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THE ONTOGENETIC DEVELOPMENT OF MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES OF BOYS AND GIRLS IN EARLY ELEMENTARY SCHOOL

ONTOGENETSKI RAZVOJ MORFOLOŠKIH ZNAČILNOSTI IN MOTORIČNIH SPOSOBNOSTI DEČKOV IN DEKLIC V PRVIH LETIH OSNOVNE ŠOLE

Abstract

A standard 11-test battery of anthropometric and motor measuring instruments was applied to a sample of 4,429 elementary school pupils (7-11 years of age) from the Coast and Gorski Kotar County in Croatia. The sample included 2,202 boys and 2,227 girls which attended first four grades of primary school. The aim of the study was to determine the ontogenetic development of particular anthropometric and motor variables within the genders across the first four grades of elementary school and to determine probable developmental gender differences in the mentioned variables. In order to determine the intragroup and intergroup differences the statistical method of MANOVA/ANOVA was applied. The results showed that anthropometric and motor variables are developing evenly and steadily in the observed age groups. That progress is in congruence with the common genetic potential (endogenous factors) and influenced by the applied teaching contents (exogenous, environmental factors). It is slightly more intensive in boys. In girls higher values were registered only for the anthropometric variable subcutaneous fatty tissue and for the motor variable flexibility.

Key words: ontogenesis, anthropometry, motor abilities, gender differences, children

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Izvleček

S standardno 11-testno baterijo smo ugotavljali antropometrične in motorične značilnosti 4429 osnovnošolskih otrok (starih od 7 do 11 let) iz Primorsko-goranske županije na Hrvaškem. V študiji je sodelovalo 2202 dečkov in 2227 deklic, ki so obiskovali prve štiri razrede osnovne šole. Namen raziskave je bil opredeliti ontogenetski razvoj nekaterih antropometričnih in motoričnih spremenljivk v prvih štirih razredih osnovne šole ter določiti morebitne razvojne razlike med spoloma v omenjenih spremenljivkah. Za ugotavljanje razlik tako znotraj skupine kot tudi med skupinami smo uporabili statistično metodo MANOVA/ANOVA. Rezultati so pokazali, da se antropometrične in motorične spremenljivke v obravnavanih starostnih skupinah enakomerno in stalno razvijajo. Razvoj poteka skladno s splošnim genetskim potencialom (endogeni dejavniki) in pod vplivom uporabljenih učnih vsebin (eksogeni dejavniki oz. dejavniki okolja). Pri dečkih je razvoj nekoliko intenzivnejši. Pri deklicah so bile višje vrednosti zabeležene le pri antropometrični spremenljivki podkožno maščobno tkivo in pri motorični spremenljivki gibljivost.

Ključne besede: ontogeneza, antropometrija, motorične sposobnosti, razlike med spoloma, otroci

INTRODUCTION

The influence (or transformational power) of various processes of physical exercise and/or sport training on growth and development in general and on certain anthropological characteristics of children in particular is one of the key issues of physical education (PE) and sport. Research studies on these topics commonly focus on various components of the entire process of managed physical exercise and/or sport training – they investigate goals, tasks, the condition of exercisers or trainees and limiting factors, as well as designs (consisting of prognosis or modelling, a diagnosis, a plan, a programme and control of the training process) of physical exercise and/or sport programmes (Findak, 1999; Malacko, 2000; Mraković, 1992, 1994; Pejčić, 2002).

It is impossible to design and apply an optimal transformational process in physical exercise or sport training with boys and girls in the period of intensive growth and development if it is not known which anthropological characteristics, abilities and motor knowledge and skills are engaged in that educational or sport process (Malacko, 2000). Further, the importance of anthropological features, that is, their hierarchically defined influence on performance and efficacy of the process, must also be known as well as which contents, methods and loads (kinesiological operators) are the best for their optimal development. Finally, it is important to know how and with which measuring instruments these features can be assessed and monitored.

The recent ever more serious warnings on the unacceptably low efficiency of PE classes, coming from both professionals and the broader community, are directing the focus of current kinesiological research onto the issues of PE teaching's effectiveness and quality. PE programmes oriented to too great a body of motor knowledge and too many motor skills that should be mastered during classes, which is typical of most school levels in many European countries, do not provide any guarantee that the transformation of relevant anthropological abilities and characteristics can be achieved. Yet the latter should be the basic aim of PE teaching in schools.

Further it should be said here that, unfortunately, the key biological principles of development are not respected in current PE curricula. Namely, it is a well-known fact that anthropological abilities and characteristics are developed and improved most successfully in those periods when such a transformation is biologically feasible, namely in the periods of childhood and adolescence. From this, the other principle emerges – the smaller the transformation coefficient of a particular anthropological, especially motor, ability or characteristic, that is, the greater the genotypic part of the variance, the earlier the commencement of development is needed. This confirms the view that it is wrong to give preference only to the instructional component of PE classes in which many contents should be mastered because motor skills, knowledge and habits can be acquired later in life, but any neglect of developing certain relevant anthropological characteristics and abilities on time can hardly be compensated for later.

Many authors have found no significant differences in anthropological characteristics between boys and girls of 7-14 years of age. The existing small, but still obvious differences are permanent throughout the entire age period with a slight tendency for them becoming bigger at the end of the period (Rajtmajer, 1997). Only at the age of 13-14 years may the dynamic enhancement

of strength be observed in boys, whereas in girls strength shows a tendency of stabilisation or even regression (Važni, 1975).

The efficiency of the transformational process depends primarily on the structure of morphological characteristics and motor abilities that should be transformed or improved (Gredelj, Hošek, Metikoš, & Momirović, 1975; Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975; Metikoš, Gredelj, & Momirović, 1979; Stojanović, Momirović, Vukosavljević, & Solarić, 1975; Strel & Šturm, 1981). This primarily regards the so-called limiting factors of trainability, that is, those factors that limit the influence of physical exercise or sport training to a considerable degree. Consequently, these factors limit the final physical or motor achievements in humans.

When the morphological characteristics and motor abilities of children in the 1^{st}-4^{th} grades of elementary school are concerned, which are the subject of this paper, one must know that they are more or less hereditary, meaning that the effects of the directed physical exercise or sport training programmes depend considerably on their respective hereditary coefficients (Pejčić, 2002).

The coefficient of heredity is part of the variance of each anthropological feature which is under the strong influence of genetic factors, namely, it denotes that part of the variance which is not sensitive to significant changes. For that purpose, Holtzinger's tables, the so-called Holtzinger's coefficient of heredity (H^2), are most commonly used although many authors have obtained similar research results (Malacko & Popović, 2001). The portion of genetically conditioned variance is not the same for every feature, ability and characteristic; it practically means that: '… the greater the portion of the genotype in the variance of a particular dimension, the lower the exogenous influence on the dimension during the lifetime span, and vice versa, the smaller the portion of the genotype in the variance, the greater the influence of the physical conditioning programmes' (Mraković, 1992).

It is well known (e.g., Malacko, 2000), for example, that no influence is possible on the morphological dimensionality of the skeleton (H^2=.98), that the voluminosity of the body can be influenced to a certain extent (H^2=.90), whereas the influence on fatty tissue is the biggest (H^2=.50). The possibility of influencing motor speed is insignificant (H^2=.90-.95); the influence on explosive power is somewhat larger (H^2=.80-.85), whereas it is biggest when strength endurance (static and dynamic alike) is in question (H^2=.50). Therefore, the physical conditioning processes should logically be directed to the development of those human characteristics and abilities that are actually transformable. Otherwise, particular human features, abilities and characteristics may not be developed to their optimum level (potential).

The second most important limiting factor is the biological fact that individual human features, abilities and characteristics, consequently the whole ontogenetic development, do not evolve evenly and simultaneously; the phenomenon is known as heterochrony in development. Basically, 'heterochrony is manifested, on the one hand, in heterochronic formation and variable tempo of maturation of particular fragments of an individual functional system, and, on the other, in heterochronic formation and maturation of various organic structures indispensable for various periods of postnatal growth and development of an organism' (Aršavskij, 1975).

Alternating changes in the process of ontogenesis proceed through certain phases, stages and periods that determine the natural sequence of the most pronounced age-related changes.

According to Mraković (1992) there is a general rule that during a lifetime span after a period of a relatively slow development (1) comes the period of accelerated development (2), followed by the stage of slowing down (3) and the stage of reaching the plateau (upper limit), or the period of retention of the achieved developmental level (4), after which the process of deterioration prevails (5). The most important task of education in general, and especially of PE or of applied kinesiology in education, can be derived from this general principle of biological development of human characteristics and abilities: during the ontogenetic development stimuli should be in the function of the maximal transformation of human abilities and characteristics, and not exclusively in the function of knowledge and skill acquisition, particularly not of the ones of the lower level.

In the conceptual approach the consensus has been reached to divide the whole ontogenesis into several stages of biological development. It is assumed that each new stage is characterised by a sequence of changes on the cellular level, which in turn determine the following phases or stages and periods of development. These stages are nowadays called the 'critical' or 'sensitive' periods of development. In the literature (e.g., Gužalovski, 1984) 'critical periods' are usually understood as periods of ontogenesis or spans of time during which a developing organism is particularly susceptible to the influence of an event, stimulus or mitigating factors coming from the environment if these influences are, by their direction, congruent with the basic trends of the natural process of morpho-functional changing. The individual development of certain features, abilities or characteristics is particularly great and fast within these spans, the adaptation potential is enhanced and favourable prerequisites are formed for the acquisition of skills, habits and information of a particular nature.

Previous research on the ontogenetic development of school children and the young has demonstrated convincingly the existence of the critical, or sensitive, periods in the development of motor functions in terms of indicators of the dynamics of motor abilities' manifestation and by defining the age-related characteristics of physiological preconditions necessary for their manifestation. According to Gužalovski (1984), Vygotsky pointed out the issue back in 1935 through his requests that optimal teaching time (terms) should be defined in accord with the critical periods in the growth and development of children. It was his opinion that the same factors may have various effects on the development of children – in one period they may have a positive influence, whereas on other occasions they may produce no effect at all (be neutral), or they may produce even negative effects.

Numerous previous research studies indicate that ontogenetic development may be defined as 'an integrated result of the combined influence of human nature (genotype) and of the environmental factors, where the internal nature of the organism, at all stages of ontogenesis, respond variably to the influences coming from the environment because it is not equally or compactly sensitive to the influence of different external elements' (Karsajevskaja, 1970).

Therefore, a profound comprehension of the limiting factors, critical (sensitive) periods, and the dynamism of the development of morphological characteristics and motor abilities within genders, as well as of developmental gender differences, which represent general laws of ontogenesis to the greatest extent, is an indispensable precondition for the efficient management of the transformational processes in physical education and sport. Based on the above demonstrated approach, concept and previous research, the aim of this cross-sectional study is to determine, on one hand, the ontogenetic development of morphological characteristics and

motor abilities of boys and girls of 7-11 years of age, pupils of the first four grades of elementary school, on the basis of the gender-related intragroup differences between the grades while, on the other hand, to also determine probable developmental gender differences in the mentioned variables across the four grades.

METHOD

Participants

The sample of participants consisted of 4,429 boys and girls, first- to fourth-graders (7 to 12 years olds) of the elementary school of the Coast and Gorski Kotar County (Primorsko-goranska županija) in Croatia. There were 2,202 male pupils (first grade $n_1 = 566$, second grade $n_2 = 561$, third grade $n_3 = 561$, fourth grade $n_4 = 514$) and 2,227 female pupils (first grade $n_1 = 575$, second grade $n_2 = 543$, third grade $n_3 = 569$, and fourth grade $n_4 = 540$).

Instruments

The sample of variables consisted of a standard 11-test battery of measuring instruments assessing anthropometric characteristics and motor abilities. The battery is regularly used in the education system of the Republic of Croatia.

In the context of morphology the following latent, that is manifest anthropometric, variables (measures) were utilised: *longitudinal dimensionality of the skeleton* – body height (ABH), *body mass and voluminosity of the body* – body weight (ABW) and forearm circumference (ACF), and *subcutaneous body fat* – upper-arm skinfold (AUS).

In the context of motor abilities the following latent, that is manifest anthropometric, variables (measures) were utilised: *speed of movement* – hand tapping (MHT), *explosive strength (power)* – standing long jump (MLJ), *body co-ordination* - polygon backwards (MPB), *dynamic muscular endurance* – sit-ups in 60 seconds (MSU), *flexibility* – straddle forward bend (MFB), *static muscular endurance* – pull-up hang (MPH) and *aerobic endurance* – 3-minute running (F3).

Procedure

In order to determine intragroup and intergroup differences between the boys and the girls of the first (M_1), second (M_2), third (M_3) and fourth (M_4) grades the statistical method of multivariate and univariate analysis of variance (MANOVA/ANOVA) was applied.

Multivariate testing of the null-hypothesis, saying that the centroids of the groups were equal to the common centroid (GENERAL MANOVA), was performed by means of Λ-relationships (Wilks' Lambda test) and Rao's coefficient (Rao's R). Their statistical significance was also determined (p-level). The univariate statistical significance of the differences (p-level) among the arithmetic means of the observed groups (grades) was calculated by using an F-test.

RESULTS

Statistically significant differences among the four groups (M – mean) of the male (Table 1) and female (see Table 2) participants (the 1^{st} - 4^{th} graders of elementary school) were obtained at the level of .00 (p=.00) for the whole 11-item set (multivariate and univariate) of anthropometric and motor variables.

In the context of anthropometry (A), the univariate differences in the means of longitudinal dimensionality of the skeletons of boys, obtained by means of variable 1 (ABH – body height) were as follows: between 1st and 2nd grades 4.69 cm, 2nd and 3rd grades 6.21 cm, and between 3rd and 4th grades 5.44 cm. The same differences in the group of girls were: between the 1st and 2nd grades 5.41 cm, 2nd and 3rd grades 6.10 cm, and between 3rd and 4th grades the difference is just 2.24 cm.

Similar findings are obvious in body mass and body voluminosity, where variables 2 (ABW – body weight) and 3 (ACF – forearm circumference) were measured. It can be concluded that boys and girls are steadily following their body weight.

Table 1: Multivariate and univariate analysis of variance (MANOVA/ANOVA) of the set of anthropometric and motor variables in boys of the first to fourth grades of elementary school

Variables	M_1	M_2	M_3	M_4	*F*	*p*
ABH	128.82	133.51	139.72	144.64	637.71	.00*
ABW	27.94	31.25	35.52	38.85	263.82	.00*
ACF	19.00	19.45	20.23	20.80	90.20	.00*
AUS	10.30	9.76	10.36	10.60	4.23	.00*
MHT	18.07	21.42	22.92	24.82	305.09	.00*
MLJ	118.33	130.45	142.50	151.86	250.51	.00*
MPB	22.73	20.02	18.26	17.86	62.19	.00*
MSU	22.83	29.06	31.04	33.19	200.18	.00*
MPH	36.69	39.40	44.63	44.98	91.27	.00*
MFB	16.69	20.99	26.33	28.86	47.72	.00*
F3	467.28	506.58	545.98	584.93	177.59	.00*

Wilks' Lambda = .34 Rao's R = 84.86 p - level = .00*

Legend:

M_1	mean value, boys 1st grade (N_1=566)	MLJ	standing long jump
M_2	mean value, boys 2nd grade (N_2=561)	MPB	polygon backwards
M_3	mean value, boys 3rd grade (N_3=561)	MSU	sit-ups in 60 sec
M_4	mean value, boys 4th grade (N_4=514)	MPH	pull-up hang
ABH	body height	MFB	straddle forward bend
ABW	body weight	F3	running for 3 min
ACF	circumference of forearm	F	F-test
AUS	upper-arm skin fold	p	level of significance
MHT	hand tapping		

The differences in the means of body weight in the group of boys were: between the 1st and the 2nd grades 3.31 kg, 2nd and 3rd grades 4.27 kg, and 3rd and 4th grades only 3.33 kg, whereas the same differences among forearm circumferences of boys were: 1st and 2nd grades 0.45 cm, 2nd and 3rd grades 0.75 cm, and 3rd and 4th grades 0.57 cm.

In girls, the same differences in body weight were: between the 1st and the 2nd grades 2.92 kg, 2nd and 3rd grades 4.26 kg, and 3rd and 4th grades only 1.72 kg, whereas the differences in forearm circumferences were: between the 1st and the 2nd grades 0.44 cm, 2nd and 3rd grades 0.73 cm, and 3rd and 4th grades 0.32 cm.

In the dimension of subcutaneous fatty tissue, measured by variable 4 (AUS – upper-arm skinfold), it is obvious that the children (both boys and girls) of the 2nd grade had the lowest values (the best achievement), whereas the 4th graders had the highest values (the worst achievement). The differences in the amount of subcutaneous fatty tissue in boys were: between the

1st and the 2nd grades -0.54, 2nd and 3rd grades 0.60, and 3rd and 4th grades 0.24. In girls, the same differences were: between the 1st and the 2nd grades -0.39, 2nd and 3rd grades 0.62, and 3rd and 4th grades 0.38.

In the context of motor variables (M), the speed of movement was assessed by means of variable 5 (MHT – hand tapping). Both boys and girls achieved enhanced values in terms of their ages. The differences in the means of the speed of movement in the group of boys were: between the 1st and the 2nd grades 3.35 repetitions, 2nd and 3rd grades 1.50 repetitions, and 3rd and 4th grades 1.90 repetitions. In girls, the same differences were: between the 1st and the 2nd grades 2.55 repetitions, 2nd and 3rd grades 1.78 repetitions, and 3rd and 4th grades 2.40 repetitions.

Table 2: Multivariate and univariate analysis of variance (MANOVA/ANOVA) of the set of anthropometric and motor variables in girls of the first to fourth grades of elementary school

Variables	M_1	M_2	M_3	M_4	*F*	*p*
ABH	127.16	132.57	138.67	140.91	552.91	.00*
ABW	26.80	29.72	33.98	35.70	209.75	.00*
ACF	18.47	18.91	19.64	19.96	73.68	.00*
AUS	11.21	10.82	11.44	11.82	5.52	.00*
MHT	17.84	20.39	22.68	25.08	396.76	.00*
MLJ	108.62	118.97	131.30	130.86	179.44	.00*
MPB	26.99	22.44	20.42	20.22	120.40	.00*
MSU	23.66	26.42	28.30	28.89	57.29	.00*
MPH	37.84	43.62	48.20	47.14	143.00	.00*
MFB	11.25	14.60	18.83	19.47	41.79	.00*
F3	445.52	473.54	509.04	525.11	110.70	.00*

Wilks' Lambda = .35 Rao's R = 84.28 p – level = .00*

Legend:

M_1 mean value, girls 1st grade (N_1=575)
M_2 mean value, girls 2nd grade (N_2=543)
M_3 mean value, girls 3rd grade (N_3=569)
M_4 mean value, girls 4th grade (N_4=540)
ABH body height
ABW body weight
ACF circumference of forearm
AUS upper-arm skin fold
MHT hand tapping
MLJ standing long jump
MPB polygon backwards
MSU sit-ups in 60 sec
MPH pull-up hang
MFB straddle forward bend
F3 running for 3 min
F F-test
p level of significance

The explosive strength of legs was assessed by variable 6 (MLJ – standing long jump). The 2nd and 3rd graders of both sexes achieved higher values, whereas the 4th graders had lower values. The differences in the means of the standing long jump in the group of boys were: between 1st and 2nd grades 12.12 cm, 2nd and 3rd grades 12.05 cm, and 3rd and 4th grades 9.36 cm. In girls, the same differences were: between 1st and 2nd grades 10.35 cm, 2nd and 3rd grades 12.33 cm, and 3rd and 4th grades 0.44 cm.

Body co-ordination was assessed by variable 7 (MPB - polygon backwards). The boys and girls from all the four age groups scored lower values, meaning they achieved good results. The differences in the means of body co-ordination in the group of boys were: between the 1st and the 2nd grades 2.71 s, 2nd and 3rd grades 1.76 s, 3rd and 4th grades -0.40 s. In girls, the same differences were: between the 1st and the 2nd grades -4.55 s, 2nd and 3rd grades -2.02 s, 3rd and 4th grades -0.20 s.

Muscular endurance (dynamic) of the trunk (abdominal muscles) was assessed by variable 8 (MSU – sit-ups in 60 s). The subjects of the 2nd and 3rd grades scored higher than the pupils of the 4th grades. The differences in the means of the variable of muscular endurance in the group of boys were: between the 1st and the 2nd grades 6.23 repetitions, 2nd and 3rd grades 1.44 repetitions, 3rd and 4th grades 2.15 repetitions. Girls: between the 1st and the 2nd grades 2.76 repetitions, 2nd and 3rd grades 1.88 repetitions, 3rd and 4th grades 0.59 repetitions.

Flexibility was assessed by variable 9 (MFB – straddle forward bend). Pupils from the 1st to the 3rd grades scored better than their colleagues from 4th grade. The differences in the means of forward bend in the group of boys were: between the 1st and the 2nd grades 2.71 cm, 2nd and 3rd grades 5.23 cm, 3rd and 4th grades 0.35 cm. In girls, the differences were: between the 1st and the 2nd grades 5.78 cm, 2nd and 3rd grades 4.58 cm, 3rd and 4th grades -1.06 cm.

Table 3: Multivariate and univariate analysis of variance (MANOVA/ANOVA) between the boys and girls of 1st to 4th grades of elementary school in the system of anthropometric and motor variables

Variables	*1st grade*		*2nd grade*		*3rd grade*		*4th grade*	
	Mb	*Mg*	*Mb*	*Mg*	*Mb*	*Mg*	*Mb*	*Mg*
ABH	128.82	127.16	133.51	132.57	139.72	138.67	144.64	140.91
ABW	27.94	26.80	31.25	29.72	35.52	33.98	38.85	35.70
ACF	19.00	18.47	19.45	18.91	20.23	19.64	20.80	19.96
AUS	10.30	11.21	9.76	10.82	10.36	11.44	10.60	11.82
MHT	18.07	17.84	21.42	20.39	22.92	22.68	24.82	25.08
MLJ	118.33	108.62	130.45	118.97	142.50	131.30	151.86	130.86
MPB	22.73	26.99	20.02	22.44	18.26	20.42	17.86	20.22
MSU	22.83	23.66	29.06	26.42	31.04	28.30	33.19	28.89
MPH	36.69	37.84	39.40	43.62	44.63	48.20	44.98	47.14
MFB	16.69	11.25	20.99	14.60	26.33	18.83	28.86	19.47
F3	467.28	445.52	506.58	473.54	545.98	509.04	584.93	525.11
	λ = .76		λ = .73		λ = .78		λ = .66	
	R = 31.48		R = 35.29		R = 28.05		R = 47.77	
	p = .00*		p = .00*		p = .00*		p = .00*	

Legend:

Mb	mean value of boys	AUS	upper-arm skin fold	MPH	pull-up hang
Mg	mean value of girls	MHT	hand tapping	MFB	straddle forward bend
ABH	body height	MLJ	standing long jump	F3	running for 3 min
ABW	body weight	MPB	polygon backwards		
ACF	circumference of forearm	MSU	sit-ups in 60 sec		

Muscular endurance (static strength of the shoulders and arms) was assessed by variable 10 (MPH – pull-up hang). The pupils of the 2nd and 3rd grades scored better than the pupils of the 4th grade. The differences in the means of pull-up hang in the group of boys were: between the 1st and the 2nd grades 4.30 s, 2nd and 3rd grades 5.34 s, 3rd and 4th grades 2.53 s. In girls: between the 1st and the 2nd grades 3.35 s, 2nd and 3rd grades 4.20 s, 3rd and 4th grades 0.64 s.

Aerobic endurance was assessed by variable 11 (F3 – 3-minute running). It is obvious that the observed subjects had enhanced values. The differences in the means of the variable aerobic endurance in the group of boys were: between the 1st and the 2nd grades 39.3 m, 2nd and 3rd grades 39.4 m, 3rd and 4th grades 38.95 m. In girls: between the 1st and the 2nd grades 28.02 m., 2nd and 3rd grades 35.50 m, 3rd and 4th grades only 16.07 m.

From Table 3 it is obvious that in the whole set (multivariate) of 11 variables there are statistically significant differences in arithmetic means (M) between boys (b) and girls (g) from the 1st to 4th grades of elementary school at the level of 0.00.

In variable 1 (ABH – body height) it is obvious that boys from all the age groups (four grades) are taller than girls, which was expected. The difference in body height between boys (Mb) and girls (Mg) is: in the first grade 1.66 cm, in the second 0.94 cm, in the third 1.05 cm, and in the fourth grade even 3.73 cm.

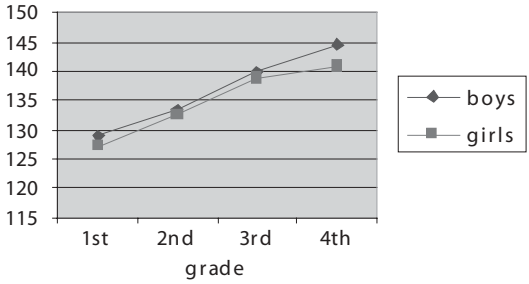

Figure 1: Gender differences in variable 1 (body height).

Something similar was expected for body weight (ABW), meaning that body weight followed the values of body height. The difference in body weight between boys (Mb) and girls (Mg) is: in the first grade 1.44 kg, in the second grade 1.53 kg, in the third 1.54 kg, and in the fourth grade even 3.15 kg.

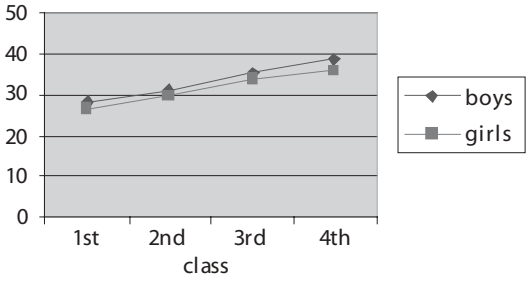

Figure 2: Gender differences in variable 2 (body weight)

In variable 3 (ACF – forearm circumference) the values were slightly higher in boys in all grades. The differences in forearm circumference between boys (Mb) and girls (Mg) were: in the first grade 0.53 cm, in the second grade 0.54 cm, in the third 0.59 cm, and in the fourth grade 0.84 cm.

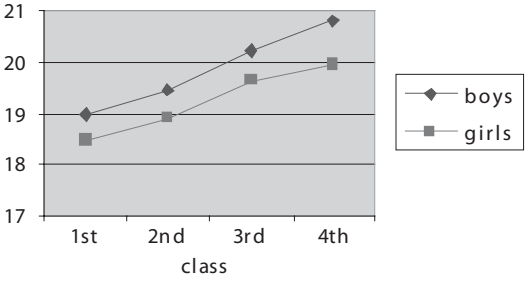

Figure 3: Gender differences in variable 3 (forearm circumference)

In variable 4 (AUS – upper-arm skinfold) the girls had higher values, which was as expected on the basis of previous research. The differences between boys and girls were in the 1st grade 0.91 cm, 2nd 1.06 cm, 3rd 1.08 cm, and in the 4th grade 1.22 cm.

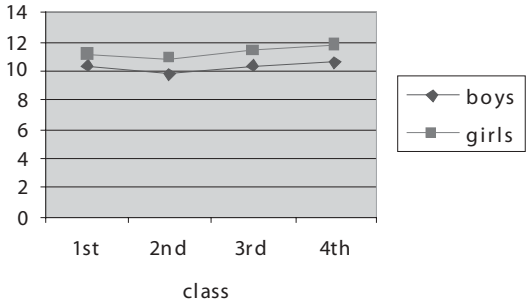

Figure 4: Gender differences in variable 4 (upper-arm skinfold)

In the context of motor abilities, where the speed of movement was assessed by variable 5 (MHT – hand tapping), boys from the first three grades achieved enhanced values, whereas the girls of 4th grade scored better than their younger colleagues. The differences between boys and girls were in the 1st grade 0.23 repetitions, 2nd 1.03 repetitions, 3rd 0.24 repetitions in favour of the boys, whereas in the 4th grade the difference of 0.26 was in favour of the girls.

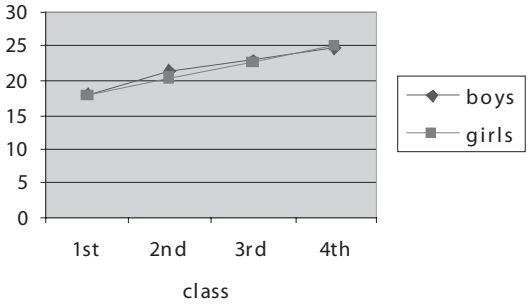

Figure 5: Gender differences in variable 5 (hand tapping)

In the context of motor abilities, where the power (explosive strength) of the legs was assessed by variable 6 (MHT – standing long jump), boys from all four grades scored considerably better than the girls. The differences between boys and girls were in the 1st grade 9.71 cm, 2nd 11.48 cm, 3rd 11.20 cm, and 4th 21.00 cm.

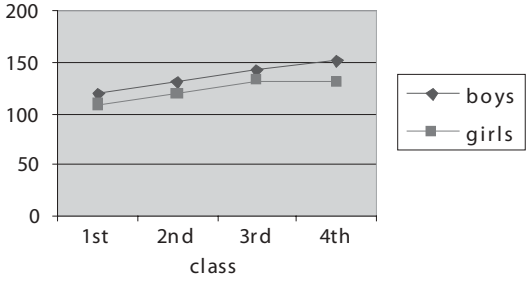

Figure 6: Gender differences in variable 6 (standing long jump)

In variable 7 (MPB - polygon backwards), assessing body co-ordination, the boys from all four grades scored better (achieved lower test results). The differences between boys and girls were in the 1st grade 4.26 s, 2nd 2.40 s, 3rd 2.74 s, and 4th 4.30 s.

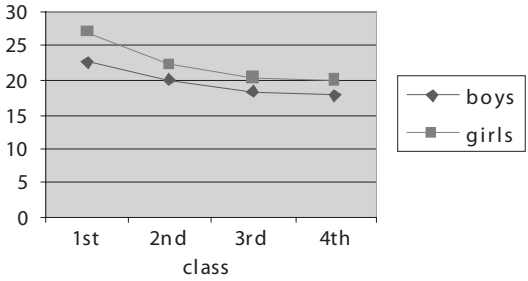

Figure 7: Gender differences in variable 7 (polygon backwards)

Muscular endurance (dynamic) of the trunk (abdominal muscles) was assessed by variable 8 (MSU – sit-ups). The girls from 1st grade performed better than the boys, but the boys from the higher grades were better than their female classmates. The differences between boys and girls were in the 1st grade 0.83 repetitions in favour of the girls, in the 2nd the difference was 2.64 repetitions, in the 3rd 2.74 repetitions, and in the 4th grade 4.30 repetitions, all in favour of the boys.

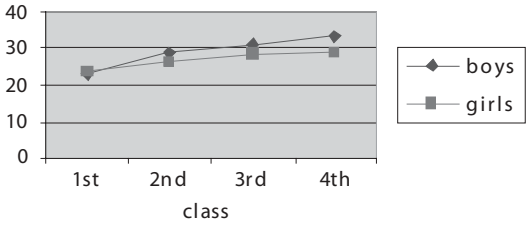

Figure 8: Gender differences in variable 8 (sit-ups)

Flexibility was assessed by variable 9 (MFB – straddle forward bend). The girls from all four grades scored better than the boys, which was as expected. The differences between boys and girls were in the 1st grade 1.15 cm, in the 2nd 4.22 cm, in the 3rd 3.57 cm, and in the 4th grade 2.16 cm.

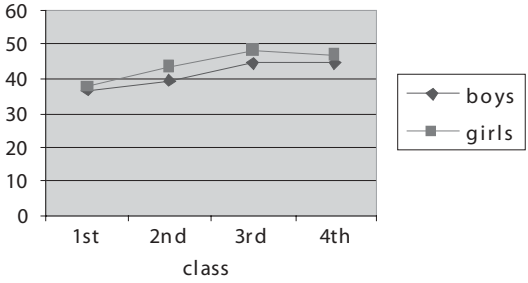

Figure 9: Gender differences in variable 9 (straddle forward bend)

Muscular endurance (static strength of the shoulders and arms) was assessed by variable 10 (MPH – bent-arm hang). The boys from all four grades scored better than the girls. The differences between boys and girls were in the 1st grade 5.44 s, in the 2nd 6.39 s, in the 3rd 7.50 s, and in the 4th grade 9.39 s.

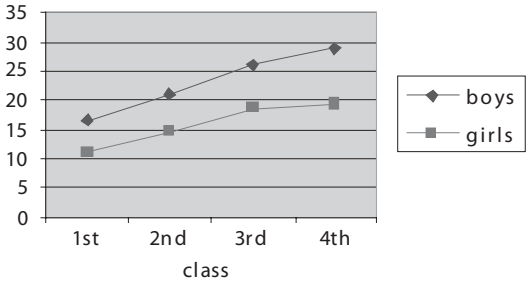

Figure 10: Gender differences in variable 10 (bent-arm hang)

Cardiorespiratory fitness (aerobic endurance) was assessed by variable 11 (F3 – 3-minute running). The boys of all four grades scored better than their female classmates. The differences between boys and girls were in the 1st grade 21.76 m, in the 2nd 33.04 m, in the 3rd 36.94 m, and in the 4th grade 59.82 m.

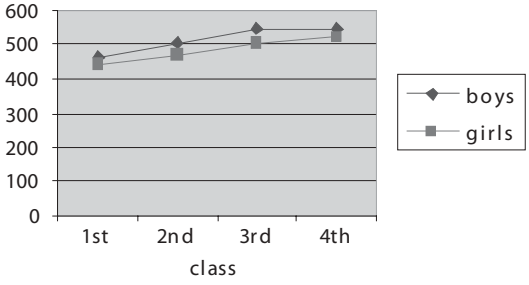

Figure 11: Gender differences in variable 11 (3-minute running)

DISCUSSION

In this research statistically significant multivariate (in the whole set of variables) and univariate (between particular variables) intergroup differences were expected among the arithmetic means of the four age subgroups (1st-4th grades) in both genders. The differences were expected due to the one-year period between the particular grade. At this stage of growth and development this is a relatively long time period in which significant changes in morphological characteristics and motor abilities may occur under the influence of internal (hereditary) and external (environmental) factors.

In addition, the statistically significant differences between boys and girls in the 1st-4th grades were expected in the whole set of variables (multivariate) and in particular variables (univariate) on the basis of the already known gender differences that are typical for these ages.

The authors were particularly interested in gaining an insight into the ontogenetic development of individual anthropometric and motor variables by gender within the same grade, as well as into gender differences occurring in the development of the same variables between particular grades.

It is obvious that the morphological (anthropometric) variables, including longitudinal dimensionality of the skeleton (ABH – body height), body mass and voluminosity (ABW – body weight and ACF – forearm circumference), are progressing in a steady and even way across the age subgroups (1st-4th grades) in accordance with the regular genetic projections and the well-known fact that this progress is somewhat more intensive in boys. As far as the variable of subcutaneous fatty tissue is concerned (AUS – upper-arm skinfold), it is obvious that in girls these values are not only somewhat higher than in boys, but that they are also showing a trend of a mild increase over the years, whereas in boys these values do not change.

The motor variables of both the boys and girls are also progressing evenly and steadily across the defined age periods (1st-4th grades). The boys achieved better in the following variables: speed of movement (MHT – hand tapping), explosive strength (power; MLJ – standing long jump), body co-ordination (MPB - polygon backwards), dynamic muscular endurance (MSU – sit-ups in 60 s), static muscular endurance (MPH – pull-up hang) and aerobic endurance (cardiorespiratory fitness) (F3 – 3-minute running), whereas the girls scored better only in the variable of flexibility (MFB – straddle forward bend).

It can be concluded that the ontogenetic development of children aged 7-11 years from the Coast and Gorski Kotar County (Primorsko-goranska županija) in Croatia is occurring evenly under the influence of both endogenous potentials and exogenous factors. The latter include: PE teaching contents, sport training contents, amount of time dedicated to the process of transformation, extensity and/or intensity of physical exercise or sport training, work conditions, expertise of PE teachers or sport trainers, interest of the community and broader society or the system of values regarding the hierarchical importance of anthropological features, abilities and characteristics, and the technology of physical exercise or sport training.

To conclude, a recommendation can be given: in designing and applying physical exercise and sport training programmes much more attention should be paid to girls, to the development, on one hand, of their static and dynamic muscular endurance and, on the other, of cardiorespiratory fitness (aerobic endurance in running). These motor abilities can be considerably transformed (improved) in this age since gender differentiation has still not started and because these abilities are not strongly hereditarily limited.

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