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The Effects of Kinesiological Activity on Motor and Intellectual Functioning of Children in Relation to Their Physical Constitution at Birth

Gustav Bala, Željko Krneta and Patrik Drid

University of Novi Sad, Faculty of Sport and Physical Education, Novi Sad, Serbia

A B S T R A C T

At birth, all children are characterized by different values of body weight and body length, caused by both genetic factors and the conditions and characteristics of their prenatal development. It is important to investigate whether these differences expressed at birth, particularly those values that are below average, can be improved by implementing a six--month period of kinesiological activity during childhood. With this purpose, a research was conducted using a sample of 214 children, aged 6,13 ±1,04 decimal years (experimental group of 93 boys and 29 girls, control group of 43 boys and 49 girls), which was divided into two subsamples by using K-mean cluster analysis based on body weight and length of children at birth. The formed subsamples were defined by the average values of the applied variables as groups of children that were below average and above average, according to their development at birth. Motor status of children was assessed by using a battery of 7 standard motor tests, and intellectual status by applying Raven's Colored Progressive Matrices. Quantitative effects of the applied kinesiological treatment were analyzed based on the initial and final status of young participants in the examined variables by using multivariate analysis of variance and covariance. Qualitative differences were defined by results of factor analyses. It was established that there were no statistically significant differences in the variable space between boys and girls in the initial measurement, in relation to the experimental and the control group, so the sample was further treated as the overall sample of children. The effects of the experimental treatment have shown significant improvement of motor and intellectual functioning of children in the experimental group of children with below average and above average development at birth.

***Key words**: infant, physical constitution, preschool children, motor status, cognitive status*

Introduction

Motor and intellectual functioning of a person is of essential significance for his/her life quality. A particular research problem has been the one of defining the motor and intellectual functioning and its determination by both genetic and exogenous factors, and especially by a regular kinesiological activity treatment.

Significant differences have been found in manifested motor abilities during the first year in prematurely born children with low birth weight in comparison to full-term born children[1]. Analysis of differences at the onset of independent walking in prematurely born children with low birth weight in relation to full-term born children has shown that the onset of independent walking is delayed approximately 2 months in prematurely born children with low birth weight[2]. Differences are also noticed in later child development regarding the motor functioning of prematurely born children with low birth weight and full-term born children, particularly in the manifestation of explosive power and body coordination[3,4]. Some authors have confirmed decreased motor efficiency of prematurely born children with low birth weight even in adolescence[5].

Krneta, Bala and Jakšić[6], by using a similar sample of children as this research, but employing a slightly different methodological approach, established that statistically significant differences in body weight and length at birth are lost after 4–6 years of growth and development. Their findings indicate that children whose development is above average at birth are more successful than children whose physical development is below average at

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birth in the performance of almost all motor tests, especially of tests assessing explosive power, repetitive strength and flexibility.

As for the cognitive development of children, there is evidence for a dramatic increase in gray matter volume in early childhood, which is followed between age 7 and young adulthood by decreases in gray matter, and the accelerated processes of myelination and connectivity of neurons in the frontal cortex during that period[7–9]. The process of increased myelination, specialization and connectivity of neurons in the prefrontal cortex region is accompanied by performance in cognitive tests, which indicates the enhanced cognitive processing speed[10–12].

Differentiation and integration of cortical networks in the prefrontal lobe are responsible for the continuous improvement in the processing speed, strategy utilization and working memory in children[13]. Physical exercise affects neurological child development[14,15] because it leads to the production of neurothropins that regulate the survival, growth, and differentiation of neurons[16], synaptogenesis and myelination[17,18], as well as angiogenesis that influences glucose and oxygen level and distribution[19].

In this research, we have tried to employ a different methodological approach to the problem of studying the relations between motor and intellectual abilities of children and their characteristics at birth. Our assumption was that characteristics of children at birth, primarily body weight and body length, are normally distributed in the population of children. Furthermore, following this assumption, we have defined two distinct target groups based on distribution of those characteristics and their interaction in the investigated population of children. The main goal of this research was to establish whether significant effects could be achieved, by applying a kinesiologic treatment of several months, on basic motor abilities and intellectual status of preschool children and children starting school, in relation to the status of their initial constitution, assessed by body weight and body length at birth.

Method

Subject sample

The subject sample was drawn from the population of preschool children attending one of the preschool institutions in Novi Sad. The sample consisted of 214 children of both sexes, aged 6.13±1.04 decimal years (experimental group of 93 boys and 29 girls, control group of 43 boys and 49 girls), who were divided into two subsamples by using K-mean cluster analysis based on body weight and length at birth. The formed subsamples were defined by the average values of the applied variables as groups of children whose development at birth was below average: experimental E1, N=63 and control C1, N=62; and above average: experimental E2, N=59 and control C2, N=30).

Sample of measuring instruments

For the purposes of subject classification into target subsamples, two anthropometric measures were used: Body weight at birth and Body length at birth. The data about these anthropometric measures were obtained from children's parents, through questionnaires. Basic anthropometric characteristics (Body weight and Body height) were measured, in accordance with the IBP program, on the day of the testing.

The following measuring instruments were used for assessing the subjects' motor status: 1) 20 m dash – to assess sprinting speed, 2) Obstacle course backwards – to assess body coordination, 3) Arm plate tapping – to assess movement frequency, 4) Seated straddle stretch – to assess flexibility, 5) Standing broad jump – to assess explosive power, 6) Bent arm hang – to assess static strength and 7) Crossed-arm sit-ups – to assess repetitive strength. For assessing the intellectual status of children, the following test was used: 1) Raven's Colored Progressive Matrices.

Here we will give a short description of the mentioned motor tests, while a more detailed standardization of measuring requirements can be found in Bala et al.[20]:

1. 20 m dash. On command GO the child that stands behind the start line has to run 20 m as fast as he/she can to the end of the track (20 m). The children run in pairs. The score was the time of running, measured in tenths of second.

2. Obstacle course backwards. The child has to walk backwards on all fours and cover the distance of 10 m, climb the top of Swedish bench and go through the frame of the bench. The task is measured in tenths of a second.

3. Arm plate tapping. For fifteen seconds the child has to tap alternately two plates on the tapping board with his/her dominant hand, while holding the other hand in between the two plates. The result is the number of alternate double hits.

4. Seated straddle stretch. The child sits on the floor, leaning against the wall, in straddle position and bows forward as far as possible. A straight-angle ruler lies down in front of the child and he/she reaches the scale with cm as far as he/she can. The result is the depth of the reach measured in cm.

5. Standing broad jump. The child jumps with both feet from the reversed side of Reuter bounce board onto a carpet, which is marked in cm. The result is the length of the jump in cm.

6. Bent arm hang. The child under-grips the bar and holds the pull-up as long as he/she can (chin above the bar). The result is the time of the hold measured in tenths of a second.

7. Crossed-arm sit-ups. The child lies on his/her back with his/her knees bent and arms crossed on the opposite shoulders. He/she rises into a seated position and returns into the starting position. The instructor's assistant holds the child's feet. The result is the number of cor-

rectly executed raises to the seated position (no longer than 60 seconds).

Raven's Colored Progressive Matrices is a non-verbal test, and its purpose is to measure g-factor according to the classical Spearman's terminology. According to Spearman's theory of intelligence, the test is defined as a measure of educative ability (in contrast to the reproductive one which saturates verbal material), which includes giving sense and importance to complex and vague contents, understanding new concordance and relations, as well as creating (non-verbal) constructs by means of which complex contents can be organized. Raven's Colored Progressive Matrices consist of three series of 12 items each: A, Ab, and B. Within each series, items are (roughly) ordered according to difficulty, and the same holds true of the series – B series is the most difficult one. On the top of each assignments there is a colored picture whose bottom part on the right is missing, with six offered solutions given below of which only one fits the deficiency of the picture. Series A represents a bright colored spot where geometric patterns are drawn, mostly in the form of lines and dots. These patterns are ordered according to a system which must be understood for selecting the correct solution. In series Ab and B, the pattern consists of four separate pictures – three of them are presented while the fourth one is missing. The task is to recognize regularity on the basis of the three given ones and to select an offered solution which completes the picture properly. Pictures in the series Ab and B are ordered in the form of a matrix 2x2, for which reason all assignments of this type are called »matrix completing assignments«. The regularity a subject should discover from the pictures is by no means related to the color of background, whose aim is to motivate – to point out the problem and keep a child's attention[21,22].

Methods of data analysis

By using a two-factor multivariate analysis of variance, it has been established that there were no statistically significant differences between boys and girls in the variable space in the initial measurement, in relation to the experimental and the control group, so the sample was further treated as the overall sample of children. Four subgroups, 2 within the experimental (E1 and E2) and 2 within the control group (C1 and C2), were formed for the purposes of solving the research problem. The subgroups were formed based on the information about birth weight and length of subjects by using K-mean cluster analysis with two target clusters. The testing of differences in the analyzed variables between the formed subgroups in the initial measurement was conducted by applying multivariate and univariate analysis of variance. The overall quantitative differences between the formed subsamples in the final measurement were also established by applying multivariate and univariate analysis of variance, while a post hoc technique with the Bonferoni correction of the significance level was used to test the differences between the subsamples. The effects of quantitative changes in the applied set of variables were analyzed by multivariate and univariate analysis of covariance. Qualitative changes, i.e. changes in the structure of general factors of variable sets, were established by calculating and comparing the final and the initial status of the first principal component of the intercorrelation matrix of those variables in each subsample of children. Significance level of $p<0.05$ was used for all statistical procedures applied.

Experimental and control treatments

Experimental treatment, i.e. plan and program of application of kinesiological activities in the experimental group of children (sports school) was implemented twice a week for 60 minutes during one academic year. Kinesiological activities applied in the training process included the following: calisthenics with and without the use of various apparatuses, preventive and corrective exercises for posture control, flat feet, elementary exercises on apparatuses, specific exercises for the development of motor abilities (especially coordination, balance, precision, all kinds of speed, agility, flexibility, as well as all kinds of strength and stamina), athletic events, elements of sports games (football, handball, basketball, volleyball, tennis), elements of martial arts (karate, wrestling), elementary games (catching, group games, etc.), children dances, outdoor activities, basic yoga asanas, stretching, and aerobics.

Control treatment included means of exercising, learning methods, and exercising itself, the purpose of which was to fulfill the requirements of the formal plan and program of preschool institutions in the Autonomous Province of Vojvodina, which is presented in the Model of the Fundamentals of the Work Program with Preschool Children[23], part VII, under the title Physical Development, Physical Activities.

Results

After the initial measurement, it has been established that there were no significant differences in the space of motor and intellectual variables between boys and girls in the overall sample of children (experimental and control group) (Table 1). Because of this, all analyses were conducted in the respective samples of boys and girls as a whole.

In Table 2, results are presented of the K-mean cluster analysis, i.e. descriptive statistics for four formed target groups of subjects based on birth Body weight and Body length. Based on the stated characteristics of the formed groups, the first experimental (E1) and the first control group (C1) were defined as children with below average development, while the second experimental (E2) and the second control group (C2) were defined as children with above average development at birth.

Values of the Body weight and Body height variables for children in separate groups in the initial and final measurement are shown in Table 3. These values according to groups can be used in the analysis as additional

TABLE 1
BASIC STATISTICS AND DIFFERENCES BETWEEN THE GROUPS ACCORDING TO GENDER IN THE INITIAL MEASUREMENT

Variable	Exsperimental Group				Control Group				f	q
	Boys		Girls		Boys		Girls			
	X	SD	X	SD	X	SD	X	SD		
20 m dash (0.1 s)	52.5	7.3	50.5	6.3	58.7	7.1	59.1	8.2	1.14	0.29
Obstacle course backwards (0.1 s)	226.6	87.7	221.7	69.7	287.8	88.9	340.5	118.8	4.23	0.04
Arm plate tapping (freq.)	17.4	4.5	18.4	4.3	13.3	2.8	13.1	2.3	1.21	0.27
Seated straddle stretch (cm)	35.6	6.5	40.7	6.8	31.8	6.9	36.9	7.9	0.00	0.99
Standing broad jump (cm)	122.5	24.0	126.2	18.5	97.7	19.9	94.8	21.1	1.02	0.31
Bent arm hang (0.1 s)	149.2	113.7	180.6	117.3	99.4	107.4	90.7	88.9	1.56	0.21
Crossed-arm sit-ups (freq.)	17.7	10.6	18.6	9.0	15.7	9.9	14.1	9.8	0.69	0.40
Raven's matrices (score)	21.8	7.1	21.5	6.9	17.2	5.3	17.2	4.6	0.03	0.85
F=0.87, Q=0.54										

TABLE 2
BASIC STATISTICS OF SUBJECT GROUPS FORMED BY K-MEAN KLASTER ANALYSIS OF VARIABLES

Statistics	E1 (N=63)		E2 (N=59)		C1 (N=62)		C2 (30)	
	Weight (kg)	Length (cm)	Weight (kg)	Length (cm)	Weight (kg)	Length (cm)	Weight (kg)	Length (cm)
Minimum	2.20	45.00	3.60	49.00	1.40	42.00	3.60	48.00
Maximum	3.50	57.00	4.80	58.00	3.50	57.00	5.00	59.00
X	3.16	50.35	3.91	52.08	3.00	49.45	3.95	52.53
SD	0.29	2.13	0.31	1.79	0.40	2.39	0.35	2.76

TABLE 3
BODY WEIGHT AND HEIGHT IN THE INITIAL AND FINAL MEASUREMENT

Group	Variables	Initial		Final	
		X (SD)	Min-Max	X (SD)	Min-Max
E1	Height (mm)	1.192 (77)	1.050–1.406	1.222 (76)	1.070–1.430
	Weight (kg)	23.1 (4.7)	10.6–37.1	24.9 (4.7)	17.4–37.9
E2	Height (mm)	1.223 (93)	1.030–1.420	1.252 (93)	1.066–1.457
	Weight (kg)	25.3 (6.4)	17.1–44.7	26.9 (6.9)	17.8–46.1
C1	Height (mm)	1.143 (72)	970–1.310	1.174 (73)	1.004–1.340
	Weight (kg)	20.8 (4.2)	13.5–35.1	22.0 (4.4)	14.4–37.1
C2	Height (mm)	1.159 (84)	1.030–1.335	1.189 (83)	1.068–1.368
	Weight (kg)	22.6 (4.6)	16.3–36.7	24.2 (5.2)	17.6–40.5

characteristics for the interpretation of differences and effects of the treatments applied on children.

Quantitative differences in the overall variable space between the two experimental and two control groups were statistically significant (F=5.91, Q=0.00) (Table 4). All variables contributed to the significance except for the Seated straddle stretch and Crossed-arms sit-ups variables. There were no statistically significant differences between the experimental groups in any variable, as well as between the control groups. However, there were significant differences between experimental and control groups in all variables, except in the Seated straddle stretch and Crossed-arms sit-ups variables.

It is known that the motor functioning in children, as well as the intellectual (cognitive), is one of general type, and for that reason, the structure of general motor factor was defined as the first principal component of the intercorrelation matrix of all the analyzed variables in the respective groups of children (Table 5). Such qualitative analysis indicates a better structure of the general factor

TABLE 4
BASIC STATISTICS AND SIGNIFICANCE OF DIFFERENCES BETWEEN THE GROUPS IN THE INITIAL MEASUREMENT

Variable	E1		E2		C1		C2		f	q
	X	S	X	S	X	S	X	S		
20 m dash (0.1 s)	52.2	6.7	51.7	7.6	58.9	7.8	58.9	7.6	15.20	0.00
Obstacle course backwards (0.1 s)	219.5	74.6	231.8	92.2	321.7	116.3	303.8	90.9	16.17	0.00
Arm plate tapping (freq.)	17.8	4.4	17.5	4.4	12.8	2.4	13.9	2.7	25.67	0.00
Seated straddle stretch (cm)	36.8	6.6	36.8	7.2	34.1	7.4	35.3	8.7	1.84	0.14
Standing broad jump (cm)	123.0	20.9	123.8	24.9	95.1	19.1	98.3	23.2	27.10	0.00
Bent arm hang (0.1s)	172.6	129.5	139.6	94.9	89.4	88.8	105.8	114.2	6.91	0.00
Crossed-arm sit-ups (freq.)	18.6	10.6	17.1	9.9	14.9	9.7	14.7	10.2	1.77	0.15
Raven's matrices (score)	21.2	6.8	22.3	7.2	17.3	4.5	16.9	5.7	9.66	0.00
F=5.91, Q=0.00										

TABLE 5
GENERAL GROUP FACTORS IN THE INITIAL MEASUREMENT

Variable	H1E1	H1E2	H1C1	H1C2
20 m dash	–0.89	–0.85	–0.78	–0.86
Obstacle course backwards	–0.87	–0.85	–0.79	–0.68
Arm plate tapping	0.89	0.83	0.63	0.66
Seated straddle stretch	0.45	0.37	0.35	0.43
Standing broad jump	0.83	0.92	0.80	0.86
Bent arm hang	0.41	0.43	0.57	0.70
Crossed-arm sit-ups	0.87	0.87	0.70	0.83
Raven's matrices	0.72	0.74	0.54	0.63
% of Variance	58.40	57.65	43.83	51.78

TABLE 6
BASIC STATISTICS AND GROUP DIFFERENCES IN THE FINAL MEASUREMENT

Variable	E1		E2		C1		C2		f	q
	X	SD	X	SD	X	SD	X	SD		
20 m dash (0.1 s)	49.2	5.4	49.1	6.0	56.1	6.5	55.9	6.2	1.70	0.16
Obstacle course backwards (0.1 s)	177.1	62.3	188.0	58.0	284.8	86.8	259.4	68.4	6.17	0.00
Arm plate tapping (freq.)	20.2	5.1	20.3	4.5	14.1	3.0	15.3	3.4	3.56	0.01
Seated straddle stretch (cm)	42.1	6.6	41.7	7.7	38.3	8.6	40.0	9.0	1.14	0.33
Standing broad jump (cm)	130.5	20.3	131.6	19.3	103.7	19.0	106.9	22.4	3.32	0.02
Bent arm hang (0.1 s)	179.7	126.4	148.9	98.7	92.8	66.4	88.4	59.2	1.25	0.28
Crossed-arm sit-ups (freq.)	26.0	9.8	25.3	8.3	13.9	9.3	15.9	9.4	12.21	0.00
Raven's matrices (score)	23.6	5.8	24.5	6.0	19.6	5.0	20.1	5.0	1.26	0.28
F=3.23, Q=0.00										

in the experimental groups, both in the percentage part of the common variance and in the size of the coefficient of correlation between the variables and the general factor. Attention must be drawn to the fact that the variable assessing intellectual functioning fits completely into the structure of the general motor factor and builds a truly unique motor-cognitive structure. Naturally, this indicates the significant correlation between motor and intellectual abilities in children.

Values of basic statistics for the same variables after the completion of the experimental treatment are presented in Table 6. Multivariate analysis of variance has shown that a statistically significant quantitative difference exists among the groups of children in the overall

TABLE 7
GENERAL GROUP FACTORS IN THE FINAL MEASUREMENT

Variable	H1E1	H1E2	H1C1	H1C2
20 m dash	–0.86	–0.87	–0.90	–0.88
Obstacle course backwards	–0.78	–0.80	–0.75	–0.81
Arm plate tapping	0.85	0.85	0.60	0.79
Seated straddle stretch	0.52	0.38	0.27	0.40
Standing broad jump	0.86	0.84	0.81	0.86
Bent arm hang	0.57	0.54	0.48	0.42
Crossed-arm sit-ups	0.85	0.82	0.64	0.67
Raven's matrices	0.54	0.61	0.44	0.59
% of Variance	55.59	53.83	41.44	49.29

set of variables (F=3.23, Q=0.00). The difference occurs mainly because of the significant difference in the Obstacle-course backwards, Arm plate tapping, Standing broad jump and Crossed-arms sit-ups variables. The superiority of children in both experimental groups in relation to both control groups has contributed to that. However, it must be noted that children in the experimental group were significantly more successful in the performance of motor tests Arm plate tapping and Standing broad jump only in relation to the C1 group (developed below average), but not in relation to the C2 group (developed above average).

Analysis of differences in the structures of general factors (Table 7) indicates that there were no significant changes in comparison to the status in initial measurement. After a more detailed analysis, it can be established that during the period in which the treatments were applied (6 months), the structure of the general factor has slightly weakened in all groups of children.

The effects of the experimental treatment were determined based on the results of multivariate and univariate analysis of covariance, which showed a significant level of improvement in motor and cognitive functioning of children in the experimental group of children with below average and above average development at birth. The improvement was established based on the status in the final measurement, but by neutralizing the effects of group differences recorded in the initial measurement, both in the overall variable set and in each individual variable in relation to all four groups of children. The results indicate that a statistically significant effect of improvement has been achieved in the overall variable set (F=2.99, Q=0.00), which was contributed by values in all variables for both experimental groups, with statistically significant values occurring in the following variables: Obstacle course backwards, Arm plate tapping, Standing broad jump and Crossed-arms sit-ups.

Discussion

Due to the fact that there were no differences between the sexes in the initial measurement, all analyses were conducted in the respective samples of boys and girls as a whole. Four groups were formed: the first experimental (E1) and the first control group (C1) were defined as children with below average development, and the second experimental (E2) and the second control group (C2) as children with above average development at birth. It must be pointed out that this result does not match the results obtained in the research conducted by Bala and Katić[24], who investigated the sex differences in anthropometric characteristics, motor and cognitive functioning of preschool children. These authors used a similar sample in their research and the results thus obtained indicated the superiority of boys in anthropometric characteristics and motor abilities, but not in cognitive functioning.

Bala, Golubović and Katić[25] analyzed the relations between laterality and motor abilities on a similar sample of children. Usage and gesture laterality of the upper extremities was assessed by a battery of tests, on the basis of which the children were evaluated as balanced or imbalanced according to their laterality. The performance of motor tasks that require whole body coordination, the speed of alternating hand motion frequency and the precision of hand aiming were assessed according to the type of laterality. There were no statistically significant sex differences in laterality distribution in children, and no differences according to laterality balance. There was no statistically significant difference in the performance of motor tests between the children with balanced and imbalanced laterality. Bala, Katić, & Mikalački[26] investigated the relationship between the socio-economic status of parents and morphological and motor dimensions of preschool children. They have established that the differences in biological growth and development and motor development recorded in preschool children from Voivodina, Serbia, should be attributed to hereditary (genetic) factor rather than environmental factors. Due to these reasons, current research did not include the indicators for assessing laterality in children and socio-economic status of their families.

Quantitative differences between the two experimental and the two control groups in the overall variable

TABLE 8
RESULTS OF MULTIVARIATE AND UNIVARIATE COVARIANCE ANALYSIS

Variable	E1		E2		C1		C2		f	q
	X	Se	X	Se	X	Se	X	Se		
20 m dash (0.1 s)	51.6	0.4	51.4	0.4	52.7	0.5	53.0	0.6	1.70	0.16
Obstacle course backwards (0.1 s)	204.1	6.61	211.3	6.7	248.7	7.1	231.3	9.1	6.17	0.00
Arm plate tapping (freq.)	18.3	0.3	18.4	0.3	16.8	0.3	17.3	0.4	3.56	0.01
Seated straddle stretch (cm)	41.2	0.5	40.8	0.5	39.7	0.5	40.5	0.7	1.14	0.33
Standing broad jump (cm)	121.8	1.5	123.2	1.6	115.9	1.6	116.5	2.1	3.32	0.02
Bent arm hang (0.1 s)	147.7	10.2	131.1	10.5	129.9	11.1	113.9	14.2	1.25	0.28
Crossed-arm sit-ups (freq.)	23.3	.775	23.7	0.7	16.8	0.8	18.4	1.0	12.21	0.00
Raven's matrices (score)	22.6	0.5	22.9	0.5	21.3	0.5	21.9	0.7	1.26	0.28
F=2.99, Q=0.00										

space in the initial measurement were statistically significant. All variables contributed to the significance except for the Seated straddle stretch and Crossed-arms sit-ups variables. There were no statistically significant differences between the experimental groups in any variable, as well as between the control groups. However, there were significant differences between experimental and control groups in all variables, except in the Seated straddle stretch and Crossed-arms sit-ups variables. This can be attributed to the fact that experimental groups consisted of children whose parents, in most cases, believed their children to have good motor behavior and wanted their children to undergo the additional kinesiological treatment, as opposed to children in the control groups who participated only in everyday activities at home and in kindergarten.

It is known that motor functioning in children, as well as intellectual (cognitive), is one of general type, and for that reason, the structure of general motor factor was defined as the first principal component of the intercorrelation matrix of all analyzed variables in the respective groups of children. Such qualitative analysis indicates a better structure of the general factor in the experimental groups, both in the percentage part of the common variance and in the size of the coefficient of correlation between the variables and the general factor. Attention must be drawn to the fact that the variable assessing intellectual functioning fits completely into the structure of the general motor factor and builds a truly unique motor-cognitive structure. Naturally, this indicates the significant correlation between motor and cognitive abilities in children.

After the completion of the experimental treatment, multivariate analysis of variance has shown that a statistically significant quantitative difference exists among the groups of children in the overall set of variables. The difference occurs mainly because of the significant difference in the Obstacle-course backwards, Arm plate tapping, Standing broad jump and Crossed-arms sit-ups variables. The superiority of children in both experimental groups in relation to both control groups has contributed to that. However, in the context of these differences, it must be noted that children in the experimental group were significantly more successful in the performance of motor tests Arm plate tapping and Standing broad jump only in relation to the C1 group (developed below average), but not in relation to the C2 group (developed above average).

Analysis of differences in the structures of general factors in the final measurement indicates that there were no significant changes in comparison to the status in the initial measurement. This can be attributed to the usual biological, motor and intellectual development of children of this age. This certainly does not mean that the experimental program did not lead to improvement in motor and intellectual functioning of children in the experimental groups, but rather that the overall development of children in all groups occurred in a similar and regular pattern. It can be concluded that the application period of kinesiological activities in the experimental groups has been short and that a longer period is required in order to establish both statistically significant quantitative, and even more qualitative differences in motor and intellectual functioning of children. This conclusion refers to children of normal biological, motor and intellectual development, although it could also be applied in cases of mild mental disability[27].

After a more detailed analysis, it can be established that during the period in which the treatment was applied (6 months), the structure of the general factor has slightly weakened in all groups of children, which can also be attributed to the growth and development of older children. Namely, it is known that correlations between biological indicators of growth and development, motor and other abilities decline with age, which leads to the decrease of generality in motor and intellectual behavior of older children and adults[28].

The effects of the experimental treatment were determined based on the results of multivariate and univariate analyses of covariance, which showed a significant level of improvement in motor and cognitive functioning

of children in the experimental group of children with below average and above average development at birth. The improvement was established based on the status in the final measurement, but by neutralizing the effects of group differences recorded in the initial measurement, both in the overall variable set and in each individual variable in relation to all four groups of children. The results indicate that a statistically significant effect of improvement has been achieved in the overall variable set, which was contributed by values in all variables for both experimental groups, with statistically significant values occurring in the following variables: Obstacle course backwards, Arm plate tapping, Standing broad jump and Crossed-arms sit-ups. Therefore, even though the significance of differences between all four groups in the initial measurement has been neutralized by the applied statistical method, the superiority of the experimental groups was maintained until the end of kinesiological activities application, i.e. until the final measurement of motor and intellectual abilities of children. It is interesting that children with below average development at birth in the experimental group had even better results than children with above average development in the experimental group in the following variables: Obstacle-course backwards, Seated straddle stretch and Bent arm hang. However, the difference was not big enough to be statistically significant.

The benefits of participating in kinesiological activities and physical exercise in childhood, especially in kindergarten, can contribute to the children's readiness for school. Bala, Krneta & Katić[29] investigated the effects of the preschool attendance period on readiness for school and motor abilities of children in kindergartens in Novi Sad. The study has shown that the entire education and motor activities in kindergarten contribute significantly to readiness for school and improvement of motor abilities in children. In these aspects, the best results were recorded in children who attended kindergarten the longest and the worst in children who attended some preschool institution for merely one year before they started school. Furthermore, aberrant behavior of children can be significantly reduced by improving motor abilities through kinesiological activities and regular physical exercise, which was established by Bala, Katić and Krneta[30] during a nine-month experimental treatment on preschool children.

The obtained results indicate that there is a tendency of improvement of motor and intellectual functioning in children who were born with below average development according to the criteria set in this study. This improvement would probably have been more prominent if the experimental treatment with kinesiological activities had lasted longer. This suggests the necessity of kinesiological activities and regular physical exercise during early childhood for all children, but under expert guidance of kinesiologists in kindergartens, schools, sport clubs, as well as within families.

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G. Bala

University of Novi Sad, Faculty of Sport and Physical Education, Lovćenska 16, 21000 Novi Sad, Serbia
e-mail: gustavbala@yahoo.com

EFEKTI PRIMJENE KINEZIOLOŠKIH AKTIVNOSTI NA MOTORIČKO I INTELEKTUALNO FUNKCIONIRANJE DJECE U ODNOSU NA TIJELESNU KONSTITUCIJU PRI ROĐENJU

S A Ž E T A K

Pri rođenju djeca su različite tjelesne težine i dužine tijela, uvjetovane kako genetskim faktorima, tako i karakteristikama njihovog prenatalnog razvoja. Važno je analizirati da li se ove razlike koje su izražene pri rođenju, naročito one koje su ispod prosječnih vrijednosti, mogu poboljšati šestomjesečnom primjenom kineziološkihaktivnosti u toku djetinjstva. U tu svrhu provedeno je istraživanje na uzorku od ukupno 214 djece, 6,13±1,04 decimalnih godina (eksperimentalna grupa od 93 dječaka i 29 djevojčica, kontrolna grupa od 43 dječaka i 49 djevojčica), koji je bio podijeljen na po dva subuzorka primjenom K-mean klaster analize na osnovu tjelesne težine i dužine pri rođenju djece. Formirani subuzorci su u odnosu na prosječne vrijednosti primijenjenih varijabli definirani kao grupe djece rođena ispodprosječno i iznadprosječno razvijena. Motorički status djece procijenjen je primjenom baterije od 7 standardnih motoričkih testova, a intelektualni primjenom Ravenovih progresivnih matrica u boji. Kvantitativni efekti primijenjenog kineziološkog tretmana analizirani su na osnovu inicijalnog i finalnog stanja malih ispitanika u ispitivanim varijablama multivarijatnom analizom varijanse i kovarijanse. Kvalitativne razlike definirane su rezultatima faktorskih analiza. Utvrđeno je da ne postoji statistički značajna razlika između dječaka i djevojčica u prostoru varijabli na inicijalnom mjerenju, a u odnosu na eksperimentalnu i kontrolnu grupu, pa je uzorak dalje tretiran kao cjelokupni uzorak djece. Efekti eksperimentalnog tretmana pokazali su značajno poboljšanje motoričkog i intelektualnog funkcioniranja djece u eksperimentalnoj grupi djece ispod i iznad prosječne razvijenosti pri rođenju.