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Development of Biomotor Characteristics and Sprint and Throw Athletic Abilities in Six- to Eight-Year-Old Girls

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A B S T R A C T

The aim of the study was to assess the effect of programmed physical education on biomotor changes in girls, and the impact of these changes on relations between the set of morphological and motor variables, and athletic variables evaluating the sprint and throw abilities. Study sample included 310 six- to eight-year-old girls, elementary school first-graders from the Split area, divided into control group (n=138) attending regular physical education classes and experimental group (n=172) attending programmed physical education classes based on the elements of athletics, apparatus gymnastics, games and general preparatory exercises. Relations between the predictor set of variables consisting of 4 morphological measures and 6 motor tests, and the sprint and ball throw criteria were determined by regression correlation analysis at the beginning and at the end of the academic year. Both groups achieved favorable quantitative result improvement between the two measurement points, however, the improvement was considerably more pronounced in experimental group, especially in the motor abilities of coordination, flexibility, movement frequency, and explosive, repetitive and static strength. On final measurement, the number of significant predictors for the criterion variables of sprint and ball throw increased from the initial measurement in both experimental and control group of subjects. In control group, trunk strength, explosive strength and movement frequency as motor abilities and body height as a morphological characteristic were found to be the best result predictors in sprint. In experimental group, coordination, flexibility, static arm strength and trunk strength as motor abilities were the best result predictors in sprint. In the study sample as a whole, explosive strength and trunk strength were identified as the best predictors of ball throw as a criterion variable. In experimental group, it was accompanied by muscle mass development and adipose tissue reduction. Based on comparison of these results and those obtained in previous studies, a new model of work in the athletics events of sprint and throw in elementary school physical education is proposed.

Key words: *biomotor development in girls, athletic abilities, kinesiologic education*

Introduction

Athletic aptitude and appropriate training development of the existing athlete's abilities are two main preconditions for top achievement in sports. Therefore, overall athlete development and preparation are a complex process where the issue of top achievements is not only based on exploration and identification of ever newer and more efficient training methods (which are being increasingly harmonized in spite of some disagreements concerning particular problems related to their improvement), but also on the search for talented individuals for particular sports events.

Nowadays, top results are being achieved at an ever younger age, thus imposing the need to introduce systematic training considerably earlier than before, i.e. at the age of 6–8 years. Children should be steered towards the events that fit best their mental and physical characteristics. The training provided at sports schools should be so planned for the young athletes to acquire as many basic motor structures of movement as possible in the first two years on an average, while at the same time influencing the development of their basic motor and functional abilities. It is definitely a very important period of

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elementary education and one of the most relevant periods in the child's phylogenesis considering growth and development. At this age, anthropologic status has not yet been fully structurally defined, thus there many potential options to influence the development[1–3], primarily by use of programmed and controlled kinesiologic treatment[4,6].

Travin and Suslov (1989)[7] consider that children should come in contact with organized sports activity in athletics at age 7–10 years, while steering towards particular athletics events should occur at age 12 (Šnajder, 1990)[8].

In Croatian educational system, a standard battery of 10 variables has been used on assessment of the children's morphological and motor status[9–13]. The morphological set consisting of only four variables has proved adequate to collect basic information on the characteristics of morphological development in children aged 7–11[11,14]. Developmental processes simply tend to establish optimal relationships among all somatotype elements-components. These relationships will determine motor efficiency through interactive connections between the morphological and motor systems. The set of motor variables is also appropriate to define motor status in children aged 7–11. Motor development is predominated by the formation of two mechanisms responsible for motor efficiency, i.e. mechanism of energy regulation and mechanism of movement structure manifestation. The former is mainly responsible for the energy component and the latter for the information component of movement. As performance of any movement and/or movement structure depends simultaneously on both energy and information components, there must be a central mechanism integrating the functions of both subordinated mechanisms.

Subjects and Methods

Study sample included 310 six- to eight-year-old girls, elementary school first-graders from the Split area, mean age 7 years ± 2 months on study entry. Study subjects were divided into control group (n=138) attending regular physical education classes and experimental group (n=172) attending programmed physical education classes based on the elements of athletics, apparatus gymnastics, games and general preparatory exercises during the academic year[6]. Thus, all study subjects received programmed kinesiologic transformation procedures for 9 months, measured at two time points (± 10 days). The purpose of these transformation processes was to support the children's biological growth and development, with special reference to the effect on their wide-spectrum motor abilities.

A standard battery of 10 variables currently used in the educational system of the Republic of Croatia was employed to assess the morphological, motor and functional status of the children. The battery of variables was suggested on the basis of a large study carried out by Kurelić et al. in 1975[9].

The morphological variables included body height (mm), body weight (dkg), forearm circumference (mm) and triceps skinfold (1/10 mm). The measures were taken according to the international biological program[15].

The motor variables included hand tapping (f), standing long jump (cm), polygon backward (s), sit-ups (f), forward bow (cm) and bent arm hang (s).

The specific motor variables used as criteria in the present study were chosen to indicate basic physical abilities of speed and strength, and to serve as representative values on assessment of the situation-motor athletic abilities of throw and sprint. The following athletic variables were applied:

- 20-m high start sprint (the task is to run the 20-m distance as fast as possible at the signal, the result being read in tenths of second), corresponding to sprint events in athletics; and
- distance ball throw (the task is to perform standing 200-g ball throw from above the head as far as possible, the result being read in decimeters), as a preparatory exercise corresponding most to the athletics event of javelin throw.

Results of numerous studies performed in elite track-and-field athletes at Olympic Games, European and World Championships have pointed to the high relevance of the basic morphological body structure[16–20]. These studies mostly employed the Heath-Carter's somatotype method for comprehensive description of the human body. The use of three components (endomorphy, mesomorphy and ectomorphy) has proved quite interesting to describe athlete characteristics. Such an approach provides an insight into the relationships of somatotype components according to particular athletics events, e.g., throwers are predominantly characterized by the mesomorph component with an average endomorph component, whereas runners are moderate mesomorphs, then ectomorphs with minimal endomorphic component, with sprinters showing a slight predominance of mesomorphy in comparison with middle-distance and long-distance runners.

Results of canonic analyses (Katić, 1996)[21] have revealed a generally negative correlation between adipose tissue and manifestation of athletic abilities of sprint, throw and long run in boys and especially in girls. Subcutaneous adipose tissue acts as ballast mass reducing the relative strength necessary for efficient sprint[22]. The role of relative strength in performing jumps and run has been reported by Ball et al. in 1992[20]. Abundant adipose tissue along with inadequate development of muscle tissue reduces the manifestation of motor abilities for athletics in male children and to an even greater extent in female children. Results have also shown that more pronounced muscle tissue without adipose tissue favors sprint performance, whereas ectomorphy with moderate mesomorphy and endomorphy favors throw performance. Delicate body build with a low proportion of all somatotype components is favorable for long run performance[21].

The development of morphological features and motor abilities in terms of situation-motor abilities for athletics is believed to proceed in parallel, with interactive or symmetric association between these two spaces. These concepts entailed the main aim of the present study, i.e. to assess the relationships between the set of morphological and motor variables, and athletic variables evaluating the sprint and throw abilities, appropriate for children aged 6–8 years. The results obtained will be used to develop a more efficient system of orientation and selection of children for athletics as a basic sports activity.

Regression correlation analysis was employed to solve the problem of relations between the set of anthropometric and motor variables, and particular situation-motor variable for athletics.

Results

The parameters of descriptive statistics pointed to a favorable quantitative result improvement in all morphological and motor variables from initial to final measurement in both experimental and control groups of subjects (Table 2). Analysis of variance yielded statistically significant between-group differences on initial measurement. Significant differences were recorded in the variables of hand tapping, trunk lifting to sitting position (sit-ups), and bent arm hang in favor of control group, and in the variable of forward bow in favor of experimental group (Table 1).

Analysis of variance on final measurement showed statistically significant between-group differences predominantly in the motor variables of bent arm hang, trunk lifting from supine position with bent legs (sit-ups), forward bow, hand tapping and polygon backward, and criterion variables of distance ball throw and 20-m high start sprint. All these variables defined the difference in favor of experimental group. Differences in morphological measures were less pronounced and referred to greater muscle mass in experimental group as compared with control group (Table 1).

TABLE 1
DESCRIPTIVE STATISTICS (Mean±SD) AND ANALYSIS OF VARIANCE (p)

Variable	Total (n=310)	Control (n=138)	Exp (n=172)	p
Initial measurement	Mean ± SD	Mean ± SD	Mean ± SD	
Stature (cm)	127.03 ± 5.37	127.19 ± 5.37	126.89 ± 5.39	
Body mass (kg)	26.12 ± 4.66	26.29 ± 4.49	25.98 ± 4.79	
Forearm circumference (cm)	17.60 ± 1.60	17.14 ± 1.42	17.96 ± 1.63	
Triceps skinfold (mm)	12.92 ± 3.99	12.78 ± 3.38	13.04 ± 4.42	
Polygon backward# (s)	26.63 ± 7.63	27.29 ± 7.96	26.10 ± 7.34	
Forward bow (cm)	41.27 ± 7.90	40.21 ± 7.74	42.12 ± 7.94	b
Hand tapping (taps/min)	18.73 ± 2.45	19.07 ± 2.56	18.47 ± 2.34	b
Standing long jump (cm)	103.83 ± 17.33	103.16 ± 16.18	104.37 ± 18.24	
Sit-ups (per minute)	20.38 ± 6.49	21.20 ± 7.17	19.73 ± 5.83	b
Bent arm hang (s)	9.83 ± 8.01	10.56 ± 8.60	9.25 ± 7.47	b
20-m run# (s)	5.11 ± 0.46	5.08 ± 0.43	5.13 ± 0.48	
Ball throwing (m)	7.10 ± 1.88	7.27 ± 1.74	6.96 ± 1.97	
Final measurement	Mean ± SD	Mean ± SD	Mean ± SD	
Stature (cm)	130.64 ± 5.65	130.43 ± 5.74	130.81 ± 5.59	
Body mass (kg)	28.95 ± 4.83	28.70 ± 4.74	29.15 ± 4.91	
Forearm circumference (cm)	18.43 ± 1.66	17.98 ± 1.47	18.79 ± 1.71	b
Triceps skinfold (mm)	12.21 ± 4.17	12.23 ± 4.02	12.19 ± 4.30	
Polygon backward# (s)	19.62 ± 4.71	20.63 ± 4.82	18.82 ± 4.47	a
Forward bow (cm)	45.49 ± 8.65	41.97 ± 7.40	48.32 ± 8.57	a
Hand tapping (taps/min)	21.38 ± 2.75	20.74 ± 2.51	21.90 ± 2.84	a
Standing long jump (cm)	118.88 ± 16.59	116.39 ± 15.62	120.87 ± 17.12	b
Sit-ups (per minute)	2544 ± 6.18	23.93 ± 6.59	26.65 ± 5.57	a
Bent arm hang (s)	16.73 ± 10.87	12.13 ± 8.68	20.42 ± 11.06	a
20-m run# (s)	4.73 ± 0.41	4.87 ± 0.39	4.61 ± 0.39	a
Ball throwing (m)	8.35 ± 2.34	7.58 ± 2.18	8.97 ± 2.29	a

#variable with opposite metric orientation, [a]$p<0.001$, [b]$p<0.05$

TABLE 2
REGRESSION ANALYSIS BETWEEN VARIABLES OF THE BIOMOTOR SPACE AND THE CRITERION VARIABLE (20-m run#)

Variable	Total (n=310)				Control (n=138)				Exp (n=172)			
	r	P-r	β	p	r	P-r	β	p	r	P-r	β	p
Initial measurement												
Stature	–0.01	–0.12	–0.16		–0.10	–0.11	–0.14		0.05	–0.13	–0.19	
Body mass	0.16	0.11	0.22	b	0.07	0.09	0.22		0.23	0.17	0.34	b
Forearm	0.10	–0.07	–0.11		0.04	–0.11	–0.21		0.12	–0.11	–0.15	
Skinfold	0.22	0.02	0.02		0.11	0.01	0.02		0.28	0.03	0.04	
Polygon#	0.28	0.09	0.09		0.24	0.11	0.10		0.33	0.13	0.13	
Forward	–0.08	–0.01	–0.01		0.03	0.14	0.13		–0.17	–0.13	–0.11	
Hand tap	–0.11	–0.03	–0.03		–0.09	–0.03	–0.03		–0.12	–0.02	–0.02	
Long jump	–0.45	–0.32	–0.34	a	–0.45	–0.35	–0.37	a	–0.46	–0.28	–0.31	a
Sit-ups	–0.21	–0.08	–0.07		–0.19	–0.08	–0.08		–0.21	–0.03	–0.03	
Bent arm	–0.28	–0.08	–0.08		–0.33	–0.13	–0.14		–0.25	–0.02	–0.02	
ρ			0.50	a			0.53	a			0.53	a
Final measurement												
Stature	–0.01	–0.12	–0.14		–0.06	–0.19	–0.23	b	0.04	–0.09	–0.12	
Body mass	0.12	0.10	0.18		0.08	0.13	0.24		0.18	0.06	0.13	
Forearm	–0.05	–0.12	–0.17	b	0.02	–0.07	–0.10		0.03	–0.11	–0.15	
Skinfold	0.22	0.06	0.07		0.08	–0.04	–0.05		0.35	0.14	0.18	
Polygon#	0.42	0.17	0.18	a	0.38	0.13	0.13		0.39	0.22	0.24	a
Forward	–0.30	–0.19	–0.17	a	–0.14	–0.06	–0.06		–0.26	–0.23	–0.20	a
Hand tap	–0.23	0.02	0.01		–0.37	–0.20	–0.19	b	–0.04	0.17	0.15	b
Long jump	–0.42	–0.13	–0.13	b	–0.43	–0.16	–0.17	b	–0.37	–0.10	–0.11	
Sit-ups	–0.42	–0.22	–0.21	a	–0.41	–0.27	–0.25	a	–0.36	–0.15	–0.14	b
Bent arm	–0.41	–0.17	–0.17	a	–0.27	–0.04	–0.04		–0.38	–0.18	–0.17	b
ρ			0.62	a			0.58	a			0.61	a

Total – (control + experimental group), Control – control group, Exp – experimental group, r – coefficient of correlation, P-r – coefficient of partial correlation, β – partial coefficients of regression, ρ – coefficient of multiple correlation, p – level of significance ([a]p<0.001, [b]p<0.01), #variable with opposite metric orientation

Both study groups showed quantitative improvement of results between the two measurement points, which was more pronounced in experimental than in control group. Thus, a statistically significant improvement of all study variables was achieved in both groups, experimental group in particular, confirming that specifically programmed physical education performed during one academic year significantly influenced quantitative changes in both motor abilities and desirable morphological features. Favorable changes were especially notable in the variables of polygon backward, standing long jump, trunk lifting from supine position with legs bent(sit-ups), bent arm hang, distance ball throw, and 20-m high start sprint.

Relations between the morphological-motor variables as a predictor set of variables and results on the athletic variables of sprint and throw as criteria are presented in Table 2 (sprint) and Table 3 (throw).

Table 2 shows results of regression analysis between the set of variables and sprint as a criterion at initial and final measurements for the control, experimental and total group of subjects (6 regression analyses in total). On each regression analysis, multiple correlation (ρ) was statistically significant, indicating the set of morphological-motor variables employed to be a good predictor of sprint performance in both study groups and study sample as a whole. On final measurement, predicting sprint performance improved significantly from the initial measurement in both subject groups. The transformation processes and the development itself led to inclusion of more basic motor abilities in the prediction of sprint performance.

On initial measurement, the variable evaluating explosive strength (standing long jump) was found superior in predicting sprint performance (P-r and Beta); in experimental group, total body mass had an even more significant but unfavorable effect on sprint performance.

On final measurement, the number of predictors for sprint as a criterion variable increased in both groups of subjects. In control group, sprint performance was best

TABLE 3
REGRESSION ANALYSIS BETWEEN VARIABLES OF THE BIOMOTOR SPACE AND THE CRITERION VARIABLE (Ball throwing)

Variable	Total (n=310)				Control (n=138)				Exp (n=172)			
	r	P-r	β	p	r	P-r	β	p	r	P-r	β	p
Initial measurement												
Stature	0.03	0.01	0.01		0.08	–0.05	–0.06		–0.02	0.06	0.08	
Body mass	0.02	0.03	0.07		0.13	0.14	0.36		–0.06	–0.05	–0.11	
Forearm	0.03	0.01	0.01		0.10	–0.08	–0.16		0.03	0.06	0.09	
Skinfold	–0.04	0.03	0.04		0.10	0.07	0.09		–0.12	0.03	0.04	
Polygon#	–0.26	–0.13	–0.13	c	–0.26	–0.22	–0.23	b	–0.27	–0.08	–0.09	
Forward	0.01	–0.08	–0.07		0.00	–0.15	–0.14		0.04	–0.03	–0.03	
Hand tap	0.26	0.20	0.19	a	0.19	0.16	0.15		0.29	0.22	0.21	a
Long jump	0.30	0.18	0.19	a	0.28	0.16	0.17	c	0.33	0.17	0.19	c
Sit–ups	0.28	0.19	0.19	a	0.23	0.18	0.17	c	0.32	0.18	0.19	c
Bent arm	0.17	0.06	0.06		0.17	0.08	0.08		0.16	0.05	0.05	
ρ			0.45	a			0.47	a			0.47	a
Final measurement												
Stature	0.13	0.06	0.07		0.13	0.11	0.13		0.12	0.07	0.09	
Body mass	0.08	0.05	0.09		0.06	0.09	0.18		0.08	0.05	0.09	
Forearm	0.16	0.09	0.12		–0.01	–0.12	–0.19		0.17	0.16	0.22	c
tblSkinfold	–0.09	–0.06	–0.08		–0.01	0.02	0.03		–0.15	–0.13	–0.18	
Polygon#	–0.32	–0.07	–0.08		–0.23	0.01	0.01		–0.33	–0.14	–0.15	
Forward	0.23	0.09	0.08		0.22	0.17	0.16	c	0.09	–0.07	–0.06	
Hand tap	0.27	0.06	0.06		0.29	0.14	0.14		0.19	–0.01	–0.01	
Long jump	0.46	0.27	0.29	a	0.37	0.20	0.22	b	0.49	0.32	0.36	a
Sit-ups	0.36	0.16	0.15	b	0.27	0.15	0.15	c	0.37	0.16	0.15	c
Bent arm	0.29	0.11	0.10		0.26	0.11	0.11		0.17	–0.03	–0.03	
ρ			0.57	a			0.50	a			0.59	a

Total – (control + experimental group), Control – control group, Exp – experimental group, r – coefficient of correlation, P-r – coefficient of partial correlation, β – partial coefficients of regression, ρ – coefficient of multiple correlation, p – level of significance ([a]$p<0.001$, [b]$p<0.01$, [c]$p<0.05$), #variable with opposite metric orientation

predicted by the motor abilities of trunk strength, explosive strength and movement frequency, and by the morphological characteristic of body height. In experimental group, the motor abilities of coordination, flexibility, static arm strength and trunk strength were best predictors of sprint performance. These quantitative changes in coordination, flexibility and strength factors found to be more pronounced in experimental group as compared with control group influenced different relations between the predictor set of variables and criteria; i.e. changes in the morphological-motor structure determining sprint performance occurred in experimental group but not in control group of subjects.

The latent structure, i.e. complexity of the criterion (sprint), in the morphological-motor space could be established on the basis of each individual variable correlation with the criterion. On initial measurement, the motor abilities of explosive strength, coordination, and static and repetitive trunk strength contributed significantly to the latent sprint structure. On final measurement, the correlations of predictor variables and the criterion increased, thus also enhancing their contribution to the latent sprint structure. This in particular applied to the development of integration of coordination and all strength factors, speed of movements and muscle tone regulation, which all taken together determine motor efficiency and thus also sprint performance.

Table 3 shows results of regression analyses between the predictor set of variables and ball throw as a criterion at initial and final measurements for the control, experimental and total group of subjects (6 regression analyses in total). The growth and development supported by kinesiologic transformation processes *via* physical education influenced in parallel the development of basic motor abilities and specific athletic throwing ability (ball throw). This resulted in better biomotor prediction of ball throw as a criterion variable on final measurement as compared with initial measurement. In total study sample, explosive strength and trunk strength were found to best predict ball throw as a criterion variable. In experimental group, it was accompanied by muscle mass development and adipose tissue reduction.

The latent structure of ball throw as a criterion variable was modified from initial to final measurement, i.e. the contribution of coordination and all strength factors to the latent criterion structure increased. Considering strength factors, strength of lower extremities, followed by trunk strength and strength of upper extremities contributed most to the latent throw structure, exactly following the sequence of muscle group activation on throw performance in athletics (e.g., javelin throw).

Discussion

Study results indicated an interactive association of the morphological and motor status with performance in the athletics events of sprint and throw in female children aged 6–8 years. These relations generally resemble those observed in elite sprinters and throwers. These athletics events require maximal energy generation, i.e. strength in a short period of time; in sprint, it is maximal relative strength associated with above-average active muscle mass, while in throwing events it is maximal absolute strength determined by total body mass. In particular developmental stage, a morphological-motor status level is achieved that limits sprint and throw performance through activation of the morphological-motor features potentially available to a higher extent in the individual. Thus, the sprint or throw performance is limited by the lack of particular characteristic and ability minimum and/or by the size of variability in the characteristics and abilities that predominantly determine performance in these athletics events. In this context, certain relations determining sprint and throw performance are also being established in relation to the specific morphological-motor status level. In this view, the experimental program of kinesiologic education used in elementary school female first-graders influenced the formation of anthropologic system optimal for performance of the sprint and throw athletics events at this age. The biomotor development of female children aged 6–8 years, which was predominantly induced by athletics procedures, was concordant with the mechanical characteristics of sprint and javelin throw, thus enabling identification of the stages of development of the morphological-motor status and of motor skill and abilities specific for athletics that proceed in parallel. The school of athletics for children aged 6–10 is usually organized in two phases, the first phase including elementary school first- and second-graders, and the second phase including third- and fourth-graders. These are followed by the phases of primary selection, for sprint at prepubertal age of 11–12 or elementary school fifth- and sixth-graders, and for throw including javelin throw at postpubertal age of 15–16 or secondary school first- and second-graders.

Sprint is in fact a simple, natural motor activity and is not difficult to perform in its elementary form. Top results are only expected to be achieved by the athletes that have better mastered technical preparation for running activity. Running technique is generally evaluated on the basis of the outer form of motion. Top technique does not only reflect a high level of technical preparation but also coordination of an array of psychophysical properties. On running, the arms perform compensatory movements together with other parts of the body. On faster run, the amplitudes are higher than on slower run. The arms move relaxing, without major exertion. Trunk positioning on running is crucial and should not exceed 85 degrees. The head should be held up, looking straight forward. Shoulder girdle and pelvis perform complementary motions. The trunk moves with each step, from forward bow and upright posture through side bow and rotation around medial axis. The speed of run mainly depends on the length and frequency of running steps. The optimal relation of the length and frequency parameters is primarily determined by the sprinter's build characteristics, motor abilities and level of special preparation. Active take-off and quick forward-upward movement of the swinging leg are key elements of run. The lower extremity muscle groups of femoral and tibial extensor muscles and plantar flexor muscles are most engaged in the action of take-off.

On javelin throw, several factors determine the overall javelin beta length. These factors include the initial speed of throw, angle of throw, air resistance and height of javelin throw. The most important factor certainly is the initial speed of throw. In the final phase of throw, the thrower increasingly adds strength to the javelin, trying to perform this movement within the shortest time possible. The low weight of the apparatus, the javelin, requires enormous speed and special throwing strength of the lower extremity, trunk and upper extremity musculaure. The throwing apparatus needs speeding up of 30–35 m/s. All this indicates that javelin can be thrown to quite a long distance by applying appropriate rhythm and excellent coordination that is substantial on transition from the cyclic to the acyclic part of movement in this complex motor action. Although standing ball throw structurally corresponds only to the phase of final exertion in javelin throw, other phases of the technique are briefly described to illustrate the complexity of this specific motor skill and to define the procedures of learning and acquiring these motor structures in the scope of athletic sports school.

The technique of javelin throw consists of four phases: approach run, five stride rhythm, delivery and recovery. In the initial phase of approach run, the thrower tends to achieve optimal speed, which depends on total running speed and thrower's technical preparation. During run, the thrower's arm moves slowly while the other arm follows the running rhythm. In the final phase of approach run (five stride rhythm), the thrower begins preparing for throw by running more sidewise. The throwing arm and shoulder stay backward and the javelin is moved backward. The hips and shoulder axis with the javelin assume throwing direction. All javelin thrower's movements proceed harmoniously, with movements deriving from one another.

Crosswise step is the connective element between the approach run and the phase of maximal exertion.

In the phase of maximal exertion, the thrower has to move with his left shoulder forward and his left leg extended forward (applying to those throwing with the right hand). Before the left leg stepping down, the bent right leg should be rotated inside with supination of the hand holding the javelin, thus to increase the shoulder girdle muscles that carry greatest burden on javelin throw. The characteristic of this phase is that the thrower's hand with the javelin is extended, forming a straight line with the shoulder, thus increasing muscle exertion. The javelin axis and shoulder axis are parallel while the thrower is looking straight forward. When the left leg starts placing from the heel to the whole foot, the most active part of final exertion begins. The thrower continues »placing« himself beneath the javelin, which is enabled by the approach run inertia due to the slowing down action of the strained left side of the body, from the leg to the shoulder, as well as to the active action-movement of extension and rotation. At this moment, the thrower harmoniously performs the elements of final exertion, i.e. thigh movement, chest anterior rotation, which causes the hand with the javelin to stay behind the back (forming the strained arch) and finally the throw that is terminated by the abrupt arm movement.

Maximal negative acceleration is first achieved in the thigh joint, followed by the elbow. This abrupt decline in the shoulder joint and elbow speeding up corresponds to the moment of greatest acceleration of the javelin speed.

Comparison of the study results and literature[6,23–27] data suggested the current educational approaches in the athletics events of sprint and throw at elementary school level to require revision. The model of children's education in athletics proposed is defined by the following elements: development of all basic motor abilities, with special reference to psychomotor speed, explosive strength, aerobic endurance and coordination (along with appropriate load, defined by the parameters of work intensity and volume), and motor learning of specific motor skills, i.e. techniques of athletics events.

As aerobic endurance is fundamental for the develpment of other motor abilities, it should be continuously influenced upon, from the very beginning, through the following phases:

– children aged 7–8 years run up to 600-m laps; running technique tends to coordination of upper and lower extremity movements with appropriate breathing; high start training (only gross errors in run and high start are being corrected);
– children aged 9–10 years run up to 800-m laps; running technique tends to coordinated work of whole body musculature with appropriate breathing technique; high start technique is being improved (training in running technique with correction of all errors in the run and high start technique); and
– children aged 11–12 years run up to 1000-m laps; running technique tends to coordination with the mechanical and functional requirements in endurance run as well as in relation to the actual anthropological status of the child.

The development of running speed or sprint should be influenced through the following phases:

– children aged 7–8 years run up to 20-m laps; sprint technique tends to integration of the basic phases of the sprinter step technique into the overall sprint structure; training in high start technique and low start technique (gross errors in the sprint and low start technique are being corrected);
– children aged 9–10 years run up to 40-m laps; sprint technique includes further training and training in the high start and low start technique, with correction of all errors; and
– children aged 11–12 years run up to 60-m laps; sprint technique tends to low start and sprint integration into the integral movement structure.

Development of abilities for throwing events in athletics should be influenced through the following phases:

– children aged 7–8 years throw a ball weighing up to 200 g and shot weighing up to 1 kg; throwing technique tends to integration of all basic phases into the integral standing throw technique (gross errors are being corrected);
– children aged 9–10 years throw a ball weighing up to 250 g and shot weighing up to 2 kg; throwing technique tends to integration of all basic throw phases and phase of approach run of up to 5 m into the integral technique (all errors in technique are being corrected); and
– children aged 11–12 years throw a ball weighing up to 300 g and shot weighing up to 3 kg; the technique of ball throw tends to integration of all basic throw phases and phase of approach run of up to 10 m into the integral technique (prolonged technique training through an adequate number of repetitions).

In the presented model of kinesiologic procedures directed toward development of basic biomotor features and specific motor abilities and skills in athletics, the upper limit of physical load for particular developmental phases in non-selected children population has been set only approximately since the achievement of this physical load limit depends on sex and level of development of anthropologic features in a particular region or country. The upper limit of physical load set for the general population of children can only be overcome by particular selected subject samples.

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RAZVOJ BIOMOTORIČKIH OBILJEŽJA I ATLETSKIH SPOSOBNOSTI SPRINTA I BACANJA DJEVOJČICA STAROSNE DOBI OD 6 DO 8 GODINA

SAŽETAK

Istraživanje je provedeno s ciljem ispitivanja utjecaja posebno programirane nastave tjelesne i zdravstvene kulture na biomotoričke promjene djevojčica, kao i utjecaj tih promjena na relacije između skupa morfoloških i motoričkih varijabli s atletskim varijablama za procjenu sposobnosti sprinta i bacanja. U tu svrhu ukupni uzorak od 310 učenica prvih razreda osnovnih škola na području grada Splita u dobi od 6 do 8 godina podijeljen je na kontrolnu skupinu ispitanica (N=138) koje su pohađale redovitu nastavu tjelesne i zdravstvene kulture i na eksperimentalnu skupinu (N=172) koje su pohađale posebno programiranu nastavu baziranu na elementima atletike, sportske gimnastike, igara, te opće pripremnih vježbi. Relacije između prediktorskog skupa varijabli sastavljenog od 4 morfološke mjere i 6 motoričkih testova s kriterijima sprinta i bacanja loptice utvrđene su regresijskom korelacijskom analizom i to na početku i na kraju ško1ske godine. Obje skupine ispitanika postigle su između dviju točaka mjerenja pozitivan kvantitativni rezultatski pomak s tim da je taj pomak znakovitiji kod eksperimentalne skupine u odnosu na kontrolnu i to posebno u motoričkim sposobnostima koordinacije, fleksibilnosti, frekvencije pokreta te eksplozivne, repetitivne i statičke snage. U finalnom mjerenju u odnosu na inicijalno mjerenje povećao se broj značajnih prediktora za kriterijske varijable sprinta I bacanja loptice kod obiju skupina ispitanica. Kod kontrolne skupine najbolji prediktori rezultata u sprintu su od motoričkih sposobnosti snaga trupa, eksplozivna snaga i frekvencija pokreta i od morfoloških obilježja visina tijela. Kod eksperimentalne skupine najbolji prediktori rezultata u sprintu su motoričke sposobnosti: koordinacija, fleksibilnost, statička snaga ruku i snaga trupa. Za ukupni uzorak ispitanika najbolji prediktori kriterijske varijable – bacanje loptice su eksplozivna snaga i snaga trupa. Ovo kod eksperimentalne skupine učenika prati razvoj mišićne mase i redukcija masnog tkiva. Komparacijom ovih i ranije dobivenih rezultata pred1ožen je novi model rada za atletske discipline sprinta i bacanja u okviru kineziološke edukacije osnovne škole.