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Biomotor Development in 1992 and 2002 Samples of Seven-Year-Old Children

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A B S T R A C T

The aim of the study was to determine quantitative and qualitative differences in the morphological-motor status between elementary school first-graders of both sexes in 1992 and 2002. A standard set of 11 variables currently used in the Croatian school system to evaluate the morphological, motor and functional status of school children was employed at the beginning of academic years in a sample of 635 children (325 male and 310 female) in 1992 and a sample of 850 children (430 male and 420 female) in 2002. The mean age of study children was 7 years (± 2 months). Results of canonic discriminative analysis revealed the male children enrolled in elementary school first grade in 2002 to show better performance on the tests of aerobic endurance, static strength and explosive strength, and to have greater mass of muscle tissue and less adipose tissue, while achieving poorer results on the test of movement frequency than their 1992 counterparts. Female children tested in 2002 showed better results on the test of aerobic endurance and all tests of strength factors, with greater mass of muscle tissue and less adipose tissue, while yielding poorer results on the tests of flexibility, coordination and movement frequency as compared with their 1992 counterparts. Factor analysis in the morphological-motor system isolated three varimax factors each in children of both sexes tested in 1992 and 2002. First factor showed a pattern of a general morphological factor predominantly defined by body weight and volume in the children of both sexes from both study years. Second factor showed a pattern of a general motoricity factor predominantly defined by explosive strength, coordination and speed in children tested in 1992, whereas in their 2002 counterparts the general motoricity factor was predominantly defined by the factors of strength and endurance. Third factor was defined by flexibility in both 1992 and 2002 children. In female children tested in 1992, second factor mostly defined energy regulation with predominance of explosive and static strength, followed by coordination, whereas third factor was defined by movement frequency and aerobic endurance. In female children tested in 2002, second factor mostly defined energy regulation with predominance of explosive and repetitive strength, followed by aerobic endurance and coordination, whereas third factor was defined by movement frequency followed by muscle tone regulation.

***Key words**: morphological and motor status of children, 1992 and 2002 children, differences*

Introduction

Proper knowledge of developmental patterns is necessary for the actions taken to provide appropriate support to the development of the bio-psycho-social characteristics of children to be efficient. Variability in the development of complex biological characteristics is influenced by the interaction of intrinsic (e.g., genetic and hormonal) and extrinsic (e.g., diet and exercise) factors, where intensive physical activity is a major environmental factor influencing the growth and development of human body. Therefore, specifically programmed kinesiologic education entails significantly greater effects on the development of almost all relevant motor abilities, aerobic endurance in particular, and of all factors of strength and flexibility, as compared with standard education[1–3]. These effects are followed by adipose tissue reduction and muscle mass increase, along with moderate skeleton development[3–8]. Thus, school as a basic educational institution should find way to provide, through high-quality general and differential programs of kinesiologic education, active support to the development of morphological-motor and functional systems as integral parts of the child's body[9–13].

Accurate and reliable assessment of the morphological-motor status is of high relevance in planning and pro-

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gramming transformation processes both in kinesiologic education at school and in various sports activities of children and adolescents. In kinesiologic practice, it is of utmost importance to optimally evaluate the individual's status with the least number of variables possible without significantly reducing the amount of relevant information. Therefore, the choice of morphological and motor variables in the present study was made on the model described by Kurelić et al. (1975)[14], determined in large samples of school children. Based on the mentioned study results, the same set of variables proposed by these authors have been officially used on monitoring and evaluation of morphological, motor and functional characteristics of elementary school children in the Republic of Croatia (Mraković et al., 1986)[15]. A battery of morphological measures is used to evaluate the ectomorphy, mesomorphy and endomorphy components. A battery of motor tests is employed to assess some basic motor abilities that are considered most relevant for the motor status evaluation. In this way, motor status is defined by two components: energy (action factors of strength and endurance) and information (coordination, speed and flexibility).

Studies[11–13] have shown the set of variables proposed by Mraković et al. (1986)[15] to properly define and assess the morphological-motor status of school children. It was therefore employed in the present study, in order to analyze quantitative and qualitative differences in the morphological-motor status between elementary school first-graders of both sexes enrolled in 1992 and 2002, as accumulated differences in biomotor development from birth through elementary school enrolment.

Subjects and Methods

The study included a sample of 635 first-graders (325 male and 310 female) enrolled in 1992 and a sample of 850 first-graders (430 male and 420 female) enrolled in 2002, aged 7 years (±2 months). A standard battery of 11 variables (4 variables from morphological system and 7 variables from motor system), currently employed in the national school system for assessment of the morphological, motor and functional status of school children[11–13,15], were used in first-graders at the beginning of the respective academic year. This set of variables was proposed on the basis of the large study reported by Kurelić *et al.* (1975)[14].

The following morphological variables were used: body height (mm), body weight (dkg), forearm circumference (mm) and triceps skinfold (1/10 mm). All measures were taken according to the international biological program[16].

The following variables were employed on motor status assessment: hand tapping (f), standing jump (cm), polygon backward (s), sit-ups (f), forward bow (cm), bent arm hang (s) and 3-min run (m)[11–13].

On data analysis, elementary statistical parameters (arithmetic mean and standard deviation, mean±SD), canonic discriminative analysis (Wilk's λ and F, multivariate tests of differences; p, level of significance of multivariate tests of differences; and F^p, significance of univariate test of differences), and factor analysis (varimax factors, V; characteristic factor values, λ; and percentage of common variance, Variance%) were employed.

Results

Quantitative differences in the morphological and motor variables between the first-graders of both sexes enrolled in 1992 and 2002 are presented in Tables 1 and 2. Qualitative, i.e. structural differences in the morpho-

TABLE 1
DESCRIPTIVE STATISTICS (Mean±SD) AND DISCRIMINATIVE ANALYSIS BETWEEN 1992 AND 2002 MALE FIRST-GRADERS

Variable	1992 (N=325) Mean±SD	2002 (N=430) Mean±SD	F^p
Stature (cm)	128.44±5.46	128.99±6.36	
Body mass (kg)	27.03±4.41	28.00±5.15	
Forearm circumference (cm)	17.85±1.59	18.95±1.78	2002[c]
Triceps skinfold (mm)	11.47±3.60	10.30±3.87	1992[c]
Polygon backward[#] (s)	22.97±6.24	22.91±6.18	
Forward bow (cm)	36.86±8.50	36.14±8.56	
Hand tapping (taps/min)	19.18±2.78	17.99±3.35	1992[c]
Standing jump (cm)	113.14±17.43	117.30±20.69	
Sit-ups (*per* minute)	21.66±6.37	22.60±6.37	
Bent arm hang (s)	10.87±9.55	17.50±18.61	2002[c]
3-min run (m)	441.01±60.12	460.86±77.45	2002[c]
Wilks' λ = 0.73		F=24.07	

[#]variable with opposite metric orientation, [c]p<0.001; Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F^p – significance of univariate test of differences

TABLE 2
DESCRIPTIVE STATISTICS (Mean±SD) AND DISCRIMINATIVE ANALYSIS BETWEEN 1992 AND 2002 FEMALE FIRST-GRADERS

Variable	1992 (N=310) Mean±SD	2002 (N=420) Mean±SD	F^p
Stature (cm)	127.03±5.37	127.11±5.40	
Body mass (kg)	26.12±4.66	26.93±4.96	
Forearm circumference (cm)	17.60±1.60	18.55±1.48	2002[c]
Triceps skinfold (mm)	12.92±3.99	11.40±4.10	1992[c]
Polygon backward[#] (s)	26.63±7.63	27.81±7.82	1992[c]
Forward bow (cm)	41.27±7.90	36.44±8.25	1992[c]
Hand tapping (taps/min)	18.73±2.45	17.77±3.12	1992[b]
Standing jump (cm)	103.82±17.33	108.06±17.68	2002[a]
Sit-ups (*per* minute)	20.38±6.49	24.09±7.07	2002[c]
Bent arm hang (s)	9.83±8.01	11.14±9.13	
3-min run (m)	418.81±63.53	443.06±72.70	2002[c]
Wilks'λ = 0.64		F = 37.26	

[#]variable with opposite metric orientation, [a]$p<0.05$, [b]$p<0.01$, [c]$p<0.001$; Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F^p – significance of univariate test of differences

logical-motor characteristics between the two samples of first-graders (1992 and 2002) are shown in Tables 3 and 4.

At the beginning of the academic year, the group of male first-graders enrolled in 2002 showed better results on the tests of aerobic endurance, static strength and explosive strength, along with greater muscle mass and less adipose tissue, but had poorer results on the test of movement frequency than the group of male first-graders enrolled in 1992 (Table 1).

The group of female first-graders enrolled in 2002 proved superior on the test of aerobic endurance and all tests of strength factors, along with a higher proportion of muscle tissue and less adipose tissue, but were inferior on the tests of flexibility, coordination and movement frequency as compared with their 1992 counterparts (Table 2).

In the 1992 male first-graders, factor analysis isolated three factors in the morphological-motor system. First

TABLE 3
VARIMAX FACTORS OF MORPHOLOGICAL-MOTOR SYSTEM VARIABLES IN 1992 AND 2002 MALE FIRST-GRADERS

Variable	1992			2002		
	V1	V2	V3	V1	V2	V3
Stature (cm)	0.71	0.09	0.11	0.69	0.06	–0.31
Body mass (kg)	0.95	–0.01	0.01	0.92	–0.10	–0.02
Forearm circumference (cm)	0.80	–0.03	0.15	0.85	–0.04	0.08
Triceps skinfold (mm)	0.74	–0.23	–0.17	0.61	–0.17	0.30
Polygon backward[#] (s)	0.06	–0.70	–0.01	0.11	–0.48	0.37
Forward bow (cm)	0.10	–0.02	0.87	–0.05	0.10	–0.75
Hand tapping (taps/min)	0.03	0.62	–0.13	0.18	0.40	–0.24
Standing jump (cm)	–0.11	0.71	0.00	–0.18	0.58	–0.29
Sit-ups (*per* minute)	0.09	0.55	0.29	0.10	0.70	0.00
Bent arm hang (s)	–0.29	0.36	0.41	–0.20	0.52	0.43
3-min run (m)	–0.11	0.43	0.18	–0.17	0.60	0.07
λ	2.72	2.06	1.12	2.57	1.90	1.22
Variance%	0.25	0.19	0.10	23.41	17.30	11.08

[#] variable with opposite metric orientation; V – significant varimax factors, λ – characteristic values, Variance% – percentage of variance explained by a particular factor

TABLE 4
VARIMAX FACTORS OF MORPHOLOGICAL-MOTOR SYSTEM VARIABLES IN 1992 AND 2002 FEMALE FIRST-GRADERS

Variable	1992			2002		
	V1	V2	V3	V1	V2	V3
Stature (cm)	0.68	0.07	0.01	0.75	–0.10	–0.12
Body mass (kg)	0.93	–0.12	–0.03	0.92	0.13	0.01
Forearm circumference (cm)	0.85	–0.02	–0.06	0.84	0.08	0.07
Triceps skinfold (mm)	0.72	–0.29	–0.10	0.67	0.25	0.05
Polygon backward# (s)	0.19	–0.61	–0.21	0.26	–0.55	–0.28
Forward bow (cm)	0.29	0.46	–0.14	0.12	0.15	0.51
Hand tapping (taps/min)	0.09	0.13	0.75	–0.05	0.01	0.73
Standing jump (cm)	–0.10	0.71	0.17	–0.09	0.68	0.26
Sit-ups (*per* minute)	0.01	0.49	0.29	0.08	0.67	0.03
Bent arm hang (s)	–0.33	0.67	–0.09	–0.37	0.40	0.24
3-min run (m)	–0.22	0.03	0.74	–0.02	0.63	–0.25
λ	2.87	1.89	1.31	2.80	2.14	1.34
Variance%	0.26	0.17	0.12	25.48	19.49	12.14

variable with opposite metric orientation; V – significant varimax factors, λ – characteristic values, Variance% – percentage of variance explained by a particular factor

varimax factor showed a pattern of a general morphological factor predominantly defined by body weight and volume; second factor showed a pattern of a general motoricity factor predominantly defined by explosive strength, coordination and speed; and third factor defined flexibility (Table 3).

In the 2002 male first-graders, three factors were isolated in the morphological-motor system. First varimax factor was morphological; second factor was a motor factor with a predominance of energy regulation, i.e. it integrated strength factors and endurance; whereas third factor defined flexibility (Table 3).

Comparison of the structure of the morphological factor isolated in the 1992 and 2002 male first-graders yielded a significantly reduced adipose tissue projection in the latter. In addition to body weight and body volume, the contribution of the adipose tissue component surpassed the contribution of skeleton in the 1992 sample, whereas an opposite pattern was recorded in the 2002 sample.

In the 1992 female first-graders, first varimax factor was defined by morphological structure with a predominance of body mass; second factor predominantly defined energy regulation with a predominance of explosive strength and static strength, followed by coordination (based on force regulator); and third factor was defined by movement frequency and aerobic endurance (based on speed regulator) (Table 4).

In the 2002 female first-graders, three factors were also isolated in the morphological-motor system. First varimax factor was defined by morphological structure with a predominance of body mass; second factor mostly defined energy regulation with a predominance of explosive and repetitive strength, followed by aerobic endurance and coordination (based on energy regulation of movement); and third factor was defined by movement frequency, followed by muscle tone regulation.

In the 1992 female first-graders, body weight and forearm circumference were the morphological measures exerting greatest projection upon the first varimax factor, followed by the variables for assessment of adipose tissue and skeleton longitudinal dimensionality. Such a pattern suggested that, in addition to mesomorphy, body mass in these subjects was saturated by endomorphy rather than ectomorphy. In the 2002 female first-graders, however, besides body weight and body volume, the contribution of skeleton to the morphological factor structure obtained exceeded that of adipose tissue, just like in their male peers (Table 4).

Discussion

In the 1992 subjects, body mass was to a significantly greater extent saturated by adipose tissue than in the 2002 subjects. In the latter, the greater proportion of muscle mass and lower proportion of adipose tissue contributed to their better performance on the tests of muscular and aerobic endurance as compared to their 1992 counterparts. Muscular and aerobic endurance developed to a greater extent in the 2002 male first-graders than in their 1992 counterparts (Table 1). It is expected that psychomotor speed, which was superior in the 1992 male first-graders, may not undergo major variation under the influence of training processes, while changes in the ability of muscle tone regulation, i.e. flexibility, will

be significantly related to appropriate transformation procedures.

The greater muscle mass and a lower proportion of adipose tissue in the 2002 female first-graders, recorded on initial measurement, contributed to their better performance on the test of aerobic endurance as compared with their 1992 counterparts. In the former, a significantly higher development of aerobic endurance, repetitive and explosive strength was observed.

The integration of force, coordination and speed through second varimax factor, and secondarily muscle tone regulation through the third varimax factor made a basis of general motor efficiency in the 1992 male first-graders (Table 3).

In the 2002 male first-graders, motor efficiency was primarily based on the integration of basic strength and endurance, i.e. ability of energy regulation of movement, and secondarily on the ability of muscle tone regulation (Table 3).

As compared with male children, female children show faster morphological development and earlier formation of a uniform morphological structure responsible for the musculature and skeleton development (mesoectomorphy) as a favorable developmental aspect, as opposed to the excessive amount of adipose tissue as an the unfavorable developmental aspect. In female children, developmental processes lead to the formation of a general morphological factor defined as ectomesomorphy and two general mechanisms responsible for motor efficiency in the form of force regulation and speed regulation[11–13].

Anthropological adaptation of man to ongoing environmental changes caused variation in the morphological-motor status between the two generations of 7-year-old children (1992 and 2002). Climatic changes induced by urbanized lifestyle, associated with atmosphere warming and pollution, have detrimental effects upon human body functions. On the other hand, there is an increasing awareness of the importance of healthy and varied diet and of the role of exercise in the overall development of man. Physical, i.e. kinesiologic activity compensates for all the unfavorable environmental effects on the morphological-motor development in children and entails both quantitative and qualitative changes in their morphological-motor status. This is manifested by the development of muscle tissue and skeleton in the form of enhanced bone mineralization on the one hand and adipose tissue reduction on the other hand[17]. These changes can be clearly depicted by comparison of the morphological factor structure in the 2002 subjects as compared with the 1992 subjects of both sexes.

As compared with the 1992 subjects, in their 2002 counterparts the enhanced physical activity resulted primarily in the increased muscular and aerobic endurance in male children, and in the increased aerobic endurance, repetitive and explosive strength in female children. Quantitative differences between the two generations led to qualitative changes as well. In male children, energy component defined by the factors of strength and endurance determined motor functioning to a greater extent than the information component. In female children, energy component defined by explosive and repetitive strength and by aerobic endurance also contributed to the general motor efficiency to a greater extent than the information component.

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BIOMOTORIČKI RAZVOJ SEDMOGODIŠNJE DJECE IZ 1992. I 2002. GODINE

S A Ž E T A K

Cilj istraživanja je bio da se utvrde kvantitativne i kvalitativne razlike morfološko-motoričkog statusa učenika prvog razreda osnovne škole oba spola iz 1992. i 2002. godine. U tu svrhu na uzorku od 635 djece (325 dječaka i 310 djevojčica) iz 1992. i na uzorku od 850 djece (430 dječaka i 420 djevojčica) iz 2002. godine starosne dobi od 7 godina (+/–2 mjeseca) primijenjena je standardna baterija od 11 varijabli na početku prvog razreda osnovne škole, koja se danas koristi u školskom sustavu Republike Hrvatske, za procjenu morfološkog, motoričkog i funkcionalnog statusa. Rezultati kanoničke diskriminativne analize su utvrdili kako su učenici muškog spola koji su upisali prvi razred osnovne škole 2002. godine u odnosu na učenike koji su upisali prvi razred osnovne škole 1992. godine, imali bolje rezultate u testu aerobne izdržljivosti, testu statičke snage, te testu eksplozivne snage, uz više mišićne mase i manje masnog tkiva, dok su imali lošije rezultate u testu brzine frekvencije pokreta. Kod učenica 2002. godine u odnosu na učenice 1992. godine utvrđeni su bolji rezultati u testu aerobne izdržljivosti i testovima za procjenu svih faktora snage, uz više mišićnog a manje masnog tkiva, dok su imali lošije rezultate u testovima fleksibilnosti, koordinacije i frekvencije pokreta. Faktorskom analizom u morfološko-motoričkom prostoru kod učenika oba spola iz 1992. i iz 2002. godine izolirana su po tri varimax faktora. Prvi faktor kod oba spola, kako kod učenika iz 1992., tako i iz 2002. godine se ponaša kao generalni morfološki faktor dominantno definiran tjelesnom težinom i volumenom. Kod učenika iz 1992. drugi faktor se ponaša kao generalni faktor motorike, dominantno definiran eksplozivnom snagom, koordinacijom i brzinom, a kod učenika iz 2002. generalni faktor motorike dominantno je definiran faktorima snage i izdržljivosti, dok treći faktor kod obje skupine definira fleksibilnost. Kod učenica iz 1992. godine drugi faktor pretežno definira energetsku regulaciju uz dominaciju eksplozivne i statičke snage, što prati koordinacija, a treći definira frekvencija pokreta i aerobna izdržljivost. Kod učenica 2002. godine drugi faktor pretežno definira energetsku regulaciju uz dominaciju eksplozivne i repetitivne snage, što prati aerobna izdržljivost i koordinacija, a treći definira frekvencija pokreta, koju prati regulacija mišićnog tonusa.