Coll. Antropol. **25** (2001) 1: 153–165
UDC 572.5:796.015-053.5
Original scientific paper

Effect of Specially Programmed Physical and Health Education on Motor Fitness of Seven-Year-Old School Children

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A B S T R A C T

The efficacy of specially programmed physical and health education on the motor development of first-grade pupils was analyzed in a sample of 633 children aged 7 years. Pupils have been divided into control group consisting of 140 boys and 137 girls attending standard program of physical and health education, and in experimental group consisting of 184 boys and 172 girls attending specially programmed physical and health education. A battery of 12 motor tests has been used on two occasions separated by nine -month interval. Analysis of time-changes (by using the model of differences) pointed to the significantly greater quantitative changes in experimental group compared with control group of children. In boys, the changes are obtained for the tests of aerobic endurance, static strength, flexibility, speed, explosive strength of sprint and throw type, and equilibrium, and in girls, they are for aerobic endurance, static strength, explosive strength of throw and sprint type, flexibility, repetitive strength, speed, and equilibrium.

Introduction

The growth and maturation are influenced by the interaction of genetic, hormonal, dietary and environmental factors[1,2]. Enhanced physical activity is one of the environmental factors with favorable impact on the growth and maturation. The use of physical activity during the period of growth results in significant changes in anaerobic strength and aerobic capacity[3–5]. Exercise has a beneficial impact on the development of oxygen consumption[6] as well as on aerobic and muscular strength, aerobic capacity, coordination and muscular endurance[7–9].

Specially programmed physical and health education, predominated by elements of athletic sports, introduced in

Received for publication July 21, 2000.

first grade, significantly influences the development of aerobic endurance, flexibility, explosive, static and repetitive strength, and equilibrium in girls[10], and of aerobic endurance, flexibility, static strength, sprint and equilibrium in boys[11].

In young school children, motor capacities improve homogeneously and continuously as a function of age and sex, and are characterized by gradual neuromuscular maturation and development of basic models of movement (walking, running, jumping) as early as preschool age. Once the basic movement structures have been adopted (about the age of 6), in addition to the child's developmental characteristics, physical activity becomes a significant factor influencing the development of the child's fitness. Between the age of 6 and 8, most neural structures approach those found in adults, while basic motor fitness has already been well developed, thus providing preconditions for differentiation of latent motor dimensions[12,13].

The aim of this study was to assess the effects that could be achieved in basic motor fitness by the implementation of programmed physical and health education including various elements of athletic sports, gymnastics and sports games.

Material and Methods

The sample of this study encompassed 633 children, 324 boys and 309 girls, all first-grade pupils, aged 7 years. They have been divided in two groups: the control group included 140 boys and 137 girls, while the experimental group included 184 boys and 172 girls. Control group subjects attended physical and health classes performed according to the current educational program (Program A, see Figure 1), whereas experimental group subjects attended physical and health classes performed according to the specially designed program that was primarily focused on the elements of athletic sports and gymnastics (Program B, see Figure 2).

The physical and health education classes, attended by the experimental groups of children, were so programmed as to include, in the form of play, various athletic, gymnastic and sports game exercises in addition to the current educational plan and program. Data were collected in Split (Croatia), a city in Central Dalmatia, with a population of 250,000. The measurements and treatment were performed by qualified professionals, under the project team surveillance. The study sample included 7-year-old pupils of both sexes, at the beginning of their intensive educational treatment.

The curriculum of the specially programmed physical education classes was based on the estimated morphological and motor status of children at their initial state[14–17]. The training performed within regular classes was of a varying orientation (e.g., strength, speed, endurance, etc.), with distribution of discontinued load. Each microcycle corresponded by its duration to a week in which one decrease followed two increases in the load, i.e., their ratio was 2:1. The experimental groups of children completed the plan of physical and health education as presented in Table 1.

The variables for motor status assessment were so chosen as to be representative for the latent dimension of the motor functioning model described by Gredelj et al.[18] and/or the model reported by Kurelić et al.[19]. Tests for observation and evaluation of the elementary school pupil motor characteristics in the Republic of Croatia proposed by Mraković et al.[20] were supplemented by additional five motor tests[21]. Each individual motor test is valid and has been used in numerous motor studies[13–16].

ATHLETICS

Walking and running

1 forming into rank, single file and circle,
2 various types of walking and running,
3 cyclic movement at a varying pace for < 1 min,
4 walking along hurdles (lines, benches, log),
5 fast running < 20 m.

Jumping

6 hopping at mixed support along a bench, log,
7 jump over horizontal hurdles,
8 jump over low hurdles < 25 cm in height,
9 full-step jump onto a platform of < 30 cm with various landing,
10 straight-running high jump with left and right leg.

Throwing and catching

11 throwing a ball straight from the spot,
12 throwing light objects over vertical hurdles,
13 various types of high toss with catching the ball,
14 various type of bouncing with catching the ball.

Climbing, crawling and skipping

15 climbing onto low natural and artificial hurdles (< 80 cm)
16 climbing up and down wall bars
17 crawling and skipping beneath the rope, branches, fellow performers,
18 crawling with carrying light objects.

Weightlifting and weight carrying

19 lifting and carrying a medicine ball or stuffed bags (< 2 kg) in various ways,
20 lifting objects of < 2 kg to a certain height (< 1.5 m),
21 lifting and carrying objects of various size (< 5 kg) in twos.

Rolling and walkover

22 sideward roll on a horizontal support, leftward and rightward,
23 sideward roll on a slanted support, leftward and rightward,
24 forward walkover on the floor and walking along the line, bench, beam, log (in continuation), forward walkover on a slanted support.

Hang and support

25 mixed facing hang (grasping one bar while hanging the legs on another one),
26 mixed side hang (hanging on the same bar with both hands and legs),
27 mixed supports (moving 'on all four') on walking, running and hopping,
28 brief group mixed hangs and supports on natural and artificial hurdles.

Dancing structures

29 walking, running, hopping and sliding, accompanied by music, recitation, and instrumental background,
30 reproducing rhythm by hand clapping.

Games

31 elementary games with running, jumping and throwing,
32 relay games,
33 water games (to get used to water),
34 snow games (with walking, running, jumping and targeting).

General preparatory exercises

35 preparatory exercises with and without accessories (bags, rope, etc.) are used to stimulate muscular strengthening, stretching, relaxation and loosening, especially of the plantar and trunk musculature.

Fig. 1. Program (A) of kinesiologic activities in physical and health education in the control group of first-grade children (official curriculum).

ATHLETICS

Walking and running

36 walking at a varying pace,
37 walking on tiptoes, across the heel, on the inner and outer side of the foot,
38 walking and running while changing direction,
39 running at a moderate pace for < 3 min,
40 fast running < 20 m starting from various positions,
41 fast running < 30 m from high and low starting position.

Jumping and vaulting

42 short- and long-rope skip and criss-cross skip,
43 jump onto and from a 40-cm platform,
44 running over 40-cm hurdles,
45 long jump,
46 running long jump from take-off board with landing onto a thick mat
47 left- and right-sided running high jump, scissors technique

Throwing

48 throwing 200-g ball with a swing above the head, from the spot and 3–4 m running,
49 ball targeting from different positions from a distance of < 4 m,
50 throwing a medicine ball of < 1 kg with both hands,
51 throwing a ball with both hands, with forward-backward swinging above the head,
52 throwing a ball with one hand over the head.

GYMNASTICS

Floor exercises

53 sideward roll,
54 forward roll,
55 backward roll,
56 combined forward and backward roll,
57 transfer with leap from crouch with front support to front support and *vice versa*,
58 supports on the floor, and on natural and artificial obstacles (e.g., branch, pole, ladder, horizontal bar, parallel bars, rings, etc.),
59 flying roll with landing onto a thick mat,
60 assisted handstand.

Apparatus exercises

61 walking along an inversely placed bench with a 180° turn,
62 hang on natural and artificial obstacles (e.g., branch, pole, ladder, horizontal bar, parallel bars, rings, etc.),
63 swinging on rings with running.

Vaulting

64 jumping onto a box and buck with kneeling and crouch front support and landing,
65 flying over a buck (< 80 cm in height).

GAMES

Basic techniques of sports games

66 catching and throwing the ball,
67 bouncing the ball,
68 high throwing off and passing the volleyball,

Elementary and relay games

69 elementary games with running, jumping, throwing, catching and targeting,
70 relay games with and without accessories.

Team games

71 dodge-ball.

GENERAL PREPARATORY EXERCISES

72 preparatory exercises with and without accessories (bar, ball, rope, medicine ball, etc.) are used to stimulate the development of muscular mass and motility of joints, to strengthen connective tissue, and to influence the development of strength factors (especially explosive strength), coordination, flexibility and aerobic endurance.

Fig. 2. Program (B) of kinesiologic activities in physical and health education in the experimental group of first-grade children.

TABLE 1
CURRICULUM OF PHYSICAL AND HEALTH EDUCATION IN EXPERIMENTAL GROUP OF FIRST-GRADE CHILDREN

Contents of work	Month										Total hours
	IX	X	XI	XII	I	II	III	IV	V	VI	
Measurements	4									4	8
ATHLETIC SPORTS											
Walking and running	1	2	1	1	1	1	1	2	1		11
Jumping	1	2	1	1	1	1	1	1	1		10
Throwing		2	1	1	1	1	1	1	1		9
GYMNASTICS											
Exercises on the floor	1	2	2	1	1	1	1	2	1		12
Exercises on the gadgets		1	2	1	1	1	1	1	1		9
Leaps		1	2	1	1	1	1	1			8
GAMES											
Basic techniques of sports games		1	1	1	1	1	1	1	1		8
Elementary games	1	1	1			1		1		1	6
Relay games	1		1	1	1		1	1	1		7
Team games				1	1	1	2	1	2	1	9
COMPETITIONS											
Competition in gymnastics						1			1		2
Competition in dodge-ball						1			1		2
Competition in athletics								2		2	4
Preparatory exercises	Every hour										
Total hours	9	12	12	9	9	11	12	12	11	8	105

Note: Duration of individual education elements is expressed in periods, by multiplying the frequency and duration for each individual education element in separate.

A battery of 12 motor tests was used in both subgroups of children twice at a nine-month interval. The variables were so chosen as to best estimate the basic motor abilities. The following variables were used:

1. sidesteps to estimate coordination/agility (the task was to cover as quickly as possible, at the »go« signal, a 4-m distance by aside step-by-step alternately to both sides 6 times consecutively),
2. polygon backward to estimate coordination in resolving a complex motor task (the task was to cover a 10-m distance at the »go« signal by walking backward on all fours, passing across a low box and through the frame of the box, the results being recorded in tenths of a second),
3. bench standing to estimate balance, with the eyes open (the task was to maintain balance as long as possible, standing on two legs crosswise on a small bench balancing with eyes open and both arms down along the body, the results being recorded in tenths of a second),
4. forward bow to estimate flexibility (from the sitting position on the floor, where the legs were extended at an angle of 45°, the subjects had to lean forward as deep as possible, so that the tips of their fingers of the clasped hands

glided along a meter on the floor, the result being the distance from the original touch, i.e. from zero until the ultimate touch recorded in centimeters),

5. plate tapping (hand) to estimate psychomotor speed (the task was to touch, within 15 s, both panels on the tapping board alternately by finger as quickly as possible, the result being the number of cycles, where each cycle represented touching of both round panels),
6. leg tapping to estimate speed (frequency of movements); (the task was to move the leg from one to the other side of the compartment as quickly as possible, within 15 s, touching the horizontal board of the pedestal by the anterior part of the foot, the result being the number of alternate strokes of the foot upon the horizontal board),
7. standing broad jump to estimate the explosive strength of the jump type (the task was to jump from the spot forward as far as possible, the result being recorded in cm),
8. throwing ball to estimate the explosive strength of throwing type (the task was to throw a small, 200-g ball over one's own head as far as possible, the result being recorded in dm),
9. 20-m run to estimate the explosive strength of running type (the task was to cover, from a high start, a 20-m distance at a maximal speed, the result being recorded in tenths of a second),
10. sit-ups to estimate the repetitive strength of the body (the task was to make as many lifts of the body as possible from the supine position with legs at 90°),
11. bent arm hang to estimate the static strength of the arms (the task was to endure as long as possible hanging by arms with the chin above the bar, the result being recorded in s), and
12. 3-m run to estimate aerobic endurance (the task was to run as far as possible in 3 min, the result being recorded in m).

In accordance with the aim of the study, results of the first and second measurement were processed by use of the SSDIF algorithm and program[18], based on discriminant and factor analysis. All data on univariate differences at a particular time point were processed by univariate analysis of variance (ANOVA). Differences between time points were processed by univariate analysis for dependent samples, multivariate analysis of variance (MANOVA) and multivariate discriminative analysis of dependent samples (SSDIF). SSDIF is a procedure which, in a model of differences between two states, analyzes the significance of quantitative changes in an entity sample that has been described in a group of quantitative variables with normal multivariate distribution, by final discriminative analysis of changes[22].

Results

Comparison of the mean values of the variables measured on the first and second measurement suggested that the motor variables must have significantly changed in the study children of both sexes (Table 2). This points to an intensive development of motor fitness in boys and girls at the age of 8, being especially pronounced in case of aerobic endurance, coordination, and all strength and flexibility factors.

Analysis of variance revealed significant sex differences for individual motor tests between the values determined at the beginning and at the end of first grade (Table 2). At the beginning of the academic year, boys had significantly better results in the tests of explosive strength, coordination (especially in polygon back-

TABLE 2
MEAN VALUES (SD) OF MOTOR VARIABLES MEASURED TWICE IN BOYS AND GIRLS

Variable measurement	Boys (n = 324)				Girls (n = 309)			
	1		2		1		2	
Sidesteps (s)	16.3	2.1	14.2	1.6	16.7	2.0 [b]	14.6	1.5 [b]
Polygon backward (s)	22.9	6.2	16.9	4.0	26.6	7.6 [c]	19.6	4.7 [c]
Bench standing (s)	1.8	0.7	2.1	0.8	1.7	0.8	2.20	0.8
Forward bow (cm)	36.9	8.5	40.2	8.2	41.3	7.9 [c]	45.5	8.6 [c]
Hand tapping (taps/min)	19.2	2.8	21.3	2.6	18.7	2.4 [a]	21.4	2.7
Foot tapping (taps/min)	15.7	1.9	17.4	1.9	15.9	1.7	17.9	1.9 [c]
Standing jump (cm)	113.1	17.4	129.4	17.1	103.8	17.3 [c]	118.9	16.6 [c]
Ball throw (m)	10.6	3.1	12.3	3.3	7.1	1.9 [c]	8.3	2.3 [c]
20-m run (s)	4.9	0.4	4.6	0.4	5.1	0.5 [c]	4.7	0.4 [c]
Sit-ups (*per* min)	21.7	6.3	26.9	6.1	20.4	6.5 [a]	25.4	6.2 [b]
Bent arm hang (s)	10.9	9.5	18.8	12.5	9.8	8.0	16.7	10.8 [a]
3-min run (m)	440.9	59.9	506.8	67.7	418.8	63.4 [c]	477.8	64.6 [c]

Significant differences between boys and girls are denoted as: [a]=$p < 0.05$; [b]=$p < 0.01$; [c]=$p < 0.001$.

ward) and aerobic endurance (3-min run), and to a lesser extent in the tests of hand tapping and repetitive trunk strength (sit-ups), while girls achieved significantly better results in the test of flexibility. At the end of the academic year, the differences between the boys and girls slightly increased, so that boys showed better results in the tests of explosive strength, coordination, aerobic endurance, and repetitive and static strength, whereas girls produced better results in the tests of flexibility and leg tapping. Accordingly, sex differences in motor fitness recorded at the beginning of the academic year generally persisted to the end of the academic year, suggesting that the lower development of strength, coordination and endurance abilities in girls must have occurred before their first-grade enrolment.

Favorable changes from the initial to the final condition were recorded for all motor variables in both control and experimental groups of children. However, these changes were significantly more pronounced in the experimental groups, as indicated by the analysis of variance between the first and second measurement and by variable differences for both boys (Table 3) and girls (Table 4). Programmed physical and health education was observed to have a very favorable effect on the development of aerobic endurance and static strength of arms and shoulder region and/or muscular endurance, flexibility, psychomotor speed, explosive strength of the sprint and throw type, and balance in boys. In girls, the same was recorded for the development of both aerobic and muscular endurance, explosive strength of the sprint and throw type, flexibility, repetitive strength of the trunk, psychomotor speed, and balance.

The training used in the study was found to have a greater impact on the motor abilities known to depend on the process of conditioning (i.e. endurance, flexibility and strength factors) than on the mainly congenital motor abilities (i.e. psychomotor speed and coordination). As expected, greatest differences in changes between the two groups were recorded for the variable of aerobic endurance for both sexes, confirming the hypothesis that the transport system for oxygen and muscular metabolism extraction is a predominant and desirable alteration, as an array of

TABLE 3
MEAN VALUES (SD) OF MOTOR VARIABLES MEASURED TWICE IN BOYS FROM THE CONTROL AND EXPERIMENTAL GROUP, AND THE STRUCTURE OF DISCRIMINANT FUNCTION (F) OF ; MEASUREMENT 2 – MEASUREMENT 1

Variable measurement	Control group (n = 140)				Experimental group (n = 184)				F
	1		2		1		2		
Sidesteps (s)	16.1	2.1	14.2	1.8	16.4	2.2 [c]	14.1	1.7	–0.46
Polygon backward (s)	23.4	7.5	17.4	4.7	22.7	5.7	16.3	3.9 [a]	–0.49
Bench standing (s)	1.8	1.0	2.0	1.0 [d]	1.6	0.9	2.3	0.9 [a]	0.18
Forward bow (cm)	36.4	8.3	37.3	7.1 [d]	37.1	8.9	42.4	8.6 [c]	0.30
Hand tapping (taps/min)	19.8	3.2	20.8	2.4 [d]	18.6	2.6 [c]	21.7	2.8 [b]	0.35
Foot tapping (taps/min)	15.9	2.0	17.2	1.9 [d]	15.5	2.1 [a]	17.6	2.0 [a]	0.39
Standing jump (cm)	111.1	19.4	127.9	19.6	114.1	16.9	131.1	16.2 [a]	0.47
Ball throw (m)	10.7	1.9	12.0	3.7 [d]	10.4	3.1	13.0	3.3	0.35
20-m run (s)	5.0	0.5	4.7	0.4 [d]	4.9	0.5	4.5	0.4 [c]	–0.48
Sit-ups *(per* min)	22.0	7.0	25.1	6.6 [d]	21.5	5.8	28.2	5.5 [c]	0.39
Bent arm hang (s)	12.7	11.7	14.0	9.9 [d]	9.6	7.2	22.4	13.0 [c]	0.29
3-min run (m)	449.3	50.6	474.8	61.4 [d]	435.1	65.3	531.3	61.9 [c]	0.52

Significantly different from the respective value in the control group: [a]=$p<0.05$; [b]=$p<0.01$; Significant within-group differences ( ): [c] = $p < 0.05$; [d] = $p < 0.01$.

TABLE 4
MEAN VALUES (SD) OF MOTOR VARIABLES MEASURED TWICE IN GIRLS FROM THE CONTROL AND EXPERIMENTAL GROUP, AND THE STRUCTURE OF DISCRIMINANT FUNCTION (F) OF ; MEASUREMENT 2 – MEASUREMENT 1

Variable measurement	Control group (n = 137)				Experimental group (n = 172)				F
	1		2		1		2		
Sidesteps (s)	16.2	2.1	14.6	1.7 [d]	17.1	2.0 [c]	14.6	1.6	–0.48
Polygon backward (s)	27.5	8.3	20.5	5.0	26.1	7.6	18.6	4.6 [b]	–0.51
Bench standing (s)	1.8	1.2	2.0	0.9 [d]	1.5	0.8 [b]	2.2	1.0 [a]	0.17
Forward bow (cm)	40.2	7.8	41.9	7.4 [d]	42.1	8.0 [a]	48.4	8.6 [b]	0.35
Hand tapping (taps/min)	19.0	2.7	20.8	2.6 [d]	18.4	2.5 [a]	21.9	2.9 [b]	0.47
Foot tapping (taps/min)	16.0	2.0	17.6	2.0 [d]	15.8	1.7	18.4	1.9 [b]	0.49
Standing jump (cm)	102.8	17.0	116.5	16.2 [c]	104.1	19.0	121.2	17.8 [a]	0.54
Ball throw (m)	7.2	1.9	7.6	2.3 [d]	6.9	2.1	9.1	2.4 [b]	0.32
20-m run (s)	5.1	0.5	4.9	04 [d]	5.1	0.5	4.6	0.4 [b]	–0.49
Sit-ups (*per* min)	21.2	7.2	23.9	6.6 [d]	19.7	5.8 [a]	26.7	5.6 [b]	0.42
Bent arm hang (s)	10.6	8.6	12.1	8.7 [d]	9.3	7.4	20.4	11.0 [b]	0.35
3-min run (m)	433.1	54.1	452.9	55.2 [d]	407.3	67.9	497.5	64.5 [b]	0.50

Significantly different from the respective value in the control group: [a] = $p < 0.05$; [b] = $p < 0.01$; Significant within-group differences ( ): [c] = $p < 0.05$; [d] = $p < 0.01$.

abilities scheduled to be influenced upon will depend on it[10]. Accordingly, the kinesiologic treatment used during an academic year had a significant impact on the overall motor status of both boys and girls.

Based on Mahalanobis measuring distance and F-test (Table 5), the hypothesis on the first and second measurement equality in the multivariate motor area in all groups was rejected. Changes were

TABLE 5
MULTIVARIANT AND UNIVARIANT TESTS OF HYPOTHESES ON DIFFERENCES BETWEEN MEASUREMENTS (2:1) IN BOYS AND GIRLS

Multivariant differences	Boys			Girls		
	Experim.	Control.	Exp.+ Cont.	Experim.	Control.	Exp.+ Cont.
Mahalanobis dist.	2.92	4.26	5.66	22.46	3.49	5.11
Hotelling T test	536.36	596.66	1833.14	3862.79	478.38	1578.73
F-test difference	42.01	45.79	147.56	301.19	36.64	126.86
DF 1	12	12	12	12	12	12
DF 2	172	128	312	160	125	297
p	0.00	0.00	0.00	0.00	0.00	0.00
Partial differences	F(EXP)	F(CON)	F(E+C)	F(EXP)	F(CON)	F(E+C)
Sidesteps (s)	122.71 [c]	126.01 [c]	393.97 [c]	310.49 [c]	100.93 [c]	360.72 [c]
Polygon backward(s)	147.05 [c]	137.92 [c]	440.49 [c]	343.08 [c]	128.80 [c]	440.63 [c]
Bench standing (s)	45.94 [c]	3.90 [a]	58.03 [c]	77.59 [c]	1.84	377.12 [c]
Forward bow (cm)	45.79 [c]	7.26 [b]	160.70 [c]	236.21 [c]	28.09 [c]	194.47 [c]
Hand tapping (taps/min)	123.27 [c]	23.16 [c]	223.47 [c]	285.60 [c]	91.80 [c]	348.47 [c]
Foot tapping (taps/min)	95.44 [c]	59.84 [c]	281.22 [c]	411.33 [c]	94.93 [c]	384.87 [c]
Standing jump (cm)	91.18 [c]	147.32 [c]	412.34 [c]	409.25 [c]	129.77 [c]	461.18 [c]
Ball throw (m)	49.48 [c]	35.72 [c]	229.76 [c]	324.53 [c]	6.07 [a]	163.92 [c]
20-m run (s)	149.22 [c]	99.33 [c]	419.99 [c]	474.68 [c]	71.18 [c]	377.12 [c]
Sit-ups (*per* min)	131.47 [c]	29.79 [c]	277.52 [c]	490.87 [c]	30.15 [c]	276.60 [c]
Bent arm hang (s)	157.66 [c]	2.22	156.31 [c]	485.46 [c]	4.67 [a]	198.69 [c]
3-min run (m)	311.12 [c]	45.53 [c]	496.59 [c]	908.10 [c]	38.46 [c]	395.91 [c]

F-test of differences in variables (F) and their significance: [a] = $p < 0.05$, [b] = $p < 0.01$, [c] = $p < 0.001$.

especially pronounced in the experimental group of girls. Partial F-tests of between--measurement differences indicated that changes have occurred in all variables in both sexes, being more pronounced in the experimental group of girls.

Accordingly, the variables for the assessment of aerobic endurance, co-ordination and explosive strength, then the variables for the assessment of speed, repetitive and static strength, and flexibility exerted an identical impact on the discriminative function of between-measurement differences in the total sample of male children (Table 6). A comparably high impact of the variables for the assessment of co-ordination, aerobic endurance, psychomotor speed, all strength factors, and flexibility was recorded in the total sample of female children. The treatment was especially efficient in girls (Table 5), characterized by a lower initial condition due to the traditionally inadequate physical activity as compared with boys (Table 5). This contributed to the uniform discriminative function structure in the experimental group of girls (Table 6), giving rise to a presumption that they had experienced qualitative modifications in their motor functioning (which, however, could not be exactly verified by these analyses).

Discussion

The results of the present study showed that the development of motor fitness follow a similar pattern in 8-year old boys and girls. However, this study is also

TABLE 6
STRUCTURE OF THE DISCRIMINANT FUNCTION OF VARIABLES DIFFERENCES (F) OF MEASUREMENT 2 – MEASUREMENT 1 IN BOYS AND GIRLS

Variable	Boys			Girls		
	F(EXP)	F(CON)	F(E+C)	F(EXP)	F(CON)	F(E+C)
Sidesteps (s)	–0.48	–0.46	–0.46	–0.28	–0.46	–0.48
Polygon backward(s)	–0.52	–0.48	–0.49	–0.30	–0.52	–0.51
Bench standing (s)	0.29	0.18	0.18	0.14	0.06	0.17
Forward bow (cm)	0.29	0.11	0.30	0.25	0.24	0.35
Hand tapping (taps/min)	0.48	0.20	0.35	0.28	0.44	0.47
Foot tapping (taps/min)	0.42	0.32	0.39	0.33	0.45	0.49
Standing jump (cm)	0.41	0.50	0.47	0.33	0.52	0.54
Ball throw (m)	0.30	0.24	0.35	0.29	0.11	0.32
20-m run (s)	–0.53	–0.41	–0.48	0.35	0.39	0.49
Sit-ups (*per* min)	0.50	0.22	0.39	0.36	0.25	0.42
Bent arm hang (s)	0.54	0.06	0.29	0.35	0.10	0.35
3-min run (m)	0.76	0.28	0.52	0.48	0.28	0.50

pointing to sex specificity in some characteristics. Sex differences in motor abilities occurring at preschool age (and even earlier in life) determine motor functions in first-grade children. Thus, boys prefer the use of strength on solving and performing motor tasks, while girls give preference to speed (and flexibility), i.e. the abilities potentially developed to a higher level.

The structure of discriminative function of variable differences between the two measurements indicated that complex changes of motor abilities occurred in both boys and girls at the age of eight, with a higher rate of development of flexibility, psychomotor speed and, to a certain extent, coordination in boys than in girls.

Flexibility is an ability that in this study greatly depended on three factors. First is obvious association of flexibility as a virtually motor ability with the domain of morphological dimensions. Second is its evident association (by no means infrequently inversely proportionate) with other abilities (e.g., strength). The third factor certainly are sex differences generated by a variety of causes, from the genetic to those related to lifestyle and unsystematic stimuli the children are exposed in their early life. Therefore, the flexibility results presented should be considered in this context. In both boys and girls, these changes are probably generated by a comparable physical activity practiced at school[3,10–12] and biological continuity of developmental functions[9,16,23].

The more so, as recent studies have shown, the stimulation of endurance development provides a basis for full development of other abilities in maturity[24]. It is necessary to take care of the fact that children are able to activate the aerobic mechanism of their body more easily than the anaerobic one, but also that the endurance training should be properly tailored to the children's physical abilities[25,26]. Other authors have support the above mentioned results comparing young adult female athletes, and concluded that the physical activity and level of physical fitness might be the main factors influencing the values of $\%VO_{2max}$ at VT during growth[6].

One of the studies compared an experimental group aged 7–12 years subject to an enhanced program of physical education with a control group on the standard school program[7]. The authors demonstrated that the children from the experimental program showed significant improvement in laboratory indices of aerobic power and muscle strength as compared with control subjects. These results were confirmed by gains in the scores for the field performance test battery of the Canadian Association for Health, Physical Education and Recreation[9]. They have also suggested an improvement in anaerobic power, coordination, and muscular endurance.

It is beyond doubt that programmed physical and health education has contributed considerably to the discriminative function structuring characterized by distinct sex specificities. The adaptation of children of both sexes to programmed physical and health education stimuli has resulted in specific changes mostly related to the energy component of movement, which is a valuable indicator of the desirable direction of programmed training for children at this age. Aerobic endurance enhancement appears to be the main basis of the development of other motor abilities that also are determined by the development of oxygen transport system, thus being the main objective of any training process. An oxygen transport system of a greater capacity would certainly influence the permeability for information and optimal movement realization, thus allowing higher levels of capacity to achieve. Finally, the potential occurrence of favorable adaptational changes effected by the treatment of appropriate intensity and volume must have produced common changes in all movements regulated by the facilitated effector permeability or control of excitatory activities of the nervous system, which mostly manifests in the explosiveness and frequency of movements.

The results showed that programmed physical and health education with elements of athletic sports and gymnastics considerably contributed to the changes in motor fitness. Therefore, the process of changes, i.e. development of motor abili-

TABLE 7
VARIMAX FACTORS OF INTERNAL STRUCTURE OF DIFFERENCES (V) AND CORRELATIONS OF DISCRIMINATIVE FUNCTION WITH VARIMAX FACTORS (C) IN BOYS AND GIRLS

Variable	Boys (324)					Girls (309)		
	V1	V2	V3	V4	V5	V1	V2	V3
Sidesteps (s)	0.02	–0.06	–0.03	0.04	0.85	–0.25	0.59	–0.16
Polygon backward(s)	0.00	–0.02	–0.05	0.90	0.03	0.05	0.74	0.07
Bench standing (s)	–0.03	–0.24	0.74	–0.25	0.08	0.52	0.33	–0.19
Forward bow (cm)	0.47	–0.18	0.40	0.16	–0.01	0.51	–0.13	0.05
Hand tapping (taps/min)	0.53	–0.03	0.05	0.00	–0.46	0.26	–0.17	0.52
Foot tapping (taps/min)	0.23	0.32	0.40	–0.11	–0.31	0.36	0.08	0.55
Standing jump (cm)	0.03	0.78	–0.11	–0.04	–0.06	–0.01	0.00	0.80
Ball throw (m)	0.61	–0.40	–0.17	–0.08	–0.03	0.56	–0.12	0.17
20-m run (s)	–0.47	–0.36	–0.04	0.38	0.11	–0.51	0.13	–0.15
Sit-ups (per min)	0.18	0.15	0.68	0.17	–0.15	0.50	–0.36	0.00
Bent arm hang (s)	0.57	0.29	0.25	0.06	0.32	0.64	0.01	0.14
3-min run (m)	0.78	0.11	0.14	–0.01	–0.02	0.68	–0.05	0.18
C	0.54	0.35	0.25	–0.44	–0.41	0.51	–0.54	0.57

ties appears to be most easily stimulated by high-quality kinesiologic stimuli and programmed training with appropriate loadings that provoke adaptation. This points to the importance of the physical and health education classes, which should be given an equal footing with other elementary school classes.

Varimax rotation of the main components of the difference correlation matrix yielded five factors, i.e. patterns in which changes induced by the treatment as well as by growth and general development manifested in the total sample of children (Table 7). Concerning the first varimax factor, the changes manifested through a number of inter-related, i.e. conditioned basic motor abilities, which make the basis of a quality level motor functioning. These are: aerobic and muscle endurance, throwing and sprint explosive strength, psychomotor speed, and flexibility. The second varimax factor is responsible for the changes in jumping explosive strength, accompanied by changes in the explosive strength of running, frequency of lower extremity movements, and static strength (in positive direction), and by changes in the explosive strength of throwing (in negative direction). The third varimax factor is responsible for equilibrium changes, which is closely related with changes in the trunk repetitive strength, and to a lesser extent with movement frequency of lower extremities and flexibility.

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UČINAK PROGRAMIRANE TJELESNE I ZDRAVSTVENE EDUKACIJE NA TJELESNU SPOSOBNOST SEDMOGODIŠNJE ŠKOLSKE DJECE

S A Ž E T A K

Djelotvornost posebno programirane tjelesne i zdravstvene edukacije na razvoj motorike u učenika prvog razreda osnovne škole analiziran je na uzorku od 633 djece, dobi 7 godina. Učenici su podijeljeni u dvije skupine: kontrolnu u kojoj je sudjelovalo 140 dječaka i 137 djevojčica koji su pohađali standardni program tjelesne i zdravstvene edukacije, te eksperimentalnu skupinu u kojoj je sudjelovalo 184 dječaka i 172 djevojčice koji su pratili posebno programirani program tjelesne i zdravstvene edukacije. Djeca su testirana na početku testiranog perioda, te nakon 9 mjeseci a korištena je baterija od 12 testova motorike. Analiza promjena (korištenjem modela razlika) ukazala je na značajno veće kvantitativne promjene u eksperimentalnoj skupini u usporedbi s kontrolnom skupinom djece. U dječaka, promjene su se odnosile na: test aerobne izdržljivosti, statičke snage, fleksibilnosti, brzine, eksplozivne snage (trkačkog i bacačkog tipa) i u ravnoteži, dok su se u djevojčica one odnosile na: test aerobne izdržljivosti, statičke snage, eksplozivne snage (trkačkog i bacačkog tipa), fleksibilnosti, repetitivne snage, brzine, te u ravnoteži.