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INFLUENCE OF CERTAIN SOCIO-DEMOGRAPHIC FACTORS ON THE RELATIONSHIPS BETWEEN MOTOR AND COGNITIVE ABILITIES OF PRIMARY SCHOOL CHILDREN

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Abstract

The main objective of this study is to determine the influence of certain socio-demographic factors on the relationships between motor and cognitive abilities of the primary school students. A total of 398 primary school students from the urban and rural environment, aged 12 to 14, were tested for motor and cognitive abilities. The influence of relevant socio-demographic factors was examined by means of a multiple hierarchical regression analysis. Two socio-demographic variables had a significant influence on the motor and cognitive abilities: residential status and father's education. Urban students revealed better results in motor (except for rural girls) and cognitive ability tests. Father's education level was the second factor exerting an additional impact on these abilities, showing higher values for the urban environment students.

Key words: urban environment, rural environment, motor abilities, cognitive abilities, students.

УТИЦАЈ НЕКИХ СОЦИО-ДЕМОГРАФСКИХ ФАКТОРА НА ВЕЗЕ ИЗМЕЂУ МОТОРИЧКИХ И КОГНИТИВНИХ СПОСОБНОСТИ УЧЕНИКА ОСНОВНЕ ШКОЛЕ

Апстракт

Главни циљ овог истраживања био је да се утврди утицај неких социодемографских фактора на везе између моторичких и когнитивних способности ученика основне школе. Укупно 398 ученика основне школе, узраста од 12 до 14 година, подвргнуто је тестирању моторичких и когнитивних способности. Утицај релевантних социодемографских варијабли испитан је применом мултипле хијерархијске регресионе анализе. Две социодемографске варијабле су имале зна-

чајан утицај на моторичке и когнитивне способности: резиденцијални статус и образовање оца. Ученици урбане средине су остварили боље резултате на тестовима моторичких (изузев девојчица руралне средине) и когнитивних способности. Ниво образовања оца је био други фактор који је значајно утицао на ове способности, а који је био израженији код ученика урбане средине.

Кључне речи: урбана, рурална средина, моторичке, когнитивне способности, ученици

INTRODUCTION

The acquisition of intellectual and motor abilities occurs in similar ways (Rosenbaum, Carlson, & Gilmore, 2001; Paz, Wise, & Vaadia, 2004). Furthermore, as Diamond (2000) suggests, motor and cognitive development may be fundamentally interrelated. There are studies that showed positive correlations between the physical activity and cognitive abilities of children (Sibley & Etnier, 2003), and several authors found a positive relationship between the physical fitness and cognitive function in children (Hillman, Castelli, & Buck, 2005; Buck, Hillman, & Castelli, 2008). Physical engagement and learning outcomes in physical education are complex and researchers have found that learning in physical education is a domain-specific and progressive process encompassing both cognitive and affective components (Shen & Chen, 2006). Some findings indicated that physical exercise improvesd the cognitive abilities and academic achievement development (Barr & Lewin, 1994; Pirie, 1995; Shephard, 1997) and cognitive functioning (Davis et al., 2007; Clark, 2008). However, there is a study with substantial cohort that confirmed a relationship between the physical and intellectual abilities (Åberg et al., 2009). One of the prominent features of the modern era is a lack of physical activities that affects children in particular, and it would be very interesting to reveal the relationships between their motor and cognitive abilities in the context of certain socio-demographic factors. Most psychologists consider inheritance, environment, and social conditions as the key factors in the intellectual development. In addition to these facts, many other socio-demographic factors contribute to the fulfillment of one's intellectual potentials. A number of psychological research studies established that the average score on intelligence tests increasd by around 3 IQ points per decade, as was the case with a specifically designed culture-free test, such as Raven's Progressive matrices (Flynn, 1987, as cited in Biro, Novović, & Tovilović, 2006). The following factors were used as a plausible explanation of this phenomenon: the complexity of everyday life, urbanization, influence of the media, and longer education (Neisser et al., 1996).

Considering the socioeconomic differences between the urban and rural environments, certain differences in motor and cognitive abilities of the students from these environments, could be expected. In a number of

studies, the authors examined motor abilities of the subjects from the urban/rural settings and found that the motor abilities differences were ambiguous. Some of them found the rural subjects to be superior (Tinazci & Emiroğlu, 2010), while other authors (Peña, Tan, & Malina, 2003; Eiben, Barabás, & Németh, 2005) proved the opposite. It is worth mentioning that another group of authors suggested that the difference between the urban/rural students' motor skill level was not uniformly distributed (Tsimeas et al., 2005). Namely, students performed seven motor skill tests and the urban students revealed better results in two tests (vertical jump and basketball throw), while the rural students were more successful in hand grip test. There were no significant differences in the remaining four tests.

Admittedly, there are studies of the cognitive abilities of the urban/rural population (Alexopoulos, 1997; Georgas, et al., 2003; Lloyd & Hertzman, 2010), but studies including subjects' different residential status motor and cognitive abilities, are practically nonexistent. Recent studies report that a socioeconomic status has a significant impact on the motor abilities, and the authors attribute this to better conditions and possibilities for subjects to engage in physical activities in the urban areas (Mikalački, Hošek-Momirović, & Bala, 2006; Matić & Jakšić, 2007; Matić & Maksimović, 2010). The relationship between motor and cognitive abilities is particularly important for students aged 12 to 14, included in this study, because it is a period when many psychosomatic changes occur. Although it has been confirmed that a greater physical activity during adolescence is very important to improve the overall development of the youth, a problem of the inadequately developed motor abilities in children of this age, is increasingly present (Milojević et al., 2002).

METHOD

Subjects

Student subjects in this study were boys and girls in the sixth and seventh grade from four primary schools of the Kraljevo municipality. The research sample (*M*age = 13.5 years) consisted of two subsamples: the urban environment students – 202, (104 boys and 98 girls) – and the rural environment students – 196, (106 boys and 90 girls). Subjects' residential status and gender equity was well balanced: the urban environment – boys 26.1%, girls 24.6% or 50.7% of the total number; the rural environment – boys 26.6%, girls 22.7% or 49.3% of the total number.

Measures

Motor ability tests (a total of 18 tests) originate from a battery of 110 motor tests (Gredelj et al., 1975; Kurelić et al., 1975). Three tests were used to estimate each of the following motor abilities: precision,

balance, coordination, speed, flexibility, and strength. These abilities are subdivided as follows: precision tests: dart throwing (DT), ball thrown at a horizontal target (BTH), and ball kick to a vertical target (BKV); balance tests: balancing on one foot on a balance rail (BBR), standing on one foot on the floor with eyes closed (SEC), and standing on a reversed balance rail (SRR); coordination tests: agility with a stick (AWS), figure eight running with ducking (8RD) and arm and leg drumming (ALD); speed tests: plate tapping (PT), foot tapping (FT) and foot tapping on the wall (FTW); flexibility tests: shoulder flexibility (SF), forward bend on the bench (FBB), and V-sit reach (VSR). Finally, strength was tested through the standing long jump (SLJ), flexed leg sit-ups (FLS) and flexed arm hang (FAH).

Cognitive abilities were examined by means of the test battery KOG 3 (Wolf, Momirović, & Džamonja, 1992) that comprises three cognitive functioning tests evaluating the efficiency of the perception (test IT-1) and the serial (test AL-4) and parallel (test S-1) processing. The test battery KOG 3 has been standardized on a population of over 50,000 participants. Test IT-1 evaluates the efficiency of a perceptive processing that decodes, structures and searches input information and, interactively with other processors, provides effects that can be interpreted as the perceptive abilities. Test AL-4 evaluates the efficiency of the serial processing that deals with the sequential cognitive processes, a sequential searching of the short-term and long-term memory, and analyses of the body of information that is transformed into a symbolic code. Test S-1 evaluates the efficiency of the parallel processing that involves a simultaneous processing of the numerous information streams and parallel searching of the short-term and long-term memory.

In this study, we hypothesized a certain influence of the relevant socio-demographic factors, namely a residential status (RS), a father's education level (FEL), a mother's education level (MEL), a father's employment status (FES), and a mother's employment status (MES), on the relationships between the students' motor and cognitive abilities.

Statistical Analysis

In a preliminary analysis, all the data were subjected to descriptive analyses. Differences in participants' motor and cognitive abilities were tested by the canonical discriminant analyses. In order to investigate the impact of the relevant socio-demographic factors on the relationships between the students' motor and cognitive abilities, we conducted a series of hierarchical regression analyses.

RESULTS

Descriptive statistics for all measures of the whole sample are presented in Table 1.

Table 1. Descriptive statistics of motor and cognitive variables of the whole sample

Variable	Boys				Girls			
	Urban		Rural		Urban		Rural	
	M	SD	M	SD	M	SD	M	SD
DT	25.17	5.35	24.04	4.88	22.64	5.78	21.56	4.69
BTH	18.21	5.08	17.58	5.30	14.45	5.09	14.04	4.90
BKV	12.21	3.97	11.75	3.62	9.49	3.61	9.61	3.58
BBR	9.18	5.17	9.24	4.71	8.98	5.93	8.65	4.06
SEC	20.50	12.61	19.44	11.88	19.22	13.93	23.32	14.84
SRR	7.63	4.93	7.27	4.09	7.16	4.03	8.43	5.37
AWS	13.37	2.62	13.46	2.49	14.16	3.11	13.94	3.52
8RD	57.24	4.26	58.18	4.44	61.33	4.14	61.68	4.15
ALD	7.36	2.92	6.92	2.94	6.66	3.06	6.44	2.98
PT	38.37	3.60	37.14	4.56	36.93	4.77	38.01	4.51
FT	30.62	3.40	30.25	3.51	29.94	3.10	31.00	3.76
FTW	20.28	2.40	19.64	2.36	18.71	2.67	18.60	2.63
SF	88.06	14.76	85.38	16.32	77.04	13.31	78.55	15.29
FBB	33.51	7.34	35.64	6.79	41.36	9.21	41.98	8.22
VSR	34.97	8.98	37.44	7.13	47.19	10.88	44.03	10.55
SLJ	175.08	25.04	171.19	24.87	151.72	20.80	152.68	21.47
FLS	23.42	4.86	21.49	5.93	18.44	4.24	19.37	4.76
FAH	28.79	18.42	30.52	18.77	14.81	12.90	18.57	13.19
IT-1	20.42	5.07	17.92	4.56	20.98	5.36	18.76	4.78
AL-4	25.30	7.86	21.71	7.61	28.07	7.81	23.48	7.95
S-1	17.73	5.83	16.84	5.32	16.79	5.21	17.44	5.39

Mean values showed that the urban environment students had higher scores in the majority of motor tests. Although the urban boys had higher means on 11 out of 18 tests, it must be noted that only a precision was the ability in which they outperformed their rural peers in all three tests, which was confirmed by the canonical discriminant analyses (p=0.00; Wilks' Lambda=.86). The difference in cognitive tests was evident in all three tests, where the urban environment boys had higher scores (p=0.00; Wilks' Lambda=.92). Descriptive statistics for all measures in the girls subsample showed that the rural environment girls had better results in 10 out of 18 motor tests. The urban environment girls were more successful in two precision tests, two coordination tests, two flexibility tests, one speed test, and one balance test. In cognitive ability tests, the urban environment girls had better scores in two out of three tests (IT-1 and AL-4). The aforementioned differences were confirmed by the canonical discriminant analyses (p=0.00; Wilks' Lambda=.80). The urban environment girls had better scores in two out of three cognitive ability tests (IT-1 and AL-4; p=0.00; Wilks' Lambda=.88).

Significant relationships between the motor and cognitive abilities have been confirmed in numerous studies (Momirović & Horga, 1982; Bala, 1999; Planinšec, 2002, 2006; Davis et al., 2007; Åberg et al., 2009). However, so far there has not been any research on the influence of the certain socio-demographic factors on these relationships. To answer the research question of probing the influence of the socio-demographic factors on the relationships between motor and cognitive abilities, we conducted three separate hierarchical regression analyses. The influence of the independent variables on each dependent variable was examined in two steps. In the first hierarchical regression analysis, a perceptive processing (IT-1) was regressed on motor variables in step one and the socio-demographic variables were entered in step two. The results of this analysis are presented in Table 2.

Table 2. Regression analyses results for motor and socio-demographic factors to efficiency of perceptive processing

Predictors	Dependent Variable IT-1			
	B1	B2	ΔF	ΔR²
Step 1			5.61	.17
DT	.10	.08		
BTH	-.05	-.06		
BKV	.02	.02		
BBR	.11*	.09		
SEC	.08	.08		
SRR	.03	.04		
AWS	.08	.07		
8RD	.07	.08		
ALD	.21**	.16**		
PT	-.02	-.01		
FT	.12*	.13*		
FTW	-.06	-.07		
SF	-.02	-.04		
FBB	-.16	-.10		
VSR	.20*	.12		
SLJ	.09	.09		
FLS	.27**	.23**		
FAH	-.20**	-.13*		
Step 2			5.98	.22
RS		-.16**		
FEL		.13**		
MEL		.05		
FES		.00		
MES		.00		

Note. Beta values are standardized parameter estimates: $^{*}p<.005$, $^{**}p<.001$

As shown in Table 2, model one explained 17% of the variance in the perceptive processing of predictors. Step two included the socio-demographic variables and explained an additional 5% of the variance. This model accounted for 22% of variance in the perceptive processing of the predictors applied. Standardized regression coefficients suggest that the flexed leg sit-ups (FLS; *B2*=.23, *p*<.001), an arm and leg drumming (ALD; *B2*=.16, *p*<.001), a residential status (RS; *B2*=-.16, *p*<.001), the father's education level (FEL; *B2*=.13, *p*<.001), and flexed arm hang (FAH; *B2*=-.13, *p*<.001) are the most significant predictors in a perceptive processing.

Table 3. Regression analyses results for motor and socio-demographic factors to efficiency of serial processing

Predictors	Dependent Variable IT-1			
	B1	B2	ΔF	ΔR²
Step 1			8.18	.25
DT	.02	.01		
BTH	.12*	.12*		
BKV	.04	.03		
BBR	.12**	.10*		
SEC	.00	-.01		
SRR	.04	.04		
AWS	.09	.08		
8RD	.02	.04		
ALD	.32**	.25**		
PT	.01	.04		
FT	.03	.04		
FTW	-.03	-.03		
SF	.01	-.02		
FBB	.14	.22**		
VSR	.09	-.01		
SLJ	.09	.07		
FLS	.13*	.07		
FAH	-.23**	-.14*		
Step 2			9.59	.33
RS		-.17**		
FEL		.12**		
MEL		.09		
FES		.05		
MES		.08		

Note. Beta values are standardized parameter estimates: *p<.005, **p<.001

The regression model in step one (Table 3) examined the contribution of the motor variables to the efficiency of serial processing, and it was significant for an arm and leg drumming (ALD; *B1*=.32, *p*<.001), a flexed arm hang (FAH; *B1*=-.23, *p*<.001), and a balancing on one foot on a balance

rail (BBR; *B1*=.12, *p*<.001). The socio-demographic variables entered in step two contributed to the additional 8% of explained variance in serial processing, making it 33% of the explained variance for the final model. The final model revealed that an arm and leg drumming (ALD; *B2*=.25, *p*<.001), a forward bend on the bench (FBB; *B2*=.22, *p*<.001), a residential status (RS; *B2*=-.17, *p*<.001), and a father's education level (FEL; *B2*=.12, *p*<.001) were all statistically significant predictors for the efficient serial processing.

The final hierarchical regression analysis for the motor and socio-demographic variables to efficiency of parallel processing is presented in Table 4.

Table 4. Regression analyses results for motor, socio-demographic factors to efficiency of parallel processing

Predictors	Dependent variable IT-1			
	B1	B2	ΔF	ΔR²
Step 1			6.32	.19
DT	.03	.03		
BTH	.03	.02		
BKV	.01	.00		
BBR	.13**	.12*		
SEC	.03	.02		
SRR	.03	.04		
AWS	.02	.02		
8RD	.05	.04		
ALD	.34**	.31**		
PT	.00	.01		
FT	.06	.05		
FTW	.01	.02		
SF	-.08	-.09		
FBB	-.06	-.07		
VSR	.03	.03		
SLJ	.00	-.01		
FLS	.11	.10		
FAH	-.07	-.05		
Step 2			5.28	.20
RS		.04		
FEL		.07		
MEL		.03		
FES		-.05		
MES		.06		

Note. Beta values are standardized parameter estimates: *p<.005, **p<.001

An arm and leg drumming (ALD; *B1*=.34, *p*<.001) and balancing on one foot on a balance rail (BBR; *B1*=.13, *p*<.001) were the only motor variables that were entered in step one, and were found to have a significant

contribution to the explained variance (19%) in the parallel processing. The socio-demographic variables entered in step two were not significant predictors to the efficiency of parallel processing.

DISCUSSION

The results of the hierarchical regression analyses, when relevant socio-demographic variables were included (Step 2), showed that two variables were significant predictors of the perceptive processing efficiency. In addition to three motor variables, a residential status and a father's education level significantly explained an additional 5% of the variance in the perceptive processing. A residential status was found to have a negative relationship with a perceptive processing indicating that the urban environment students had a more efficient perceptive processing (urban was coded 0; rural was coded 1). Likewise, all students whose fathers have a higher education had a more efficient perceptive processing. That ratio favors the urban students – 31.7% of the urban students' fathers have a college or university education as opposed to 10.7% of the rural students' fathers. The final hierarchical regression model of the relationships between the motor and socio-demographic variables to the efficiency of the serial processing revealed that, apart from the two motor variables, the residential status and father's education level were statistically significant predictors of the efficient serial processing. These socio-demographic variables contributed to additional 8% of the explained variance in perceptive processing, or 33% of the explained variance for the final model. Almost identical values of the standardized regression coefficients of the residential status and father's education level to the first regression analysis indicate that the urban residence students whose fathers have a higher education, exhibit a more efficient serial processing. These findings match to a certain degree those from an earlier study (Mikalački, Hošek-Momirović & Bala, 2006) and indicate that the urban environment students have better preconditions (available sport facilities, clubs, gymnasiums, etc.) to develop their motor abilities. On the other hand, it seems that the father's education level plays a major role in the students' cognitive functioning, where, once again the urban environment children had better scores. The final hierarchical regression testing the relationship between the motor and socio-demographic variables to efficiency of the parallel processing showed that only two motor variables (arm and leg drumming and balancing on one foot on a balance rail) were significant predictors to the efficiency of parallel processing, while the socio-demographic variables were not significant. These results are consistent with the previous study results by Vasić and Trogrlić (2002) who found that the subjects' residential status and parents' education level were significant predictors of the cognitive functioning. The rural environment subjects had significantly lower scores on all cognitive efficiency estimates (perceptive,

serial, and parallel processing). Our results clearly indicate that the correlation between the motor and cognitive abilities is influenced by the residential status and father's education level. Additionally, numerous studies confirmed that the socioeconomic status, parents' education level and gender could influence the development of the cognitive and motor abilities (Okely & Booth, 2004; Gabbard, 2004; Noble, Tottenham, & Casey, 2005; Novović et al., 2009).

CONCLUSION

The presented findings show that the urban environment students have better scores in the majority of the applied tests (except in the motor tests for rural girls) and that the socio-demographic factors probably contribute significantly to these differences. It is reasonable to attribute the differences to the complexity and the quality of living in an urban environment.

This study has several limitations. First, we did not include all the socio-demographic factors with a possible influence on the relationships between the motor and cognitive abilities (school equipment, availability of the sport facilities, extracurricular activities, etc.). Second, our findings could not be generalizable to all populations because the study was conducted in the area of one municipality (albeit the biggest one in Serbia). Third, we used a cross-sectional study design that limits the study to relationships, so the directionality of the relationships cannot be inferred. The longitudinal studies with experimental design in this area would be particularly useful. For instance, subjects could be exposed to an experimental treatment of the specially designed physical activities that could aid cognitive functioning. This could help identify the abilities/activities that have the greatest influence on the cognitive functioning. Clearly, more work is needed to additionally explore all factors influencing the relationships between the motor and cognitive abilities for different environments subjects. Future research that would include more socio-demographic indicators and cover a larger area, would be worthwhile conducting.

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УТИЦАЈ НЕКИХ СОЦИО-ДЕМОГРАФСКИХ ФАКТОРА НА ВЕЗЕ ИЗМЕЂУ МОТОРИЧКИХ И КОГНИТИВНИХ СПОСОБНОСТИ УЧЕНИКА ОСНОВНЕ ШКОЛЕ

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Сажетак

Значајна повезаност између моторичких и когнитивних спсобности потврђена је у бројним истраживањима (Момировић & Хорга, 1982; Бала, 1999; Planinšec, 2002, 2006; Davis et al., 2007; Åberg et al., 2009). Поред тога, утврђено је да физичко вежбање има позитиван утицај на когнитивне способности, школски успех (Barr & Lewin, 1994; Pirie, 1995; Shephard, 1997) и когнитивно функционисање (Davis et al., 2007; Clark, 2008). Међутим, аутори овог истраживања нису наишли на ранија истраживања која су у обзир узела утицај неких социодемографских фактора на ове везе. Опште позната карактеристика модерног доба је недостатак физичке активности, што посебно негативно утиче на децу и њихов развој, те је прави изазов испитати повезаност између њихових моторичких и когнитивних способности у контексту одређених социодемографских фактора. Скорија истраживања код нас указују да социоекономски статус има значајан утицај на моторичке способности у смислу бољих услова и могућности које урбана средина омогућава за ангажман у некој физичкој активности (Микалачки, Хошек-Момировић, & Бала, 2006; Матић & Јакшић, 2007; Матић & Максимовић, 2010).

Резултати овог истраживања показали су да, поред три моторичке варијабле, две социодемографске варијабле (резиденцијални статус и образовање оца) представљају значајне предикторе ефикасности перцептивног и серијалног процесуирања информација. Штавише, добијени резултати указују да ученици из урбане средине имају боље резултате на већини примењених тестова (изузев моторичких тестова код девојчица) и да управо социодемографски фактори вероватно дају најзначајнији допринос тим разликама.