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The relationship between physical, motor, and intellectual development of preschool children

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Abstract

The study examined the relationship of physical, motor, and intellectual development of preschool children. The sample included 72 children aged 5.60 (±0.32) years. Two anthropometric measures (body height, body weight), two motor skills tests (obstacle course, broad jump), and an intelligence test (Raven's CPM) were applied. Taxonomic analysis identified two distinctive developmental profiles in terms of physical growth and motor competence: 1) Shorter children of a lower body weight, less competent; 2) Taller, heavier and more competent children. Physical growth and motor development are positively correlated in children aged 5-6, with no such relation between these domains and intelligence.

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Keywords: Preschool children; Development; Physical growth; Motor development; Intelligence

1. Introduction

Development is a lifelong process, and different aspects of development (physical, motor, cognitive, emotional, etc.) are correlated and interdependent in multiple ways. The complex interreaction of our genes, and our social, cultural, and physical environment, is what defines us. According to the current theories, cognition, perception, motor behavior, and emotions are in close relationship [1].

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During the first 7-8 years of life, development of basic movement patterns depends largely on the rate of neuromuscular maturation of an individual, residual effect of movement experience and current movement experience, as well as growth and maturation status [2]. When fundamental movement patterns are once established, learning and exercising become significant factors of influence on motor competence.

Physical and motor development of the child must be considered within a certain context. Lifting head or unaided sitting of the infant is not an exclusive source of maturation processes (age-dependant ones) as physical and social characteristics of environment play significant roles in it too. Adolph and Berger use the example of crawling and learning to walk to illustrate how much everyday practice and mothers' expectations in bringing up children are significant for mastering motor benchmarks [3]. Maturation of brain and nerve structures produces favorable effects on power and balance by increasing speed and efficiency of information processing. Brain growth is very fast during infant age and young childhood, and it continues the growth pattern of the brain and related tissues commenced in the prenatal period. Relationship between motor development and brain growth is especially expressed at the infant age, and this can also be related to a unique cerebellum growth spurt. Intensive and fast development of cerebellum is significant for coordination, postural control, balance and muscular tone [2], and for cognitive functioning, as well [4]. Independent walking increases child's mobility andopportunities for social interactions, while motor development in general has significant effects on the child's cognitive and language development [5].

Relatedness of different developmental aspects is also confirmed by association of motor, cognitive, and other deficits often encountered in developmental disorders. For example, Developmental Coordination Disorder (DCD), which is essentially deficient motor coordination, is often followed by other developmental problems such as disorder of attention, speech/language, behavior, etc. [6].

Within the context of the current understanding of integrality of development, research was carried out with an aim to examine the relationship between physical, motor, and intellectual development, i.e. to identify developmental profiles of preschool children. Better understanding of the relationship between different developmental domains could help in creating the most supportive developmental environment in preschool years.

2. Method

2.1. Participants

The study was carried out in the Preschool institution *"Radosno detinjstvo"* Novi Sad, Serbia. Recruiting the participants was approved by the Preschool institution's management, as well as by parents of children who attended the preschool institution during data collection. Prior to testing, all parents got information about testing procedures to be used and gave the written consent. Children's participation was voluntary, so that the final sample included the total of 72 healthy children (35 boys and 37 girls). Age of participants on the date of measurement, i.e. testing, was 5.60 (±0.32) decimal years.

2.2 Measures

All anthropometric measuring and motor testing were carried out in the morning (from 8.00 to 12.00) by trained personnel who followed standardized procedures. Within the broader project, higher number of measures and tests was applied, with the following ones used for the requirement of the current study:

Anthropometric measures. *Body height* was measured in mm by Martin anthropometer. Body height measurement was taken barefooted with feet together, whereas the head was positioned according to the

Frankfurt horizontal plane[7]. *Body weight* was measured by decimal scale with 0.1 kg result precision, with participants wearing only t-shirts, underwear and pants[7].

Motor skills tests. *Obstacle course backwards* was measured by stopwatch, with results expressed in 0.1 s. Participants were instructed to move backwards in quadrupedal position along the distance of 10 m. While moving backwards, it was necessary to pass over a wooden frame and through an opening of vaulting box [8]. *Standing broad jump* was measured on the carpet with distances measured in centimeters, starting from the lower end of the spring board. Participants had the task to jump from the lower (non-elastic) part of the spring board onto the carpet, as far as they could provided they landed on both legs. Upon landing, measurement was taken from the back foot print [8].

Intelligence test. *Raven's Colored Progressive Matrices (RCPM)* represents one of the standard nonverbal g-factors or fluid intelligence. It is aimed for testing intelligence of children at the age of 5 to 11 years. The test consists of three series of different weight (A, B, and AB series), each of which consists of 12 items. Test reliability is satisfactory for the age of participants included in this study [9].

2.3. Data analysis

Statistical processing included basic descriptive statistics for all variables. Variables were then standardized, and the standardized values enabled definition of taxons by means of squared Euclidean distance applying Ward's method of taxonomic analysis. After that, descriptive statistics were calculated for taxons obtained in this manner, whereas differences were confirmed by univariate analysis (ANOVA), and presented for individual variables by means of a box plot.

3. Results and discussion

Basic descriptive statistics for the whole sample is presented in Table 1. The obtained values of the analyzed variables do not deviate from the expected ones for a given age, so they were suitable for further analyses.

Table 1. Descriptive statistics of anthropometric, motor and intelligence variables

Variables	$\bar{X}$	SD	MAX	MIN
Anthropometric variables				
Body height (cm)	1174.72	60.52	1332	1015
Body weight (0.1 kg)	226.47	45.42	389	163
Motor skills variables				
Obstacle course backwards (0.1s)*	277.54	99.15	652	134
Standing broad jump (cm)	105.78	15.92	142	65
Intelligence variable				
Raven's matrices (C)	17.79	4.95	32	6

* variable with the opposite metrics

Due to the fact that variables belong to different metric domains, all variables were primarily standardized in order to conduct taxonomisation of the data. Squared Euclidean distance was taken as a characteristic measure of distance of taxonomic procedure, while Ward's procedure was applied for forming groups of similar characteristics. When bringing clusters to relationship, care was taken to keep the sum total (i.e. sum of squares within all groups) as low as possible.After singling out final taxons, two groups of participants were made, whose basic statistical characteristics are presented in Table 2.

Table 2. Basic descriptive statistics of groups made by taxonomisation

Variables	Taxon 1 (N=34 or 47.22%)		Taxon 2 (N=38 or 52.78%)	
	$\bar{X}$	SD	$\bar{X}$	SD
Anthropometric variables				
Body height (cm)	1131.59	44.63	1213.32	44.86
Body weight (0.1kg)	199.85	22.53	250.29	47.66
Motor skills variables				
Obstacle course backwards (0.1s)*	316.12	109.22	243.03	75.06
Standing broad jump (cm)	98.21	13.83	112.55	14.70
Intelligence variable				
Raven's matrices (C)	17.21	4.23	18.32	5.51

* variable with opposite metrics

By application of univariate analysis it is possible to conclude that there are statistically significant differences in four out of five analyzed variables. Significant differences were found in variables Body height (F=59.85; p=0.00), Body weight (F=31.70; p=0.00), Obstacle course backwards (F=11.15; p=0.00), and Standing broad jump (F=18.08); p=0.00). At the same time, there were no significant differences between groups made by taxonomisation in the intelligence variable (F = 0.90; p = 0.35).

According to the taxonomic procedure, two distinct groups of children can be defined, with the following characteristics: 1) The first group includes shorter children of a lower body weight, with lower results in motor skills tests; 2) The second group includes taller and heavier children, who achieved higher results in motor skills tests.Unlike anthropometric and motor skills variables, intelligence was not crucial for the distinction of taxons.

Although correlation between height and performance of different motor tasks in children and adolescents generally ranges from low to moderate, taller and heavier individuals tend to be stronger. On the other hand, higher body height and weight may be related to faster biological maturation. Within same age group, children who are more biologically mature are generally taller and heavier, and they have more lean body mass (especially boys), than average and late maturers. Although relevant studies are still lacking, it is believed that children who mature earlier tend to perform better in motor tests than the slow maturers of the same chronological age [2].

Interesting interaction of environmental factors and motor/cognitive skills is supported by the results of a recent study [10]. Although a strong relationship between children's motor and cognitive functioning was not confirmed, the results suggest that children from high-income families have better cognitive abilities and weaker motor abilities, whereas children from poorer families have better motor abilities but weaker cognitive ones [10]. It is possible that children from poorer families have more autonomy and less parental supervision, which might have produced positive effects on motor development. An interesting study on a large sample of intellectually advanced children showed that they were significantly more advanced in motor development than general population [11]. However, this sample had a set of specific characteristics such as high socio-economical status, developmental and genetic factors etc., which might have affected their intellectual and motor development.

There is an increasing evidence for the adverse relationship between cognitive abilities and low weight, short length, and head circumference of a newborn child with reference to gestational age, whereas preterm delivery is related to motor abilities of children. In addition, it is also suggested that postnatal growth is a more important determinant of the intelligence coefficient than intrauterine development [11]. Another study indicates that children of high and low gross motor development do not differ significantly in terms of perceptive skills and intellectual abilities, but they do differ in visual-motor integration [12].

As for the limitations of the study, they relate mostly to the characteristics of the study sample and reduced number of motor skills and intelligence variables. Improved research design in further studies might enable a more thorough insight into the integral development of preschool children.

5. Conclusion

The study was conducted with an aim to examine the relationship between physical, motor, and intellectual development of preschool children. The obtained results indicate that there are two distinctive developmental profiles in terms of children's physical development and motor competence. According to the characteristics of these developmental profiles, it can be concluded that physical growth and motor development have positive correlations in children aged 5-6, whereas no such relations is found between these two developmental domains and intelligence.

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