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THE MECHANISMS OF MORPHOLOGICAL-MOTOR FUNCTIONING IN MALE PRIMARY SCHOOL FIRST- TO FOURTH-GRADERS

MEHANIZMI MORFOLOŠKO-MOTORIČNEGA DELOVANJA PRI UČENCIH OD 1. DO 4. RAZREDA OSNOVNE ŠOLE

Abstract

Four morphological and seven motor variables were assessed in a sample of 2,205 male children (divided into four age groups) aged from 7 to 11 years. Boys were first- to fourth-graders of different primary schools from the Primorje-Gorski Kotar County, Croatia. The aim of the study was to analyse the morphological-motor structures according to age. A factor analysis was performed for each of the four subject groups. The results clearly show that the morphological-motor functioning of the boys changes with age. Developmental processes lead to the formation of the general morphological factor defined as mesoectomorphy and the general mechanism responsible for motor efficiency in the form of the parallel regulation of strength, speed (movement frequency) and endurance. The results we obtained were found to be consistent with the existing relevant models related to the morphological and motor system. Further, the results allow for the creation of a model integrating relevant elements of the existing models in order to define the function of the body as a whole, which represent the basic determinants of kinesiologic education for primary schoolers.

Key words: morphological-motor structures, boys, development, regulatory mechanisms

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Izvleček

V vzorcu 2205 dečkov, starih od 7 do 11 let (razdeljenih v štiri starostne skupine), smo izmerili 4 morfološke in 7 motoričnih spremenljivk. Dečki so obiskovali prve štiri razrede različnih osnovnih šol Primorsko-goranske Županije na Hrvaškem. Namen študije je bil analizirati morfološko-motorično strukturo skupin različno starih dečkov, zato smo spremenljivke vsake podskupine faktorizirali. Rezultati so pokazali, kako se s starostjo dečkov spreminja morfološko-motorična shema. Razvojni proces oblikuje generalni morfološki faktor, ki teži k mezoektomorfiji in generalni faktor motorične učinkovitosti, ki se kaže kot vzporedno uravnavanje sile, hitrosti in vzdržljivosti. Dobljeni rezultati so skladni z že obstoječimi relevantnimi modeli morfološkega in motoričnega prostora ter pojasnjujejo delovanje organizma kot celote. Oblikovanje organizma kot celote pa je tudi osnovni cilj športnega poučevanja v osnovnih šolah.

Ključne besede: morfološko-motorične strukture, dečki, razvoj, uravnalni mehanizmi

INTRODUCTION

Most studies investigating the structure of morphological characteristics have included stable samples, i.e. subjects with little chance of any substantial result oscillations. Relatively reliable indicators of the final morphological structure and dimension relations that can be considered final or permanent have thus been obtained (Hofman & Hošek, 1985; Szirovicza, Momirović, Hošek, & Gredelj, 1980). These results show that four morphological dimensions can generally be identified in adult individuals. A three-dimensional model is found in adolescents (Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975), whereas two morphological dimensions have generally been identified in children (Katić, Zagorac, Živičnjak, & Hraski, 1994).

The general developmental tendencies reflect on all other body subsystems, which are interrelated and require a multisegmentary and multidisciplinary approach whenever possible (Ismail & Gruber, 1965; Ismail, Kane, & Kirkendal, 1969; Katić, 1977, 2003; Katić et al., 1994).

Previous studies of motor abilities which employed the functional approach enabled a cybernetic model of motor functioning in humans to be designed. In these studies, the model is functionally defined by physiologic mechanisms which, according to Bernstein's (1966) and Anohin's (1970) theories of afference and reafference processes, act at different levels of the nervous system and are included in the regulatory circuits of a higher or lower order depending on the motor task content (Gredelj, Metikoš, Hošek, & Momirović, 1975; Kurelić et al., 1975).

The model of motor functioning is based on the idea of identifying the functional mechanisms latently contained in the complex pattern of the central nervous system's functioning and which underlie motor reactions. This concept relies on a hypothesis that has been confirmed on several occasions, namely that output motor manifestations are directly conditioned by the efficient functioning of particular cortical and subcortical areas of the central nervous system, including the reflex arc area, and by the efficient co-ordination of variedly located and different functional mechanisms.

In line with this theoretical concept of the functional structure of the motor area, as substantiated by the clinical experiments of Luria (1966, 1973) and many others, the empirical studies of Kurelić and colleagues (1975) point to the possible existence of four functional mechanisms defining the general mechanism of energy regulation and general mechanism of movement regulation in a higher order area. Studies have shown that the motor area is multidimensional, with the existence of primary, secondary and tertiary factors in adults (Gredelj et al., 1975).

Some studies of the structure of motor abilities in children show that at least two motor dimensions in the motor area exist in children (Mraković & Katić, 1992; Katić et al., 1994; Katić & Viskić-Štalec, 1996). This is because at the age of 6-8 years the majority of neural structures approach the adult stage and basic motor abilities are well developed, thus ensuring the prerequisites for latent motor dimension differentiation (Malina & Bouchard, 1991).

A valid and reliable assessment of the morphological-motor status is essential for the planning and programming of transformation processes in both kinesiologic education at school and the various sports activities of children and adolescents. The kinesiologic practice should imply the optimal individualised evaluation using the least possible number of variables, thereby avoiding a significant reduction of the amount of relevant information. Therefore, the variables most relevant to evaluating the basic morphological characteristics and motor abilities, while at the same time assessing a coexisting model of the morphological or motor status, should be chosen (Gredelj et al., 1975; Kurelić et al., 1975).

In the present study, the choice of morphological and motor variables was made using the morphological and motor model developed by Kurelić et al. (1975) based on large samples of a population of school children. The same set of variables proposed by these authors on the basis of their study results was used in a follow up and evaluation of the morphological, motor and functional characteristics in primary school children in the Republic of Croatia (Mraković, Findak, Gagro, Juras, & Reljić, 1986). The morphological set of measures is used to evaluate the components of ectomorphy, mesomorphy and endomorphy. The set of motor tests is used to evaluate some basic motor abilities considered to be most important for the children's motor status assessment. In this way, motor status is defined by two components, i.e. energy component (action factors of strength and endurance) and information component (co-ordination, speed and flexibility). The existence of the general morphological factor and general motor factors will be evaluated in male primary school first- to fourth-graders.

METHOD

Participants

The study sample included 2,205 male first- to fourth-graders aged 7-11 years from primary schools in the Primorje-Gorski Kotar County in the Republic of Croatia. The sample was subdivided into four groups as follows: first graders (n = 566), second-graders (n = 560), third-graders (n = 651) and fourth-graders (n = 518). All children were free of any apparent aberrations and able to follow the standard programme of primary school activities.

Instruments

The standard battery of 11 variables currently used in the education 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. The morphological variables included body height (mm), body mass (dkg), forearm circumference (mm) and triceps skinfold (1/10 mm). The measures were taken in line with the international biological programme.

The motor variables included hand tapping (taps/min), standing jump (cm), polygon backward (s), sit-ups (number/min), forward bow (cm), bent arm hang (s) and 3-minute run (m).

Procedure

In the data analysis elementary statistical parameters and standard factor analysis were used. The basic descriptive parameters (Mean and SD), varimax factor, characteristic factor values (lambda) and percentage of common variance (variance %) according to subgroups are presented in tables. Pooled results from the four factorial analyses are shown.

Although the study was carried out in transversal samples, the results can also be interpreted through parameter changes as a function of time because the samples are representative of the respective population and included a large number of subjects.

RESULTS

The basic decriptive parameters of the morphologic measures and motor tests are presented in Table 1.

Table 1: Decriptive parameters of morphological and motor variables for primary school first- to fourth-grade boys

Variables	1st grade (n = 566) M (SD)	2nd grade (n = 560) M (SD)	3rd grade (n = 561) M (SD)	4th grade (n = 518) M (SD)
Body height(cm)	128.82 (6.36)	133.51 (6.47)	139.72 (6.21)	144.38 (8.99)
Body mass (kg)	27.94 (5.24)	31.30 (6.45)	35.53 (7.50)	38.82 (8.16)
Forearm circumference (cm)	19.01 (1.75)	19.48 (1.96)	20.24 (1.95)	20.77 (2.50)
Triceps skinfold (mm)	10.30 (3.92)	9.78 (3.59)	10.36 (4.57)	10.60 (3.91)
Hand tapping (taps/min)	17.89 (3.40)	21.45 (3.85)	22.92 (4.53)	24.78 (3.94)
Standing jump (cm)	118.50 (20.9)	130.65 (20.6)	142.50 (21.4)	151.55 (23.1)
Polygon backward (s)	22.73 (6.25)	20.05 (6.40)	18.27 (6.41)	17.86 (4.81)
Sit-ups (number/ minute)	22.83 (6.38)	29.10 (7.50)	31.04 (8.11)	33.12 (7.69)
Forward bow (cm)	36.69 (8.41)	39.46 (8.29)	44.64 (11.6)	44.91 (11.4)
Bent arm hang (s)	16.70 (16.7)	21.01 (14.0)	26.33 (21.3)	28.95 (20.2)
3-min run (m)	467.29 (79.8)	507.34 (78.9)	545.99 (92.2)	583.79 (105.0)

Body height showed a steady increase from the first to the fourth grade, being more pronounced between the second and third grades (6 cm). The rise in body height was paralleled by an increase in body mass and volume (forearm circumference) and, to a lesser extent, in adipose tissue.

The male first- to fourth-graders showed the continuous development of all factors of strength (standing jump, bent arm hang) and aerobic endurance (3-min run) as well as of psychomotor speed (hand tapping), whereas the intensified development of co-ordination (polygon backward) and flexibility (forward bow) was recorded from the first to third grades, showing a declining tendency thereafter. Of motor abilities, the greatest relative changes occurred in explosive strength (standing jump) and aerobic endurance (3-min run).

The results of the factorial analysis are presented in Tables 2 and 3. Factorial analysis of the battery of variables identified three factors in first- and second-graders, and two factors in third- and fourth-graders each, the general morphological factor (V1 in Table 2 and V2 in Table 3) showing an ever more homogeneous structure is being regularly identified in first- to fourth-graders. In first- and second-graders, two motor factors (V2 and V3 in Table 2) found to integrate into the general motor factor (V1 in Table 3) in third- and fourth-graders were identified.

In first-graders the variables of body mass and forearm circumference showed the highest projection on the first varimax factor, followed by the variable assessing the skeleton's longitudinal dimension (body height) and the variable for adipose tissue assessment. Accordingly, in these children body mass was saturated by mesomorphy (forearm circumference) rather than ectomorphy (body height) and endomorphy (triceps skinfold).

Table 2: Factorial analysis (varimax factors -V) of morphological-motor area variables in first- and second-grade boys

Variables	*1st grade (n = 566)*			*2nd grade (n = 560)*		
	V1	V2	V3	V1	V2	V3
Body height (cm)	0.69	0.06	-0.31	0.14	0.39	0.13
Body mass (kg)	0.92	-0.10	-0.02	0.88	-0.14	-0.07
Forearm circumference (cm)	0.85	-0.04	0.08	0.85	0.02	0.03
Triceps skinfold (mm)	0.61	-0.17	0.30	0.76	-0.09	0.12
Hand tapping (taps/min)	0.18	0.40	-0.24	0.00	0.07	-0.72
Standing jump (cm)	-0.18	0.58	-0.29	-0.21	0.63	-0.19
Polygon backward (s)	0.11	-0.48	0.37	0.35	-0.18	0.66
Sit-ups (*number*/ minute)	0.10	0.70	0.00	0.02	0.55	-0.47
Forward bow (cm)	-0.05	0.10	-0.75	0.05	-0.08	-0.55
Bent arm hang (s)	-0.20	0.52	0.43	-0.31	0.55	-0.24
3-min run (m)	-0.17	0.60	0.07	-0.09	0.77	0.08
Lambda	2.57	1.90	1.22	2.38	1.79	1.61
Variance %	23.41	17.30	11.08	21.60	16.24	14.66

In second-graders, the first varimax factor showed the formation of mesoendomorphy (body mass, forearm circumference and triceps skinfold) as a general morphological factor, whereas the skeleton's longitudinal dimension (body height) contributed to energy mobilisation through the second varimax factor. In second-graders, the formation of two motor dimensions occurred, one of them (second varimax factor - V2 in Table 2) being responsible for energy mobilisation in the form of all factors of strength and endurance (standing jump, sit-ups, bent arm hang and 3-min run), and the other (third varimax factor – V3 in Table 2) responsible for the regulation of movement in terms of speed (hand tapping), co-ordination (polygon backward) and flexibility (forward bow). This process of motor dimension formation had begun in an earlier stage of development, as evident from the structure of these dimensions in first-graders where a differentiation of the factor of flexibility responsible for muscle tonus regulation occurred first (1st grade V3 in Table2).

The clear differentiation of the two motor management factors in second-graders was followed by the process of homogenising the motor system components by forming the general motor factor responsible for overall motor functioning (first varimax factor – V1 in Table 3) in third-graders. In these children, the general morphological factor defined by the uniform development of all somatotype components was identified as the second varimax factor (3rd grade V2 in Table 3).

In fourth-graders, morphological development took over the leading role in overall morphological-motor development. There was the considerable integration of motor co-ordination (polygon backward) in the morphological system (4th grade V2 in Table 3). Along with the general morphological factor defined by the uniform development of all somatotype components, a general motor factor predominated by the energy component (standing jump, sit-ups, bent arm hang, 3-min run) over the information component (hand tapping, polygon backward) mainly based on the cortical regulation of movement was also identified.

Table 3: Factorial analysis (varimax factors -V) of morphological-motor area variables in third- and fourth-grade boys

Variables	3rd grade (n = 561)		4th grade (n = 518)	
	V1	V2	V1	V2
Body height (cm)	0.14	0.71	0.30	0.73
Body mass (kg)	-0.20	0.87	-0.04	0.93
Forearm circumference (cm)	-0.08	0.85	0.09	0.87
Triceps skinfold (mm)	-0.40	0.64	-0.19	0.56
Hand tapping (taps/min)	0.59	0.20	0.49	0.10
Standing jump (cm)	0.69	-0.04	0.78	-0.21
Polygon backward (s)	-0.67	0.44	-0.43	0.34
Sit-ups (*number*/ minute)	0.75	-0.05	0.73	-0.02
Forward bow (cm)	0.53	0.17	0.42	0.20
Bent arm hang (s)	0.61	-0.31	0.61	-0.29
3-min run (m)	0.40	-0.08	0.65	-0.21
Lambda	2.88	2.75	2.67	2.79
Variance %	26.19	24.99	24.28	25.36

DISCUSSION

In the present study, a classic factorial analysis was used to identify the boys' morphological-motor structures. In this way, the mechanisms responsible for the morphologic-motor functioning at a particular age, namely from first- to fourth-graders, were identified.

A set of just four morphological variables proved adequate for providing relevant information on the characteristics of the status of morphological development in boys aged 7 to 11 years. Put simply, the developmental processes tend to establish optimal relationships among all elements of somatotype components. These relationships will primarily determine motor efficiency due to the interactive connections between the morphological and motor systems.

The chosen set of motor variables properly defined the motor status of the boys aged 7-11 years. The motor variable projections on isolated factors pointed to the following conclusions.

During motor development the formation of two mechanisms responsible for motor efficiency, i.e. the mechanisms of energy regulation and of movement structuring manifestation, prevails. The former is mainly responsible for the energy component, and the latter for the information component of movement. The study results confirm the validity of the model of motor functioning proposed by Kurelić et al. (1975). As the performance of any movement and/or movement structure clearly depends on both the energy and information components, the existence of a central mechanism integrating the functions of both subordinated mechanisms was postulated. All of this was found to be fully present in second-graders.

In the next stage of motor development, i.e. in boys aged 9 and 10 years, motor functions were observed to integrate to form a unique motor structure. The motor structure thus acquired has been found to be defined in fourth-graders as a general motor factor clearly showing substantial elements of a functional model (Horvat & Mraković, 1984), i.e. regulators of strength (explosive strength), speed (repetitive strength of the trunk that is to a much greater extent saturated by frequency than by strength in boys of this age), and endurance (aerobic and muscle endurance). These regulators also integrate all other basic motor abilities to some extent, co-ordination and flexibility in particular, which have reached a satisfactory level in the previous stage. The regulator of strength is thereby associated with muscle endurance, and that of speed with aerobic endurance. Accordingly, the terms 'strength endurance' and 'speed endurance' are used in sports terminology.

Kinesiologic activities are complex and their motor efficiency depends on all basic and functional abilities that should be in an optimal inter-relationship. This is accomplished by the regulators located at lower and higher levels of management, with the high-level regulators co-ordinating the work of the lower-level regulators. To be efficient, every movement or structure of movements should be co-ordinated and levelled, with the appropriate use of strength, speed, movement amplitude and muscle tonus. Motor learning influences motor functioning to switch from the predominantly cortical to the predominantly subcortical level (Schmidt, 1975). Thus, programmes in the form of biomotor structures are being formed and the learned motor structures are automatically performed, whereby the choice of reaction, i.e. the mode of implementing the adopted motor programmes in a particular situation, occurs at the cortical level.

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