12.0, separately for each age group. The relations between motor variables and fluid intelligence were estimated with multiple regression analysis. The system of predictors was represented by the manifest motor variables, while the criterion was represented by the result of the intelligence test.

RESULTS

The results of the regression analysis in 10 year olds show (TABLE 1) that there is no significant correlation between the entire system of motor variables and fluid intelligence on the level of $p < .05$, with the multiple correlation coefficient (R), as an indicator of the connection of the predictors with the criterion, being .35, which means that 12% of the common variance between motor and intelligence variables is explained. Of the individual motor variables, a significant coefficient of β on the level $p < .05$ belongs to drumming with the hands (.22).

TABLE 1
Summary of regression analysis for 10 years old boys

Motor Dimension and Variable	**r**	**Part – r**	**β**	**p**
Speed of movement				
Hand tapping	.09	.03	.05	.64
Hand tapping 25 cycles	–.06	.03	.06	.60
Foot tapping	.08	.05	.07	.46
Strength				
Standing broad jump	–.00	–.03	–.05	.65
Put the medicine ball	.02	.02	.03	.72
60 m run	–.03	–.02	–.03	.77
Bent arm hang	–.02	–.01	–.01	.88
Hand grip	.04	.06	.06	.40
Sit-ups 60	–.03	–.08	–.12	.23
Sit-ups 20	.05	.10	.38	.17
Sit-ups 30	.05	–.07	–.28	.32
Agility				
Running around two stands with obstacle	–.01	.01	.02	.84
Running, rolling, crawling	–.06	–.01	–.02	.82
Running around three stands	.07	.14	.21	.06
Coordination of movement				
Drumming with the hands	.23	.18	.22	.01
Drumming with the hands and feet	.11	.02	.02	.80
Match juggling	.02	.00	.00	.96
Polygon backwards	–.04	–.00	–.01	.94
Climbing and descending	–.03	–.02	–.04	.71
Flexibility				
Back arm twist	.06	.05	.06	.45
Forward bow	–.01	–.01	–.02	.89
Sit and reach	–.01	–.00	–.00	.98
Balance				
Standing on a low beam	.04	–.01	–.01	.88
Flamingo balance	–.04	–.05	–.06	.46
Endurance				
600 m run	–.01	.05	.07	.49
Endurance shuttle run	.21	.09	.15	.06
$R = .35$ $R^2 = .12$ $p = .62$				

TABLE 2 shows the results for 12 year old boys. The multiple correlation coefficient (R) had an expected value of (.50), which means that there is 25% common variance between motor variables and fluid intelligence. The coefficient R is significant at the level of $p < .05$. The most important motor variable which has a significant coefficient of β at the level of $p < .05$ is hand tapping, 25 cycles (.26).

TABLE 2
Summary of regression analysis for 12 years old boys

Motor Dimension and Variable	r	Part – r	β	p
Speed of movement				
Hand tapping	–.03	–.10	–.15	.16
Hand tapping 25 cycles	–.19	–.17	–.26	.02
Foot tapping	.01	.13	.18	.07
Strength				
Standing broad jump	.07	-.06	–.10	.42
Put the medicine ball	.04	–.01	–.02	.83
60 m run	–.07	.02	.04	.73
Bent arm hang	.15	.07	.09	.33
Hand grip	.12	.07	.09	.31
Sit-ups 60	.09	.00	.00	.97
Sit-ups 20	.09	–.07	–.30	.32
Sit-ups 30	.10	.06	.27	.36
Agility				
Running around two stands with obstacle	–.06	.06	.10	.38
Running, rolling, crawling	–.15	–.03	–.04	.68
Running around three stands	–.01	.07	.12	.29
Coordination of movement				
Drumming with the hands	.22	.05	.07	.50
Drumming with the hands and feet	.18	.10	.13	.18
Match juggling	.09	.04	.05	.57
Polygon backwards	–.15	–.08	–.13	.29
Climbing and descending	–.13	–.02	–.03	.75
Flexibility				
Back arm twist	–.21	–.12	–.16	.09
Forward bow	.24	.07	.16	.32
Sit and reach	.17	–.01	–.03	.84
Balance				
Standing on a low beam	.18	.04	.05	.56
Flamingo balance	.00	.07	.09	.30
Endurance				
600 m run	–.13	–.02	–.03	.79
Endurance shuttle run	.21	.09	.15	.21
$R = .50$ $R^2 = .25$ $p = .03$				

The results of the regression analysis for 14 year olds show (TABLE 3) that there is a significant correlation between the entire system of motor variables and fluid intelligence on the level of $p < .05$, with the multiple correlation coefficient (R) being quite high (.45), which means that 20% of the common variance between motor variables and intelligence is explained. The motor variables which have a significant coefficient of β at the level of $p < .05$ are the following: running around three stands (.26), foot tapping (.20), drumming with the hands (.17), bent arm hang (.17) and back arm twist (.15).

TABLE 3
Summary of regression analysis for 14 years old boys

Motor Dimension and Variable	r	Part – r	β	p
Speed of movement				
Hand tapping	.03	–.04	–.06	.51
Hand tapping 25 cycles	–.04	.00	–.00	.99
Foot tapping	.08	.16	.20	.02
Strength				
Standing broad jump	.07	.08	.14	.24
Put the medicine ball	–.02	.04	.06	.51
60 m run	.01	.08	.12	.24
Bent arm hang	.13	.14	.17	.03
Hand grip	–.06	–.05	–.07	.42
Sit-ups 60	–.03	–.06	–.07	.38
Sit-ups 20	.07	–.02	–.04	.73
Sit-ups 30	.13	.06	.13	.31
Agility				
Running around two stands with obstacle	–.08	.03	.04	.66
Running, rolling, crawling	–.02	.02	.02	.75
Running around three stands	–.16	–.16	–.26	.01
Coordination of movement				
Drumming with the hands	.19	.13	.17	.04
Drumming with the hands and feet	.11	.03	.04	.62
Match juggling	.17	.09	.10	.17
polygon backwards	.01	.12	.19	.07
Climbing and descending	–.10	–.07	–.10	.28
Flexibility				
Back arm twist	–.17	–.14	–.16	.04
Forward bow	–.02	–.02	–.06	.68
Sit and reach	–.02	–.02	–.06	.69
Balance				
Standing on a low beam	.01	–.12	–.15	.07
Flamingo balance	–.09	–.04	–.06	.50
Endurance				
600 m run	.06	–.05	–.07	.89
Endurance shuttle run	.21	.09	.15	.21
$R = .45$ $R^2 = .20$ $p = .02$				

DISCUSSION

We can say that the obtained results are partly consistent with expectations and with results of the previous studies. The results show that there are positive and significant associations between motor and intellectual variables, but there are some differences among all age groups. In 12 year old boys the connection between motor variables and intelligence is the highest, followed by 14 year old boys, where it is a little lower; the connection is not significant and it is the lowest in 10 year old boys. The nexus between motor performance and fluid intelligence is the result of various factors.

The most important motor dimension which shows the strongest connection with the intellectual variable is the coordination of movement in rhythm. Motor tasks involving the coordination of movement in rhythm (variable drumming with the hands) consist of simple movements. However, these are integrated into a rhythmical whole in an unusual way, which makes them complex mostly on the information level. Such movements are abstract and not carried out in everyday situations. The ability of motor coordination is influenced by different cognitive processes which include visuo-processing, visuo-spatial processing and working memory, very important is also the processing speed (Tirre & Raouf, 1998). Planinšec (2002) also states that the speed of information processing plays a very important role in the fast realization of coordination-demanding motor tasks. This speed of information processing is important for the efficiency of intellectual processes (Vernon & Mori, 1992). Pogačnik (1994) suggests that this holds true for the intelligence test TN–20 as well. Bestawros, Langevin, Lalonde and Botez-Marquard (1999) conclude that there is a relationship between measurements of the speed of information processes and the solving of problem situations, which implies a possibility of a common neuro-biological bases for the speed of processing information and human realization functions. The speed of processing information plays an important role in structuring, regulation and motor control, especially when motor tasks are performed at maximum speed.

The nexus between the speed of movement (variables of hand tapping for 25 cycles and foot tapping) and intelligence has already been confirmed (Mohan & Bhatia, 1989; Planinšec, 2002). This connection was explained with a faster and more efficient central nervous system or nerve conduction velocity. It is a fact that speed of movements does not require intelligence. Some researchers have already established that the nerve conduction velocity is correlated with intelligence and speed of movement (Reed & Jensen, 1991; Vernon & Mori, 1989). The speed of neural transmission is important for the speed of information processing, which has a significant influence on the level of intelligence (Bestawros et al., 1999; Vernon & Mori, 1992). The intelligence tests is characterised by time limitation, therefore intellectual speed contributes significantly to the result (Pogačnik, 1994). All this proves the existence of the connection between the speed of movement with the result of the intelligence test.

Fluid intelligence is also connected with variable running around three stands. Motor tasks which are characterised by the quick changing of the direction of movement are complex (Jurimae & Saar, 1998; Planinšec, 2001). Informational complex movement tasks require the successful processing of information, and this also requires intellectual activity (Planinšec, 2002; Tirre & Raouf, 1998).

Contrary to expectation, flexibility (variable back arm twist) falling under the category of motor variables is significantly connected with fluid intelligence, which has already been confirmed (Momirović & Horga, 1982). It was also surprising that there is a significant connection between intelligence and the functional strength (variable bent arm hang), which has also been proved by other researchers (Kovač & Strel, 2000). The implementation of tasks involving flexibility and functional strength certainly does not require intelligence.

CONCLUSION

It has been confirmed that developmental changes have significant associations with the closeness of the nexus between manifest motor indicators and fluid intelligence. The findings of Cole and Harris (1992) regarding relations between motor and intellectual abilities, which seem to be developmentally unstable, can be confirmed. Direction of the relationship between motor abilities and intelligence remains unclear. Therefore it would be advisable to investigate the causal link between motor and intellectual dimensions and to find out which factors influence the relationship. We suggest additional studies for the future where a broader children's age range would be discussed. This might help to gain a better insight into the influence of developmental factors on the relations between motor and intellectual dimensions.

Acknowledgement

The collection of data was carried out within the framework of the longitudinal study with the title *An analysis of the development trends of motor abilities and morphological characteristics and their relations to the psychological and sociological dimensions of Slovenian children and youth*. The author would like to thank Janko Strel, Ph.D., for his help.

REFERENCES

Bestawros, A., Langevin, J. P., Lalonde, R., & Botez--Marquard, T. (1999). Relationship between choice reaction time and the tower of Hanoi test. *Perceptual and Motor Skills, 88(2)*, 355–362.

Bonifacci, P. (2004). Children with low motor ability have lower visual-motor integration ability but unaffected perceptual skills. *Human Movement Science, 23(2)*, 157–168.

Carretta, T. R., & Ree, M. J. (1997). Expanding the nexus of cognitive and psychomotor abilities. *International Journal of Selection and Assessment, 5(3)*, 149–158.

Cole, K. N., & Harris, S. R. (1992). Instability of the intelligence quotient – motor quotient relationship. *Developmental Medicine and Child Neurology, 34*, 633–641.

Eggert, D., & Schuck, K. D. (1978). Untersuchungen zu Zusammenhängen zwischen Intelligenz, Motorik und Sozialstatus im Vorschulalter. In H. J. Müller, R. Decker, & F. Schillingh (Eds.), *Motorik im Vorschulalter* (pp. 67–82). Schorndorf: Hofmann Verlag.

Eurofit. European Tests of Physical Fitness. (1993). Strasbourg: Council of Europe.

Gallahue, D. L., & Ozmun, J. C. (1998). *Understanding Motor Development: Infants, children, adolescents, adults.* Boston: WCB/McGraw-Hill.

Jurimae, T., & Saar, M. (1998). Shuttle-run test: The role of jumping ability, flexibility, coordination and balance. *Journal of Human Movement Studies, 35(5)*, 201–217.

Kovač, M., & Strel, J. (2000). The relations between indicators of intelligence and motor abilities. *Kinesiology, 32(1)*, 15–25.

Mejovšek, M. (1977). Relacije kognitivnih sposobnosti i nekih mjera brzine jednostavnih i složenih pokreta. *Kineziologija, 7(1-2)*, 77–137.

Mohan, J., & Bhatia, S. (1989). Intelligence, sex and psychomotor performance. *Indian Psychological Review, 28(3)*, 34–35.

Momirović, K., & Horga, S. (1982). Kanoničke relacije hipotetskih dimenzija izvedenih iz mjera kognitivnih i motoričkih sposobnosti. *Kineziologija, 12(5)*, 121–124.

Momirović, K., Hošek, A., & Gredelj, M. (1987). *Odnosi između inteligencije i koordinacije pokreta.* Novi Sad: Savez pedagoga fizičke kulture Jugoslavije.

Planinšec, J. (2001). Qualitative changes to human motor dimensions in boys between the ages of 10 and 14. *Collegium Antropologicum, 25*, 561–571.

Planinšec, J. (2002). Relations between the motor and cognitive dimensions of preschool girls and boys. *Perceptual and Motor Skills, 94*, 415–423.

Planinšec, J., & Pišot, R. (2003). Nexus between the motor performance and cognitive abilities of preschool girls. *Annales, 13*, 289–294.

Pogačnik, V. (1994). *TN Test nizov. Priročnik.* Ljubljana: Produktivnost, Center za psihodiagnostična sredstva.

Pogačnik, V. (1995). *Pojmovanje inteligentnosti.* Radovljica: Didakta.

Reed, T. E., & Jensen, A. R. (1991). Arm nerve conduction velocity (NCV), brain NCV, reaction time, and intelligence. *Intelligence, 15*, 33–47.

Strel, J. (1996). *Analiza razvojnih trendov motoričnih sposobnosti in morfoloških značilnosti in relacij obeh s psihološkimi in sociološkimi dimenzijami slovenskih otrok in mladine.* Ljubljana: Fakulteta za šport.

Šturm, J. (1980). Zanesljivost motoričnih testov. *Šport, 38(3)*, 2–16.

Thomas, J. R., & Chissom, B. S. (1972). Relationships as assessed by the canonical correlation between perceptual-motor and intellectual abilities for preschool and early elementary age children. *Journal of Motor Behavior, 4*, 23–29.

Tirre, W. C., & Raouf, K. K. (1998). Structural models of cognitive and perceptual-motor abilities. *Personality and Individual Differences, 24(5)*, 603–614.

Vernon, P. A., & Mori, M. (1989). Intelligence, reaction times, and nerve conduction velocity. *Behavioral Genetics, 19*, 779.

Vernon, P. A., & Mori, M. (1992). Intelligence, reaction times, and peripheral nerve conduction velocity. *Intelligence, 16*, 273–288.

Zimmer, R. (1981). *Motorik und Persönlichkeitentwicklung bei Kindern im Vorschulalter.* Schorndorf: Verlag Hofmann.

VZTAH MEZI ZJEVNÝMI MOTORICKÝMI UKAZATELI A FLUIDNÍ INTELIGENCÍ U PREPUBERTÁLNÍCH CHLAPCŮ

(Souhrn anglického textu)

Cílem studie bylo zkoumat korelaci mezi zjevnými motorickými ukazateli a fluidní inteligenci u chlapců. Vzorek zahrnoval 550 chlapců ve věku od 10 do 14 let. Pro měření motorického výkonu byla použita baterie 26 testů. Testování inteligence bylo prováděno pomocí testu TN-20. Vícenásobná regresní analýza prokázala existence korelace mezi motorickými proměnnými a fluidní inteligencí. Nejužší korelaci bylo možno pozorovat mezi fluidní inteligencí a motorickými úkoly vyžadujícími pohybovou koordinaci rytmu s rychlostí pohybu. Korelaci mezi motorickým výkonem a fluidní inteligencí záviselo na věku. U 12letých chlapců je vztah mezi motorickými proměnnými a fluidní inteligencí nejvyšší. Následují 14letí chlapci, nejnižší závislost je pak u 10letých chlapců. Výsledky naznačují, že vývojové změny mají významný vliv na vztahy mezi motorickým výkonem a fluidní inteligencí.

Klíčová slova: motorická výkonnost, tělesná zdatnost, fluidní inteligence, korelace, chlapci.

Ass. Prof. Jurij Planinšec, Ph.D.

University of Maribor
Faculty of Education
Koroška 160
2000 Maribor
Slovenia

Education and previous work experience

Doctor's degree on Faculty of Sport, University of Ljubljana. Works as an Associate Professor at the Faculty of Education, University of Maribor and at the Institute of Kinesiological Research, University of Primorska. His research interest is related to the motor behavior, health related physical activity and physical self-concept of children and adolescents.

First-line publication

Planinšec, J. (2001). The qualitative changes of human motor dimensions in boys between the ages of 10 and 14. *Collegium Antropologicum, 25*, 561–571.

Planinšec, J. (2002). Relations between the motor and cognitive dimensions of preschool girls nad boys. *Perceptual and motor skills, 94*, 415–423.

Planinšec, J., & Pišot, R. (2003). Nexus between the motor performance and cognitive abilities of preschool girls. *Annales, Series Historia Naturalia, 13*, 289–294.

Planinšec, J. (2003). Assessment of physical activity of young children. *Slovenian Journal of public health, 42*, 58–65.

Planinšec, J., & Matejek, Č. (2004). Differences in physical activity between non-overweight, overweight and obese children. *Collegium Antropologicum, 28*, 747–754.

Planinšec, J., Fošnarič, S., & Pišot, R. (2004). Physical self-concept and physical exercise in children. *Studia Psychologova, 46*, 89–95.

Planinšec, J., & Fošnarič, S. (2005). Relationship of perceived physical self-concept and physical activity level and sex among children. *Perceptual and motor skills, 100*, 349–353.