SEX AND AGE DIFFERENCES IN THE ANTHROPOLOGICAL CHARACTERISTICS OF EARLY SCHOOL-AGED CHILDREN

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Abstract
A battery of measuring instruments comprising 15 variables (eight variables of morphological characteristics, six variables of motor ability, and one variable of functional ability) was applied on a sample of 157 participants (93 boys and 63 girls) from the city of Rijeka, Republic of Croatia, aged 7-10 years, of which 44 were first-grade, 34 were second-grade, 40 were third-grade, and 39 were fourth-grade pupils. The aim was to determine their sex and age differentiation using the t-test for independent samples and a multivariate analysis of the variance. The results showed that, between boys and girls of this age, boys have less skinfolds and are better than girls in the coordination test, explosive leg strength, and functional abilities, while girls are better at flexibility. Age differences showed that children differed in all variables. The conclusion is that, in the morphological space of children aged 7-10 years, developmental processes based on sex differentiation and genetic determination are fairly uniform, while this is more pronounced in the motor and functional space in favor of boys of this age.

***Key words**: differences, boys and girls, ages 7-10, kinanthropological characteristics.*

Introduction

The role of motor development in the overall development of the child is unquestionable, and the motor space of children has been constantly explored throughout history, with particular emphasis on the study of morphological characteristics in order to prevent obesity, develop motor and functional abilities and skills at all stages of development, i.e., so as to enable the possibility of early interventions and prevention. For this reason, children of early school age should meet their biological mobility needs, and schools should be able to enable their pupils with such opportunities in order for them to achieve sustainable development in all dimensions of the anthropological status (morphological, motor, functional, cognitive, conative, social, and health dimensions). After birth, all child's abilities (motor, intellectual, musical) are just potentials that are about to develop. They are determined by hereditary factors, but they also depend on the conditions in which the child grows, and these abilities can be affected by learning and exercise to the extent that innate boundaries allow (Starc, Čudina-Obradović, Pleša, Profaca, & Letica, 2004).

Understanding the lawfulness of development is necessary for purposeful actions that serve as quality support to the development of the bio-psycho-social characteristics of the child. Thus, specially programmed kinesiology education, compared to the standardized one, produces significantly greater effects in the development of almost all relevant motor abilities, and, in particular, aerobic endurance, all strength factors, and flexibility (Babin, Katić, Ropac, & Bonacin, 2001; Katić, Maleš, & Miletić, 2002).

When working with children aged 7-10 years, their age and sex differences should be taken into account so that, by using adequate kinesiological content, they could increase their adaptive capacities with respect to environmental factors since it is during this period that the greatest transformational influences are possible.

Throughout life, the process of growth and development takes place in a discontinuous manner, with new forms of understanding and responding to the world appearing at certain periods. There are three major areas of development in each developmental period: social and emotional development, cognitive or cognitive development, and physical development. Social and emotional development refers to self-understanding and communication and relationships with other people, while cognitive development implies changes in intellectual capacity. Apart from the health aspect, physical development is manifested in the growth of the body and changes in its proportions, functional maturation of the organism, and the development of perceptual and motor abilities (Berk, 2004). Given that the authors generally agree that motor development should play the role of a control parameter in the overall development of the child (Bushnell & Bordeu, 1993; Piek, Dawson, Smith, & Gasson, 2008), it is necessary to study motor development at all stages of development throughout the growing-up period.
Malacko, Stanković, Doder, and Pejčić (2015) applied a system of 10 variables (four morphological and six motor) to a sample of 655 participants (348 boys and 307 girls) aged 7-11 years, with the aim of using the multivariate

analysis of the variance and canonical discriminant analyses to determine the significance of differences in arithmetic environments between the sexes in the morphological characteristics and motor abilities. The results obtained show that there is a statistical significance between the sexes at the level of p = .00 across the system of applied variables. Boys achieved better results in the motor skills of explosive power, body coordination, repetitive power, and static power, while the girls demonstrated better values only in flexibility. Using a canonical discriminant analysis, one discriminant function was isolated, whose structure consisted of seven variables, six of which belonged to boys and only one (sit and reach) to girls. The authors concluded that, in the teaching of Physical Education at this age, for both sexes, it is equally important to take into account the development (major changes) of morphological characteristics and motor abilities, which are not genetically limiting but are prone to change. The aim of this research is to determine statistically significant sex and age differentiation in the arithmetic means of the applied system of morphological, motor, and functional variables in order to optimally model, diagnose, plan, program, conduct, and control the physical exercise of early school-aged children.

Research methods

Sample

According to the set research aim, the sample of participants consisted of 157 pupils enrolled in the first through fourth grade of primary school in the city of Rijeka. Of the total sample, 44 (33 boys and 11 girls) were first-grade pupils, 34 (22 boys and 12 girls) were second-grade pupils, 40 (18 boys and 22 girls) were third-grade pupils, and 39 were fourth-grade pupils (21 boys and 18 girls). All participants were clinically healthy without any aberrant conditions, and all measurements were performed with the prior consent of the parents.

Sample of variables

The sample of variables consisted of a total of 15 variables (eight variables of morphological characteristics, six variables of motor abilities, and one variable of functional abilities). Morphological variables were measured according to Weiner and Lourie (1969) and Mišigoj-Duraković (2008). The body mass index was measured according to Deurenberg, Pieters, and Hautvast (1990), while the tests of motor and functional variables were measured according to Findak, Metikoš, Mraković, and Neljak (1996).

Morphological variables

- Longitudinal dimensionality of the skeleton: **HEIGHT** – body height (mm);
- Body volume and mass: **WEIGHT** – body mass (kg); **C.UA** – upper arm circumference (mm); **C.ABD** – abdomen circumference (mm): **C.HIP** – hip circumference (mm);
- Transverse dimensionality of the skeleton: **S.UA** – upper arm skinfold (mm); **S.B** – back skinfold (mm);
- Derived measure: **BMI** – body mass index (kg/m²).

Motor variables

- Speed of movement frequency: **TAPPING** – hand tapping (fr);
- Coordination: **POLYGON** – backwards polygon (sec);
- Explosive power: **JUMP** – Standing long jump (cm);
- Repetitive power: **PULL** – number of Pull-up hangs (fr); **ABDOMEN** – Sit-ups in 60 seconds (fr);
- Flexibility: **SIT-REACH** – Sit and reach (cm).

Functional variable

- Aerobic endurance: **RUN** – Running for 3 minutes, expressed in meters (m).

Methods of data processing

Basic descriptive parameters (arithmetic mean and standard deviations and minimum and maximum scores) were calculated for each variable and each group of participants, separately for both age and sex. The t-test for independent samples was used to determine sex differences between the groups of participants, and the multivariate analysis of the variance was used to determine differences by age, sex, and sex-age interaction. All analyses were performed with a statistical significance level of p = 0.05.

Results and discussion

From the results presented in Table 1, where the descriptive results of morphological, motor, and functional variables in the basic central and dispersive statistical parameters are presented, it is clearly observable that the results improve as children grow older, and certain differences are observed between boys and girls. The obtained results indicate that children show better results as they get older, which is a consequence of growth and development. They grow about 5 cm/year on average and increase their body mass between the first and second grade by about 3 kg. Research shows that, after the age of five, children grow at a relatively stable pace – an average of 5 to 6 cm and 2 to 3 kg with a slight decrease in height gain or weight gain (Johnson, 1986; Tanner, 1978; Roede, 1985); however, a greater increase in body mass is observed between the second and third grade in both girls and boys, suggesting that they are gaining weight prematurely, which leads to an imbalance, i.e., excessive weight at that age.

Table 2 depicts the results of the t-test for independent samples between boys and girls in the total sample, where there are differences in two morphological, three motor, and one functional variable. The results of the t-test, which was used to test for the statistical significance in the kinanthropological characteristics between boys and girls, indicate differences in two morphological measures: the upper arm skinfold and the back skinfold in favor of larger skinfolds in girls by about 4 mm compared to the boys.

Table 1. Basic descriptive parameters of male and female pupils enrolled in grades 1 through 4 (AS = arithmetic mean; SD = standard deviation).

VARIABLES	BOYS				GIRLS			
	1.GRADE AS±SD	2. GRADE AS±SD	3. GRADE AS±SD	4. GRADE AS±SD	1. GRADE AS±SD	2. GRADE AS±SD	3. GRADE AS±SD	4.RAZRED AS±SD
HEIGHT	129±6.48	137.8±7.49	140.56±7.18	146.52±6.11	129.5±5.30	133.1±5.32	138.07±6.80	149.47±8.09
WEIGHT	29.6±7.38	33.2±9.67	36.89±9.73	40.67±8.00	29.9±5.29	29.4±7.12	36.09±9.72	46.29±14.23
BMI	17.4±3.08	17.2±3.27	18.46±3.68	18.86±3.12	17.25±2.73	16.4±2.94	18.72±3.72	20.39±4.72
S.B	10.6±6.03	10.3±7.17	13.33±9.38	11.95±7.41	12.7±2.73	10.8±7.7	15.14±8.35	20.11±11.47
S.UA	12.2±5.58	13.7±7.09	11.92±6.83	16.45±9.05	13.9±5.25	12.9±5.03	14.32±4.91	26.36±10.18
C.ABD	63.2±8.54	64.9±10.13	66.72±10.35	68.52±8.96	61.8±6.88	59.1±7.45	63.59±8.41	71.00±11.57
C.HIP	71.1±7.75	73.2±9.25	76.52±8.43	79.52±7.59	71.7±6.68	70.2±9.42	75.95±8,44	82.72±11.09
C.UA	20.3±2.73	20.7±3.54	20.81±3.14	22.38±2.94	20.6±2.42	20.1±2.84	20.95±2.65	24.67±4.58
POLYGON	21.2±4,63	21.0±7,20	16.66±4.12	17.27±4.85	23.7±4,36	20.8±4.59	20.19±6.29	22.17±5.22
TAPPING	20.2±2.98	22.6±2.98	22.94±2.34	26.43±2.60	20.3±2.80	22.4±2.68	23.82±2.87	25.61±3.87
JUMP	124.6±19.48	138.1±18.86	145.11±20.77	146.05±20.70	115.2±13.7	127.9±15.59	129.59±19.27	131.50±20.23
ABDOMEN	26.5±2.98	31.1±6.72	35.17±7.76	35.24±6.53	23.6±8.18	36.4±5.28	34.77±9.65	35.88±6.69
SIT-REACH	55.0±10.06	59.3±14.64	56.56±10.28	61.10±9.72	62.0±9.46	69.9±5.76	75.05±11.13	70.00±15.32
PULL	15.3±9.61	11.9±14.52	16.43±10.35	20.16±19.13	23.4±8.92	7.4±5.0	18.74±18.20	9.30±10.36
RUN	477.8±66.17	503.4±51.78	521.67±75.28	515.63±83,03	410.0±56.96	491.3±44.08	456.70±69.09	504.11±51.61

Table 2. T-test for independent samples (ASM = arithmetic mean for boys; ASF = arithmetic mean for girls; SDM = standard deviation of boys; SDF = standard deviation of girls; t-value = t-test; p = significance level).

	ASM	SDM	ASF	SDF	t-value	p
HEIGHT	137.43	9.3	138.71	9.83	-0.82	0.411
WEIGHT	34.31	9.47	36.34	12.09	-1.17	0.243
BMI	17.89	3.27	18.48	3.94	-1.01	0.313
S.B	**11.29**	**7.23**	**15.68**	**9.97**	**-2.74**	**0.007**
S.UA	**13.44**	**7.16**	**17.41**	**8.85**	**-3.11**	**0.002**
C.ABD	65.45	9.47	64.54	9.88	0.58	0.561
C.HIP	74.5	8.75	76.05	10.18	-1.02	0.311
C.UA	20.95	3.12	21.78	3.74	-1.5	0.135
POLYGON	**19.41**	**5.63**	**21.48**	**5.42**	**-2.3**	**0.023**
TAPPING	22.65	3.6	23.44	3.58	-1.36	0.177
JUMP	**136.51**	**21.6**	**127.5**	**18.56**	**2.7**	**0.008**
ABDOMEN	31.24	7.6	33.88	8.79	-1.95	0.053
SIT-REACH	**57.7**	**11.4**	**70.27**	**12.12**	**-6.57**	**0.00**
PULL	15.55	13.41	15.56	14.46	0.00	0.998

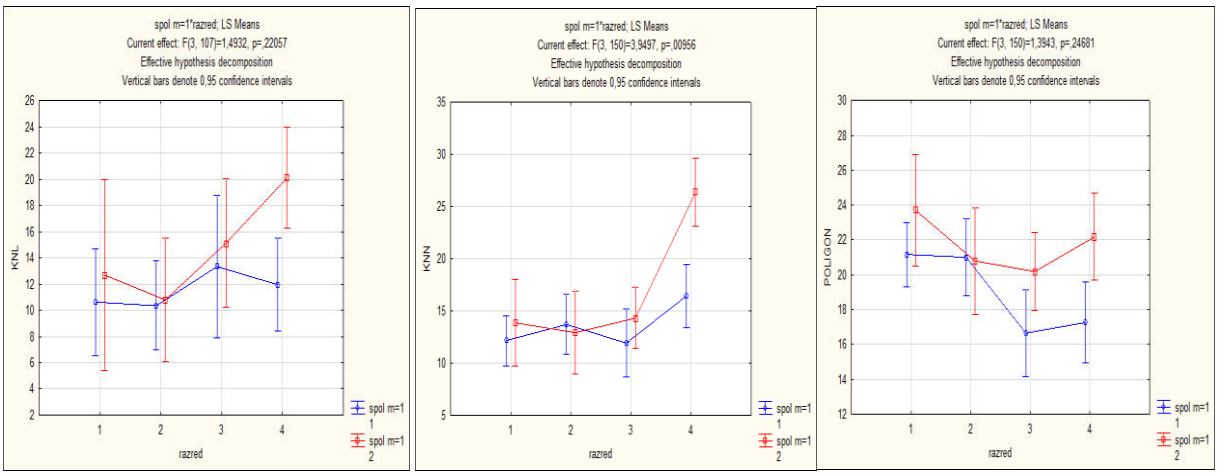
The obtained results confirm that the differentiation between the sexes begins at an early school age, i.e., some researches have recorded differences as early as in the preschool age (Trajkovski & Mišigoj-Duraković, 2014).

Standards of body fat percentage for school children and youth (6 to 17 years), based on measures of the back and upper arm skinfolds obtained in a population of American children (Lohman, 1987; according to Mišigoj-Duraković, 2008), indicate that the total sum for the boys, when their skinfolds are combined, are approximately 24 mm and, compared to the standards, at a moderate risk of obesity, while, for the girls, the total sum is approximately 33 mm, which makes them a high risk of obesity, which is a concern for both sexes.

Significant differences were obtained in the motor coordination test (POLYGON), with better results for about 2 seconds in favor of the boys as well as in the explosive leg strength test (JUMP), where boys were better than girls by about 9 cm.

Better results, in favor of the girls, were obtained in the flexibility test (SIT-REACH), where girls were better by 13 cm than the boys. Similar results have been confirmed in other studies (Malacko et al., 2015). The results of significant differences in the back and upper arm skinfolds, and polygon backwards are shown in the graphs.

Table 3 shows the results of the multivariate analysis of the variance in morphological characteristics, where differences were made by sex, age, and sex-age interaction.



Graphs 1. Differences by age and sex in the back skinfold, upper arm skinfold, and polygon backwards.

Table 3. Difference between individual groups of participants in the morphological characteristics (F = F-test; p = significance level).

		F	p
HEIGHT	**SEX**	0.50	0.332
	AGE	46.25	0.000*
	INTERACTION	2.06	0.108
WEIGHT	**SEX**	0.00	0.943
	AGE	16.55	0.000*
	INTERACTION	1.62	0.186
BMI	**SEX**	0.13	0.714
	AGE	4.61	0.004*
	INTERACTION	0.70	0.552
S.B	**SEX**	3.30	0.071
	AGE	2.85	0.040*
	INTERACTION	1.49	0.220
S.UA	**SEX**	7.89	0.005*
	AGE	13.13	0.000*
	INTERACTION	3.95	0.009
C.ABD	**SEX**	1.59	0.208
	AGE	5.31	0.001*
	INTERACTION	1.27	0.280
C.HIP	**SEX**	0.00	0.971
	AGE	10.08	0.000*
	INTERACTION	0.79	0.499
C.UA	**SEX**	0.93	0.337
	AGE	8.25	0.000*
	INTERACTION	1.42	0.239

The obtained results indicate that children differ significantly in age in all variables (height, weight, body mass index, back and upper arm skinfolds, abdominal, hip, and upper arm circumference), which had been expected, while they differ only in the upper arm skinfold with regards to sex, whereby girls have a significantly larger skinfold than boys. We can, therefore, conclude that sex differentiation begins with the measurements of skinfolds at an early school age, while some studies suggest that the differences in the subcutaneous adipose tissue dimension can be observed from the preschool age (Trajkovski Višić, 2004) in favor of larger dimensions for girls, as well as that the experimental sports program for preschool children does not cause significant improvements in anthropometric measures, except in skinfolds where the experimental group differs significantly from the control group in terms of a greater reduction of subcutaneous adipose tissue over a period of nine months. Similar findings have been obtained by other authors on larger measures of body mass and body volume in boys and larger skinfolds in girls (Bala & Katić, 2009).

Table 4 presents the results of the multivariate analysis of motor and one functional ability variance where sex, age, and sex-age interaction are distinguished.

Table 4. Difference between individual groups of participants in motor skills and one functional skill (F = F-test; p = significance level).

		F	p
POLIGON	**SEX**	8.93	0.003*
	AGE	3.65	0.014*
	INTERACTION	39.99	0.247
POLYGON	**SEX**	0.00	0.989
	AGE	23.98	0.000*
	INTERACTION	0.554	0.646
JUMP	**SEX**	14.50	0.000*
	AGE	66.01	0.000*
	INTERACTION	0.220	0.882
ABDOMEN	**SEX**	0.276	0.600
	AGE	13.08	0.000*
	INTERACTION	1.67	0.175
SIT-REACH	**SEX**	34.24	0.000*
	AGE	3.11	0.028*
	INTERACTION	1.819	0.146
PULL	**SEX**	0.251	0.616
	AGE	3.17	0.026*
	INTERACTION	2,5.	0.061
RUN	**SEX**	12.77	0.000*
	AGE	6.67	0.000*
	INTERACTION	2.09	0.103

The results obtained indicate that children differ significantly in all variables of motor abilities (coordination, strength, flexibility, speed of

alternative movements). As they get older, they achieve better results, as other studies have confirmed. In the area of aerobic endurance measured by the 3-minute running test and where children averaged between 410 and 570 meters, this means that their aerobic ability was better expressed with increasing age. Significant differences with respect to age were confirmed in four variables. Boys dominated in three tests: polygon, jump, and run, while girls achieved better results in the flexibility test.

Conclusion

It may be concluded that, in the morphological space of children aged 7-10 years, developmental processes based on sex differentiation and genetic determination are fairly uniform, while this is more pronounced in the motor and functional space in favor of boys at this age.

In light of all the above, it can be stated that detailed knowledge about the limiting factors and critical (sensitive) periods (Koprivica, Arunović, & Radisavljević, 1994), as well as the dynamics of development of morphological characteristics and motor abilities within and between the sexes, which mainly describe general regulations of ontogeny, are a necessary prerequisite and precondition for the proper and effective management of transformation processes in education and sport, which applies equally to all other dimensions of personality.

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