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Quantitative Sex Differentations of Motor Abilities in Children Aged 11–14

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A B S T R A C T

Sex differentiations of motor development in certain time periods of growing in boys and girls are changes provoked by maturity. The aim of this research was to establish sex differentiations in motor abilities on the transversal sample of 1020 subjects, pupils from the fifth to the eighth grade of the elementary school. Sex differentiations are significantly more expressed in puberty than in pre-puberty age, which approves that the development trend of certain motor abilities is different compared to the sex. We established a statistically significant difference between boys and girls in performing applied motor tests in all four age categories. In both younger and older age groups it is evident girls are more superior to boys in flexibility manifested in the bigger range of movement in a certain joint or a set of joints, i.e. in joint movability, as well as in the easiness and gracefulness of movements. In children of younger ages, motor efficiency of boys in relation to girls is manifested in the greater power of the trunk, greater explosive power of jump and sprint type and in coordination. The boys of older age have increased the difference in explosive power, particularly of throw type with better agility, equilibrium and greater static strength of arm and shoulder belt. There has evidently been a greater development of the muscle mass in the male sex compared to the female sex. On the basis of research results it has been concluded that the motor development follows faster, i.e. sooner in girls compared to boys and that puberty peak happens at the age of twelve for girls (6^{th} grade) and at the age of thirteen for boys (7^{th} grade).

***Key words**: growing and development, sex dismorphism, motor abilities, puberty*

Introduction

Many determinants of the man's development have remained integrated in his anthropological structure and represent the persistent basis of man as a being. In their study, Katić et al., 2001[1] recognized the basic motor abilities related to the phylogenetic development of man. By acting upon the development of motor abilities, the development of the body as a whole, i.e. its composition and structure, are also being influenced. So, changes in the morphological structure occur, which at the same allow for higher motor efficiency and further development of motor abilities. Obviously, the morphological-motor development should be observed through interactions of the morphological and motor systems, thereby employing targeted kinesiologic treatments to bring the structures of these systems into optimal inter-relationships. The general programs of kinesiologic education should thereby maintain the already attained development and support further development of the relevant motor abilities and desirable morphological features. Accordingly, partial programs should tend to eliminating developmental deficits in the children's overall morphological-motor status. In this way, the minimum state in the morphological and motor characteristics of development that should be achieved by every normal child during a particular stage of development is also determined.

Kinesiologic education should follow the basic determinants of the man's development (described in Katić et al., 2001[1]). Therefore, it should tend to achieve the following: minimum of characteristic persistence (evaluated by the variables used), minimum of movement routine, minimum of movement skills, minimum of movement knowledge, and acting on the development of creation on movement. These terms are developmental components of the integral maturation of the movement concepts in man, which do not disappear on attaining the minimum, but their development should be permanently influenced upon and upgraded.

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Thorough understanding of developmental patterns is required for efficient actions to provide quality support to the development of biomotor characteristics of a child. Therefore, a specially programmed kinesiologic education compared with standard kinesiologic education results in significantly better effects on the development of almost all relevant motor abilities as well as on aerobic endurance and strength and flexibility factors in particular (Babin et al., 2001[2]; Katić et al., 2002[3]). These are accompanied by adipose tissue reduction and muscle mass increase, with moderate skeleton development Malina and Bouchard (1991)[4].

Results in the study conducted by Bala and Katić (2009)[5] showed that in seven-year-old girls, as opposed to seven-year-old boys, processes of integration of motor and cognitive abilities are conducted faster and more powerfully. Studies conducted with first-grade students of elementary school also showed that in females, as opposed to males, the process of integration of aerobic endurance[6] and coordination[7] into morphological-motor system occurs earlier, i.e., faster. Also, factors of general motor efficacy, which are defined, besides by coordination, by regulators of force and velocity[8,9], are formed earlier.

Katić and Bala, 2012[10] conducted a study with the aim of identifying and defining factors responsible for cognitive and motor development of girls in the period between 10 and 14 years of age, as well as the factors responsible for integration processes of cognitive and motor status related to age. In relation to that study, Katić et al. (2012)[11] have analysed quantitative and qualitative differences between the sexes in cognitive-motor functioning in prepubertal and pubertal period. The results showed that cognitive functioning had a significant role in the motor efficacy of girls and boys aged 10 to 14. In the age group of 10–12 years, in females, cognitive functioning is related to the motor system which integrates the regulation of muscle tone with agility/coordination, whereas in males there is a relation between cognitive abilities and the regulator of speed of upper extremities movement frequency. In the age group of 13–14 years, in females, cognitive functioning is involved in forming the factors for regulation of coordination and the intensity of energy mobilization in lower extremities, and to some degree, in the factor for regulation of intensity of energy mobilization in upper extremities and strength of the trunk, whereas in males the integration of synergetic regulation of movement in terms of balance and agility in terms of speed of direction change is carried out with significant involvement of cognitive abilities.

Based on the research of the motor functioning in children aged 11–14, Pavić et al. (2008)[12] concluded that female sex is dominated by the information component of movement, while male sex is dominated by energy component of movement.

Compared to the previous researches which established structural, i.e. qualitative changes of motor abilities in relation to age and as a consequence of developmental functions continuity[8–12] or as a consequence of an increased physical activity within a specific sport activity[13–20], the basic problem of this research is establishing quantitative sex differentiations in motor abilities in pupils between 5th and 8th grade in the elementary school, and the obtained differences will be presented with regard to the sex and age.

Subjects and Methods

Subject sample

The sample includes 1020 subjects, i.e. children of both sexes attending the fifth to the eighth grade of the elementary school in Split who, at the beginning of the experimental procedure, were 11, 12, 13 or 14±2 months, regarding their grade.

The sample of subjects divided according to age and the sex:

Year	Boys	Girls	Total
11	122	167	289
12	119	129	248
13	112	117	229
14	100	153	254
Total	453	566	1020

Variables sample

A battery of 11 motor tests used in this study was selected on the basis of experience in adult subjects. These tests estimate the effectiveness of the following functional mechanisms: movement structuring, tone and synergetic regulation, regulation of excitation intensity, and regulation of excitation duration (Gredelj et al., 1975)[21]:

- to estimate functional coordination of primary motor abilities:
  1) Steps laterally,
  2) Obstacle course backwards (Polygon backward);
- to estimate balance:
  3) Board balance;
- to estimate flexibility:
  4) Seated straddle stretch (Forward bow);
- to estimate frequency of simple movements:
  5) Arm plate tapping,
  6) One foot tapping;
- to estimate explosive strength power:
  7) Standing broad jump,
  8) 20-m dash,
  9) Medicine ball throw from supine position;
- to estimate repetitive strength of the trunk:
  10) rossed-arm sit-ups;
- to estimate static strength of arms:
  11) Bent-arm hang.

Data analysis

Basic statistical parameters were calculated for both groups of study subjects per variable (mean and standard deviation). The significance of quantitative differences in the overall space of variables was defined from the results of univariate analysis of variance (ANOVA). Canonical discriminant analysis was applied to establish the qulitative differences (discriminant structure) between sexes in a certain age.

Results

The research established sex differentiations in motor development in school children aged 11–14, and determined the differences in development and/or integration functions with regard to the sex.

We applied variance analysis to establish quantitative motor development indicators among groups of children same sex but different ages of a different age, while canonical discriminant analysis was applied to establish the differences between the sexes in a certain age.

Based on the variance analysis between age groups in boys, we may assume that between ages 11 and 12, there is a significant development of flexibility and frequency of leg movements, between ages 12 and 13 there is an intensive development, particularly of explosive power, agility, the speed of movement frequency and repetitive and static power, as well as in balance and flexibility, and between ages 13 and 14 there is a significantly intensive development of explosive power of throw type, basic power of trunk and flexibility, followed by an important development of other factors of strength and coordination (Table 1).

TABLE 1
BASIC PARAMETERS OF STATISTIC MOTOR VARIABLES IN BOYS AGED 11–14

Variables	11 (N=122)	12 (N=119)		13 (N=112)		14 (N=100)	
	$\overline{X}$±SD	$\overline{X}$±SD	p	$\overline{X}$±SD	p	$\overline{X}$±SD	p
Polygon backward#	13.73±3.26	13.32±3.60		12.99±3.81		11.29±2.88	a
Steps laterally#	11.22±1.21	11.04±1.58		10.03±1.30	a	9.47±1.27	b
Board balance	7.26±4.92	6.44±4.46		7.81±5.00	b	6.70±5.47	
Forward bow	44.35±9.44	48.31±9.00	a	45.46±10.28	a	57.56±13.33	a
Arm plate tapping	28.52±2.65	30.76±3.70	a	33.10±3.45	a	34.13±7.69	
One foot tapping	18.51±2.44	18.30±2.24		19.79±3.61	a	21.10±3.67	
Standing jump	163.10±18.97	167.99±21.99		182.77±23.89	a	195.09±20.72	a
Medicine ball throw	3.99±0.71	4.26±1.02		5.08±0.96	a	9.57±3.05	a
20 m dash#	4.23±0.39	4.21±0.42		4.00±0.42	a	3.81±0.43	a
Sit-ups (*per* min.)	22.79±3.37	22.35±4.09		24.63±4.06	a	33.15±9.84	a
Bent-arm hang	15.16±15.34	17.24±17.09		25.61±20.83	a	39.44±29.84	a

#variable with opposite metric orientation, p – significance of differences in relation to the previous age ($^{a}p<0.01$, $^{b}p<0.05$)

TABLE 2
BASIC PARAMETERS OF MOTOR VARIABLES IN GIRLS AGED 11–14

Variables	11 (N=167)	12 (N=129)		13 (N=117)		14 (N=153)	
	$\overline{X}$±SD	$\overline{X}$±SD	p	$\overline{X}$±SD	p	$\overline{X}$±SD	p
Polygon backward#	16.09±4.23	14.06±3.03	a	14.82±3.82		12.99±2.58	a
Steps laterally#	11.32±0.88	10.97±1.25	b	10.62±1.08	b	10.65±0.95	
Board balance	5.46±3.61	6.74±5.32	b	6.24±4.19		5.21±3.80	b
Forward bow (cm)	58.26±13.17	63.49±11.59	a	64.97±11.90		68.90±12.16	b
Arm plate tapping	28.46±3.97	29.56±3.28	b	31.67±3.37	a	31.58±4.01	
One foot tapping	18.13±1.96	19.31±2.08	a	19.22±1.90		22.33±6.00	a
Standing jump	154.33±20.08	161.51±19.75	a	159.40±24.87		166.88±18.94	b
Medicine ball throw	3.71±0.61	4.17±0.78	a	4.67±0.81	a	4.70±0.85	
20 m dash#	4.39±0.38	4.25±0.43	a	4.10±0.37	a	4.25±0.50	b
Crossed-arm sit-ups	20.22±3.15	22.09±3.25	a	22.43±4.08		21.35±4.50	b
Bent-arm hang	13.73±10.73	14.68±12.27		16.75±14.94		18.41±11.82	

#variable with opposite metric orientation, p – significance of differences in relation to the previous age ($^{a}p<0.01$, $^{b}p<0.05$)

TABLE 3
SEX DIFFERENTIATIONS (DF) OF MOTOR ABILITIES IN CHILDREN AGED 11–14 (RESULTS OF CANONICAL DISCRIMINANT ANALYSIS)

Variables	11 (N=289)		12 (N=248)		13 (N=229)		14 (N=253)	
	DF	p	DF	p	DF	p	DF	p
Obstacle course backwards# (s)	–0.34	B[a]	–0.12		–0.20	B[a]	0.18	B[a]
Steps laterally# (s)	–0.05		0.03		–0.20	B[a]	0.30	B[a]
Board balance (s)	0.24	B[a]	–0.03		0.14	B[b]	–0.09	
Seated straddle stretch (cm)	–0.66	G[a]	–0.80	G[a]	–0.72	G[a]	0.25	G[a]
Arm plate tapping (freq.)	0.01		0.19	B[b]	0.17	B[b]	–0.12	
One foot tapping (freq.)	0.10		–0.26	G[a]	0.08		0.07	
Standing broad jump (cm)	0.25	B[a]	0.17	B[b]	0.40	B[a]	–0.40	B[a]
Medicine ball throw (m)	0.23	B[a]	0.06		0.19	B[a]	–0.67	B[a]
20 m dash# (s)	–0.22	B[a]	–0.05		–0.10		0.26	B[a]
Crossed-arm sit-ups (freq.)	0.44	B[a]	0.04		0.22	B[a]	–0.46	B[a]
Bent-arm hang (s)	0.06		0.10		0.20	B[a]	–0.28	B[a]
Centroids:								
Boys	1.04		0.94		1.23		–2.16	
Girls	–0.76		–0.87		–1.18		1.41	
Can R	0.67		0.67		0.77		0.87	

#variable with opposite metric orientation, B – Boys, G – Girls, [a]$p<0.01$, [b]$p<0.05$

Based on the variance analysis among age groups in girls, we may assume that between ages 11 and 12 there is a significantly intensive development of all power factors (except for the static power of arms), the speed of movement frequency particularly of legs, coordination of all body and flexibility, between ages 12 and 13 there is an intensive development particularly of explosive power of throw type, the speed of movement frequency of upper extremities, followed by sprint and agility, and between ages 13 and 14 there is a significantly intensive development of the frequency movement speed of lower extremities, coordination of the whole body, explosive power of legs and flexibility (Table 2).

Sex differentiations of motor characteristics between ages 11 and 14 (Table 3):

- at the age of 11, boys, compared to girls, have significantly better results in power factors, particularly in repetitive and explosive power, coordination and balance, while girls compared to boys have much better flexibility;
- at the age of 12, girls compared to boys have extensively better flexibility and frequency speed of lower extremities, while boys compared to girls have slightly better results in movement frequency of upper extremities and explosive power of jump type;
- at the age of 13, boys compared to girls have significantly better results in all the variables except for the flexibility variable where girls are extremely better. Boys have better results particularly in the explosive power of jump and throw type, repetitive power, muscle endurance and agility;
- at the age of 14, the differences between boys are even more expressed particularly in all power factors: explosive (throw type), repetitive and static, and in coordination (more agility) while girls are significantly better in flexibility.

In all of the four age categories we established a statistically significant difference between boys and girls in performing applied motor tests.

In younger age groups (11 and 12) girls are more superior than boys in flexibility manifested in the larger movement range in a certain joint or a set of joints, i.e. in joint movability, as well as easiness and gracefulness of movements. The basis of flexibility is a mechanism for the regulation of muscle tonus which functions much better in the female sex. Motor efficiency of boys compared to girls is manifested in the greater power of the trunk, greater explosive power of jump and sprint type and coordination.

In older age groups (13 and 14) the differences in flexibility are even more evident on behalf of the girls, which enables them the realisation of movements with greater amplitudes. However, the difference in explosive power has increased in favour of boys, particularly of throwing type with better agility, equilibrium and greater static power of arms and shoulder belt. There has evidently been a greater development of muscle mass in the male sex compared to the female sex.

Sex differentiations are significantly more expressed in puberty than in pre-puberty age which confirms that development trend of certain motor abilities is different with regard to the sex, with the exception of psychomotor speed development.

Discussion

Based on variance analysis among the groups of children aged 11–14, we established quantitative indicators of motor development for boys in Table 1 and for girls in Table 2. The results show that the development of motor abilities progresses differently regarding the sex: in boys, the development is mostly expressed between ages 12 and 13, i.e. at the age of thirteen, and in girls between ages 11 and 12, i.e. at the age of twelve. In addition to this, the dynamics of development of certain motor abilities is also different at a certain age in both boys and girls.

In boys, a significant development of psychomotor speed comes first (at the age of twelve), followed by a significant development of all power factors, primarily static power of and /or muscle endurance and explosive power of throw and jump type as well as repetitive power (continuously at the ages of 13 and 14), agility at the age of 13, and the coordination of the whole body at the age of 14.

Girls first undergo a significant development of flexibility whose basis is the regulation of the muscle tonus, followed by coordination of the whole body, psychomotor speed particularly of lower extremities, and explosive power of upper and lower extremities. All of these changes, i.e. improvements of the analysed motor abilities in the function of time dominantly take place at the age of 12.

Bala et al. (2009)[22] have concluded there is a continuous positive trend in the development of all the analysed motor variables, i.e. motor abilities in boys and girls of preschool age, but these changes are less intensive regarding ages 11–14.

Thus the differences in motor variables among boys in age categories are statistically significant at younger ages, while at the older ages, i.e. before starting school, this difference is statistically insignificant. The exceptions are the variables to assess elasticity (Seated straddle stretch) and power (Bent-arm hang and Crossed-arm sit-ups) since a relatively minor development of these abilities may be observed during the analysed period[22].

The improvement of results in the tests for the assessment of motor abilities is manifested in every analysed age in girls as well. It is particularly present in variables to assess coordination at a younger age (Obstacle course backwards) and static power (Bent-arm hanging), but also in running speed (20-metre dash) at an older age (6.5–7 years old)[22].

In this research a different dynamics in the development of motor abilities at ages 11–14 in boys and girls reflects on the sex differentiations as well, and they are more expressed in puberty than in pre-puberty.

At the age of 11, discriminant function distinguishes boys from girls who have a significantly better motor flexibility compared to boys who have a significantly greater power of the trunk and the coordination of the whole body and explosive power in relation to girls.

At the age of 12, discriminant function indicates that the difference in flexibility increases in favour of girls who, at the same time, have a significantly better psychomotor speed of lower extremities than boys who, to a minor extent, have better psychomotor speed of upper extremities and explosive power of jump type than the girls. Thus, at the age of 12, in the motor sense, girls start puberty earlier than the boys.

At the age of 13, and even more at the age of 14, under the influence of puberty peak, discriminant functions in boys indicate significantly greater motor abilities in relation to girls, particularly in all power factors, and agility/coordination, while girls still have better flexibility, i.e. the regulation of muscle tonus.

The development of motor functions does not happen independently of cognitive functions since there is an interaction connection between cognitive and motor status, i.e. a unity of the cognitive motor functioning stressed in the theory of integrated development[23]. Therefore, to integrally explain sex motor differentiations, one needs information on the development of cognitive abilities[24] and information on the relation between these cognitive abilities and motor abilities[5,11,12].

The results of the research conducted by Bala and Katić, 2009[5] have showed that in most seven-year-old girls, unlike in seven-year-old boys, the processes of motor and cognitive abilities integration happen faster and more intensively.

This finding is consistent with the studies performed in elementary school first-graders, demonstrating the process of aerobic endurance[6] and coordination[7] integration into the morphological-motor system to occur earlier in female than in male children, with earlier formation of the factor of general motor efficiency defined by the force and speed regulators and coordination in the former[8,9]. Force regulation was related to simultaneous (parallel) information processing, as on performing motor tests, i.e. standing broad jump and obstacle course backwards, whereas speed was related to serial information processing, as on arm plate tapping and 1-min crossed-arm sit-ups (Katić et al., 2004)[8]. Each movement integrates force and speed, while a superior mechanism regulates the force to speed relations for the movement to be efficient. This superior mechanism is responsible for solving not only motor but also cognitive problems[8].

Cognitive abilities are particularly expressed in forming motor structures, i.e. in complexes determining motor efficiency in certain kinesiological activities at the ages 11–14[11,12]. And this particular age is crucial for the processes of orientation and selection in almost all kinesiological activities.

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REFERENCES

1. KATIĆ R, BONACIND, BLAŽEVIĆ S, CollAntropol, 25 (2001) 573. — 2. BABINJ, KATIĆ R, ROPACD, BONACIND, CollAntropol, 25 (2001) 153. — 3. KATIĆ R, MALEŠ B, ROPAC D, PADOVAN M, Coll Antropol, 26 (2002) 229. — 4. MALINA RM, BOUCHARD C, Growth, maturation, and physical activity (Human Kinetics Book, Champaign, 1991). DOI: 10. 1016/B978-0-12-383882-7.00014-3. — 5. BALA G, KATIĆ R, Coll Antropol, 33 (2009) 1071. — 6. KATIĆ R, PEJČIĆ A, BABIN J, Coll Antropol, 28 Suppl 2 (2004) 357. — 7. KATIĆ R, SRHOJ LJ, PAŽANIN R, Coll Antropol, 29 (2005) 711. — 8. KATIĆ R, PEJČIĆ A, VISKIĆ-ŠTALEC N, Coll Antropol, 28 (2004) 261. — 9. KATIĆ R, Coll Antropol, 27 (2003) 351. — 10. KATIĆ R, BALA G, Coll Antropol, 36 (2012) 69. — 11. KATIĆ R, BALA G, BAROVIĆ Z, Coll Antropol, 36 (2012) 563. — 12. PAVIĆ R, TRNINIĆ V, KATIĆ R, Coll Antropol, 32 (2008) 829. — 13. BLAZEVIĆ S, KATIĆ R, POPOVIĆ D, Coll Antropol, 30 (2006) 327. — 14. KRSTULOVIĆ S, ŽUVELAF, KATIĆ R,CollAntropol, 30 (2006) 845. — 15. KATIĆ R, GRGANTOV Z, JURKO D, Coll Antropol, 30 (2006) 103. — 16. GRGANTOV Z., NEDOVIĆ D, KATIĆ R, Coll Antropol, 31 (2007) 267. — 17. KATIĆ R, BLAZEVIĆ S, ZAGORAC N. Coll Antropol, 34 (2010) 1341. — 18. ČAVALA M, KATIĆ R, Coll Antropol, 34 (2010) 1355. — 19. MILIĆ M, GRGANTOV Z, KATIĆ R, Coll Antropol, 36 (2012) 959. — 20. KATIĆ R, JUKIĆ J, MILIĆ M, Coll Antropol, 36 (2012) 555. — 21. GREDELJ M, METIKOŠ D, HOŠEK A, MOMIROVIĆ K, Kineziologija,5 (1975) 5, 7. — 22. BALA G, JAKŠIĆ D, KATIĆ R, Coll Antropol, 33 (2009) 373. — 23. BALA G, KATIĆ R, Coll Antropol, 33 (2009) 353. — 24. FAJGELJ S, BALA G, KATIĆ R, Coll Antropol, 34 (2010) 1015.

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KVANTITATIVNE SPOLNE DIFERENCIJACIJE MOTORIČKIH SPOSOBNOSTI KOD DJECE OD 11–14 GODINA

SAŽETAK

Spolne diferencijacije motoričkog razvoja u određenim vremenskim periodima odrastanja dječaka i djevojčica su promjene koje se zbivaju sa sazrijevanjem. Cilj ovog istraživanja je da se na transverzalnom uzorku od 1020 ispitanika učenika od petog do osmog razreda osnovne škole utvrde spolne diferencijacije motoričkih sposobnosti. Spolne diferencijacije su znatno više izražene u pubertetskoj nego u predpubertetskoj dobi, što potvrđuje da je trend razvoja pojedinih motoričkih sposobnosti različit u odnosu na spol. U sve četiri uzrasne kategorije ustanovljena je statistički značajna razlika između dječaka i djevojčica u izvođenju primijenjenih motoričkih testova. Kod mlađe i starije uzrasne dobi ispitanika vidljivo je da su djevojčice superiornije od dječaka u fleksibilnosti koja se manifestira na veći opseg kretanja u određenom zglobu ili nizu zglobova dakle na zglobnu pokretljivost, kao i na lakoću i gracioznost pokreta. Kod mlađih uzrasta djece motorička efikasnost dječaka u odnosu na djevojčice ogleda se u većoj snazi trupa, većoj eksplozivnoj snazi tipa skoka i sprinta, te koordinaciji. Dječaci starije uzrasne dobi povećali su razliku u eksplozivnoj snazi posebno tipa bacanja uz bolju agilnost, ravnotežu i veću statičku snagu ruku i ramenog pojasa. Očito je došlo do većeg razvoja mišićne mase kod muškog spola u odnosu na ženski spol. Temeljem rezultata istraživanja zaključeno je kako se motorički razvoj odvija brže, tj. prije kod djevojčica u odnosu na dječake i da se pubertetski zamah događa za djevojčice u dvanaestoj godini (6. razred), a za dječake u trinaestoj godini (7. razred).