ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Anthropometric and growth characteristics of schoolchildren in Novi Sad

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SUMMARY

Introduction/Objective Growth, development and maturation are periods marked with individual physical characteristics, which provide the insight into the health status together with anthropometric indicators and physical appearance of an individual.

The aim was to determine body height and body weight of a representative sample of schoolchildren from Novi Sad, to make a comparative analysis in relation to age and gender, and to determine the beginning of accelerated growth.

Methods Sample included 11,676 pupils aged 6–15 years, from Novi Sad, Serbia. The basic anthropometric measurements (body height and body weight) were performed according to recommended methodology.

Results The average values of boys' body height ranged from 125.39 cm in those aged up to six years, to 175.09 cm for boys aged 15, and in girls from 124.07 cm at the age of six, to 165.77 cm for the oldest examined girls. The average values of boys' body weight ranged from 25.58 kg at the age of six to 61.38 kg at the age of 15, and in girls from 23.94 kg in youngest to 54.46 kg, at the age of 15. The analysis of body weight and body height relation in the sample of boys and girls showed significant differences in all age groups, being most significant in boys aged from 11 to 13 years and in girls aged from nine to 12 years, marking the beginning of the rapid growth period.

Conclusion Having analyzed two basic anthropometric characteristics, i.e. body height and body weight, the authors found significant differences in the increase of these characteristics among the age groups of the study sample. In addition, the results of this research are in accordance with those reported in literature, which suggest that a sudden ponderal and statural growth starts earlier in girls than in boys.

Keywords: anthropometric measurements; development and growth; schoolchildren

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INTRODUCTION

Body dimensions are a very important individual characteristic in all phases of life, starting from the intrauterine period to the late adulthood. Morphological, that is anthropometric characteristics including body weight (BW), body height (BH), subcutaneous adipose tissue thickness as well as others, play a significant role in the assessment of growth, development, health status and maturation of the organism. They are also in association with morbidity and mortality [1, 2, 3].

Measuring and assessing physical characteristics in childhood and in adolescence are important for the assessment of growth, development, maturation and nutritional status, and they give important information on health potential as well. Physical characteristics of boys and girls start to differ after the period of infancy, which is well documented in literature. One of the most important differences is the sudden increase in BH among boys just before the beginning of their sexual maturation, which starts a year or two later than in girls. Boys grow more rapidly than girls do in the period of puberty, and continue to grow longer than girls [4–7].

The school period is an important period from the perspective of growth and development of children. At the beginning of primary school, sustained growth continues. According to literature, the average growth of children is about 5–6 cm per year and gain in weight is about 2 kg, while the percentage of body fat reduces. After the 10th year of age, an average weight gain is about 4 kg per year, and new accumulation of body fat commences [8, 9].

Also, in schoolchildren, the differences in body characteristics are expected regarding gender. At the age of seven years, boys are expected to be taller than girls on average about 2 cm. The differences in BW are insignificant. On average, at the age of 10 years, girls are expected to be 1 cm taller and 1 kg heavier than boys, while their subcutaneous adipose tissue is about 25% thicker compared to boys [9]. Analyses of body dimensions in schoolchildren and adolescents are sporadic in our region – rela-

tively rare and targeted individual studies are performed on small samples of schoolchildren [10–15].

This research was aimed at determining BH and BW of schoolchildren from Novi Sad, and at making a comparative analysis in relation to age and gender, as well as at determining the beginning of accelerated growth.

METHODS

Subjects

The study sample consisted of 11,676 pupils (5,946 boys and 5,730 girls) aged six to 15 years attending 18 primary schools on the territory of the city of Novi Sad and surrounding boroughs. Since there are 34 primary schools on the territory of the city of Novi Sad, the sample consisted of pupils from 18 schools, i.e. more than 50% of all primary schools, in order to ensure the sample representativity. The schools were chosen by the random choice method. All children attending these schools at that time underwent measurements.

Data collection

The Sample was obtained during a 10-year data collection, in the period of 2001–2010.

The researchers used anthropometric measurements with parameters recommended by the World Health Organization and the Professional-Methodological Instructions for the Application of the Regulation on the Health Care of Women, Schoolchildren and Students of the Institute for Mother and Child Health Care of Serbia [16, 17], including:

– Measuring of body BH, expressed in centimeters (cm) by an anthropometer (UNICEF Portable Anthropometer, Raven Equipment Limited, Dunmow, UK) with a maximum deviation of 0.1 cm. The subjects were barefoot, his/her heels touching each other, and the head in such a position that the Frankfort plane is horizontal;

– Measuring of BW, expressed in kilograms (kg) with a maximum deviation of 0.1 kg, by a WPT 150OW medical digital scale (Radwag, Radom, Poland).

The measurements were made in the morning during the physical education class when the subjects were dressed in T-shirts, shorts, and socks.

The biological age of each pupil was determined according to the date of birth and date of measurement; for example, children aged from five years and six months to six years and five months were included in the age group of six years. All pupils from the study sample were included in their respective age groups accordingly.

Due to the age of the subjects, the parents were asked to give their written consent to let their children undergo anthropometric measurements. Hence, there were three documents accompanying the research: information on the research for the parents, information on the research for the pupils, and the form for the parents' written consent.

The Ethics Committee of the Faculty of Medicine, University of Novi Sad, approved the aforementioned documents.

In addition to the parents' written consent, the written consent for measuring the pupils was obtained from the Ministry of Education of the Republic of Serbia, School Administration of Novi Sad, Board of Management and Principals of Primary Schools, Primary School Parent Forum, school board, and council of each school included in the study. Individual contacts were made with school psychologists and/or pedagogues.

Data analysis

Sample data were analyzed using IBM SPSS Statistics for Windows software, Version 21 (IBM Corp., Armonk, NY, USA).

The statistical analysis included the following descriptive statistical parameters: mean value, standard deviation, minimum and maximum of all values, coefficient of variation (CV) and confidence interval. The following multivariate and univariate procedures were applied: multivariate analysis of variance (MANOVA), univariate analysis of variance (ANOVA), Student's t-test.

RESULTS

Tables 1–4 show the basic anthropometric characteristics measured separately for boys and girls.

Body height – boys

The average values of BH for the boys' sample ranged from 125.39 cm in those aged up to six years to 175.09 cm in the oldest boys, aged 15 (Table 1).

CV values suggest the homogeneity in all age groups among boys.

Increased skewness values of BH in boys indicate that the distribution was negatively asymmetrical, meaning that the result distribution curve skewed to the higher values, i.e. higher values prevailed in relation to normal distribution in age groups from seven to 12 years. The decreased skewness values indicate that the distribution was positively asymmetrical, meaning that the result distribution curve skewed to the lower values, i.e. lower values prevailed in relation to normal distribution in age groups of six, 14, and 15 years. The skewness values indicate that the distribution was symmetrical in boys aged 13 years.

Higher kurtosis values indicate that the curve was peaked in the age groups of seven to 10 years, 12, 14, and 15 years. The negative kurtosis values indicate that the curve was flat in boys aged six, 11, and 13 years.

The distribution of BH values of boys ranged mostly within normal distribution (p) in boys aged six and 15 years. The distribution of values deviated from the normal distribution (p) in other age groups of boys, i.e. in those seven to 14 years old.

Table 1. Body height (cm) in the boys' sample

Age	n	Mean	SD	SE	Min.	Max.	CV	CI		Skewness	Kurtosis	p
6	41	125.39	4.36	0.68	115.0	132.2	3.48	124.01	126.76	-0.69	-0.26	0.886
7	580	128.73	5.89	0.24	110.2	149.2	4.57	128.25	129.21	0.16	0.12	0.000
8	756	134.18	6.37	0.23	111.4	159.9	4.75	133.72	134.63	0.10	0.31	0.000
9	786	139.19	6.74	0.24	117.6	161.4	4.84	138.72	139.66	0.11	0.11	0.000
10	788	144.88	6.89	0.25	123.4	173.5	4.75	144.40	145.36	0.19	0.41	0.000
11	799	150.52	7.36	0.26	127.2	173.7	4.89	150.01	151.04	0.14	-0.14	0.000
12	780	156.35	8.42	0.30	130.8	187.0	5.39	155.76	156.94	0.22	0.17	0.000
13	760	163.84	9.38	0.34	131.0	189.6	5.73	163.17	164.51	0.02	-0.15	0.000
14	565	170.83	8.89	0.37	126.1	196.6	5.21	170.10	171.57	-0.34	1.05	0.000
15	91	175.09	8.20	0.86	147.6	195.0	4.68	173.38	176.79	-0.12	1.00	0.756

n – number; SD – standard deviation; SE – standard error; Min. – minimun; Max. – maximum; CV – coefficient of variation; CI – confidence interval

Table 2. Body weight (kg) in the boys' sample

Age	n	Mean	SD	SE	Min.	Max.	CV	CI		Skewness	Kurtosis	p
6	41	25.58	4.64	0.72	18.3	43.1	18.13	24.11	27.04	1.32	3.39	0.670
7	580	26.92	5.11	0.21	16.4	54.3	18.97	26.50	27.33	2.65	4.23	0.000
8	756	30.33	6.46	0.23	13.8	62.9	21.31	29.87	30.80	1.71	-0.04	0.000
9	786	33.10	6.92	0.25	20.3	68.4	20.92	32.61	33.58	1.65	-0.25	0.000
10	788	37.21	8.53	0.30	13.4	78.2	22.92	36.62	37.81	1.64	-0.27	0.000
11	799	41.72	9.32	0.33	25.9	84.0	22.35	41.07	42.37	1.62	-0.34	0.000
12	780	46.60	11.29	0.40	24.6	96.3	24.23	45.81	47.39	1.64	-0.25	0.000
13	760	52.50	12.31	0.45	27.0	99.6	23.45	51.63	53.38	1.67	-0.14	0.000
14	565	57.64	11.73	0.49	15.7	102.8	20.35	56.67	58.61	2.66	4.57	0.000
15	91	61.38	11.51	1.21	27.2	98.7	18.76	58.98	63.78	0.52	1.14	0.146

Body weight – boys

Average values of BW for the boys' sample ranged from 25.58 kg in the youngest age group of schoolchildren (six years old) to 61.38 kg in the oldest boys, aged 15 years (Table 2).

CV values suggest the homogeneity in six-, seven-, and 15-year-old boys, and higher values indicate the homogeneity in the age group from eight to 14 years.

Skewness values of BW were increased, indicating that the distribution was negatively asymmetrical. This means that the result distribution curve skewed to the higher values, i.e. higher values prevailed in relation to normal distribution in all age groups among boys.

Higher kurtosis values indicate that the curve peaked in those aged six, seven, 14, and 15 years and negative values indicate that the curve was flat in boys aged eight to 13 years.

According to measured BW values in boys, the distribution of values ranged mostly within normal distribution (p) for six- and 15-year old boys, and deviated from the normal distribution (p) in other analyzed age groups.

Figure 1 shows the increase in BW and BH by age groups. Each ellipse in the graph represents an analyzed boys' age group. If the ellipses overlap, it means there were some similarities between these age groups; if these ellipses are wider, they indicate the age group was less homogenous regarding these parameters.

When ellipses do not touch each other, it means the differences were significant between the age groups. It can be noticed that the widest distance is between the age groups 11–13, which means that the increase in BW and BH was the highest for these ages. The shortest distance
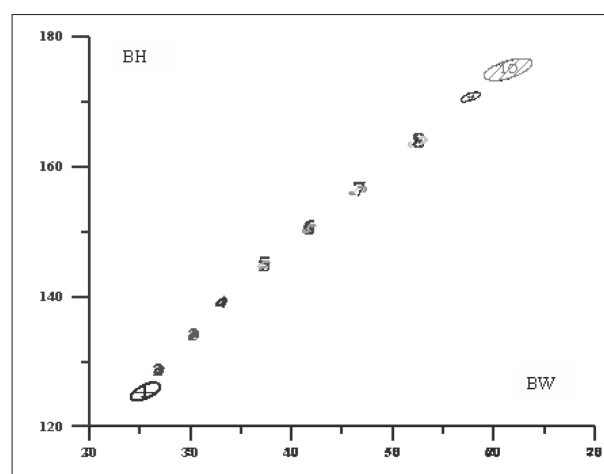
1 – 6 years; 2 – 7 years; 3 – 8 years; 4 – 9 years; 5 – 10 years; 6 – 11 years; 7 – 12 years; 8 – 13 years; 9 – 14 years; 10 – 15 years

Figure 1. Confidence interval by age groups among boys in relation to body weight (BW) and body height (BH)

is between the ages of six and seven, which means that the differences in BW and BH were the smallest for these ages, which in turn indicates that the growth was the lowest in these parameters.

Body height – girls

Average values of BH for the sample of girls attending primary schools in Novi Sad ranged from 124.07 cm in those aged up to six years to 165.77 cm in the oldest girls, aged 15 (Table 3).

CV values suggest the homogeneity in all age groups among girls.

Analizing BH in girls, the increased skewness values indicate that the distribution was negatively asymmetrical, meaning that the result distribution curve skewed to higher values, i.e. higher values prevailed in relation to normal distribution in ages of six, seven, nine, 11, and 15 years.

Skewness values indicate that the distribution was symmetrical for the ages of eight, 10, and 12. The decreased skewness values indicate that the distribution was positively asymmetrical, meaning that the result distribution curve skewed to lower values, i.e. lower values prevailed in relation to normal distribution in 13- and 14-year-old girls.

Higher kurtosis values indicate that the curve peaked in girls aged six, eight, nine, 12, 13, 14 and 15 years, and negative kurtosis values indicate that the curve was flat in girls aged seven to 10 years.

In the analyzed group of girls, the distribution of BH values ranged mostly within normal distribution (p) in age groups of six and 15 years, and deviated from normal distribution (p) in other age groups of girls, i.e. in those seven to 14 years old.

Body weight – girls

The average values of BW for the girls' sample ranged from 23.94 kg in the youngest age group of schoolchildren (six years old) to 54.46 kg in the oldest girls, aged 15 years (Table 4).

CV values suggest the homogeneity in girls aged six, seven, 13, 14, and 15 years, and higher values indicate the homogeneity in the age group from eight to 12 years.

Analyzing BW in girls, skewness values were increased, indicating that distribution was negatively asymmetrical.

That means that result distribution curve skewed to higher values, i.e. higher values prevailed in relation to normal distribution in all age groups among girls.

Higher kurtosis values indicate that the curve peaked in those aged seven, eight, 10, 14, and 15 years, and negative values indicate that the curve was flat in six-, 11-, and 12-year-old girls.

The distribution of BW values in the group of analyzed girls ranged mostly within normal distribution (p) in girls aged six and 15 years. The distribution of values deviated from normal distribution (p) in other age groups of girls.

Figure 2 shows the relation of BW and BH in girls of all age groups. It can be noticed that the widest distance was
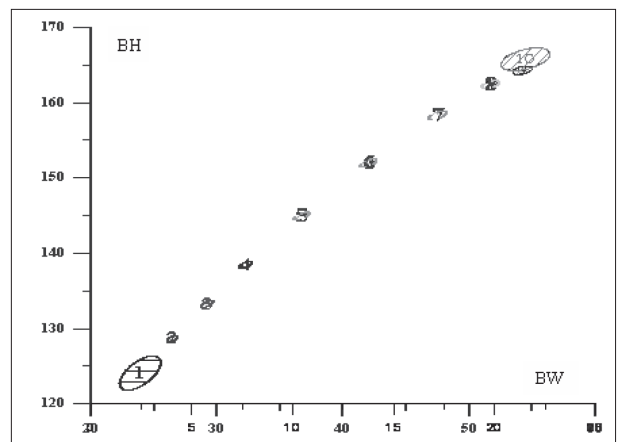
1 – 6 years; 2 – 7 years; 3 – 8 years; 4 – 9 years; 5 – 10 years; 6 – 11 years; 7 – 12 years; 8 – 13 years; 9 – 14 years; 10 – 15 years

Figure 2. Confidence interval by age groups among girls in relation to body weight (BW) and body height (BH)

Table 3. Body height (cm) in the girls' sample

Age	n	Mean	SD	SE	Min.	Max.	CV	CI		Skewness	Kurtosis	p
6	25	124.07	5.60	1.12	116.2	138.9	4.51	121.76	126.38	0.93	0.39	0.300
7	576	128.63	5.70	0.24	112.9	147.8	4.43	128.17	129.10	0.07	-0.05	0.000
8	696	133.26	6.34	0.24	111.5	157.2	4.76	132.79	133.73	0.02	0.72	0.000
9	744	138.48	6.53	0.24	119.5	163.0	4.72	138.01	138.95	0.31	0.33	0.000
10	736	144.94	7.32	0.27	120.8	169.3	5.05	144.41	145.47	0.00	-0.20	0.000
11	793	151.99	7.88	0.28	127.5	178.0	5.18	151.44	152.54	0.06	0.00	0.000
12	764	158.30	7.74	0.28	134.0	187.9	4.89	157.75	158.85	0.01	0.22	0.000
13	743	162.44	6.93	0.25	140.1	180.6	4.26	161.95	162.94	-0.33	1.07	0.000
14	562	164.30	6.85	0.29	139.9	183.5	4.17	163.75	164.87	-0.69	3.78	0.000
15	91	165.77	7.35	0.77	149.0	185.4	4.43	164.24	167.30	0.14	0.06	0.965

Table 4. Body weight (kg) in the girls' sample

Age	n	Mean	SD	SE	Min.	Max.	CV	CI		Skewness	Kurtosis	p
6	25	23.94	4.01	0.80	18.9	32.2	16.74	22.29	25.60	0.83	-0.53	0.391
7	576	26.50	5.09	0.21	13.4	51.5	19.19	26.09	26.92	2.70	4.44	0.000
8	696	29.26	6.38	0.24	13.6	65.5	21.79	28.79	29.74	1.87	0.53	0.000
9	744	32.32	6.90	0.25	18.8	70.3	21.36	31.82	32.82	1.73	0.04	0.000
10	736	36.74	8.47	0.31	18.7	77.2	23.06	36.13	37.36	1.74	0.08	0.000
11	793	42.03	9.31	0.33	22.9	83.8	22.15	41.39	42.68	1.63	-0.32	0.000
12	764	47.52	9.89	0.36	25.5	85.8	20.80	46.82	48.22	1.68	-0.15	0.000
13	743	51.72	9.98	0.37	26.3	101.1	19.29	51.00	52.44	1.72	0.01	0.001
14	562	54.19	9.34	0.39	35.6	97.2	17.24	53.41	54.96	2.78	5.17	0.001
15	91	54.46	9.36	0.98	36.8	90.1	17.19	52.51	56.41	1.15	2.84	0.639

between the ages nine to 12, which means the increase in BW and BH was the highest for these ages. It is also evident that the ellipses 9 and 10 overlap, which means the girls aged 14 and 15 had similar BW and BH values.

DISCUSSION

This paper analyzes the basic anthropometric characteristics BH and BW of primary schools pupils in Novi Sad.

The average values of for the boys' sample ranged from 125.39 cm in those aged up to six years, to 175.09 cm in the oldest boys, aged 15.

By analyzing BH results obtained for boys from our study sample in relation to results of other studies performed in the neighboring countries and worldwide, it can be noticed that the BH values found in boys from Novi Sad were not only higher than in majority of their peers according to available data but they were also higher in relation to results obtained by previous studies performed in Novi Sad [18–23].

Average values of BH for the sample of girls attending primary schools in Novi Sad ranged from 124.07 cm in those aged up to six years, to 165.77 cm in the oldest girls, aged 15.

By comparing the obtained average values of BH of girls included in this research with results of similar international and national studies, it can be concluded that girls from Novi Sad had higher average values of BH than their peers encompassed by other studies, including previous research performed on schoolchildren population in Novi Sad [18–23].

In addition to BH, BW was analyzed in this research as an important anthropometric parameter, which represents one of the indicators of nutritional status of children, and it is more determined by environmental factors and lifestyle than BH.

Average values of BW for the boys' sample ranged from 25.58 kg in the youngest age group of schoolchildren (six years old) to 61.38 kg in the oldest boys, aged 15 years.

The comparison of average values of BW recorded in schoolchildren from Novi Sad included in this research with results of similar studies performed both worldwide and in our region suggests that the average values of this parameter found in our boys were higher than those recorded in boys from France and India in all age groups. In addition, their values were higher than values reported in the youngest age group of American boys. These values were also higher than those found in children from Novi Sad who participated in previous studies. However, average BW values were lower than those recorded in boys from the surrounding countries and American boys aged 15 years [18–23].

Average values of BW for the girls' sample ranged from 23.94 kg in the youngest age group of schoolchildren (six years old) to 54.46 kg in the oldest girls, aged 15 years.

By comparing the results shown for BW of the girls included in this research and the results obtained in similar studies it can be seen that average values of BW in the youngest age group from this study sample were lower only in relation to their peers from the neighboring countries and the girls who had participated in the study performed in 2001. However, when average BW values recorded in the oldest age group of girls in all studies are compared, it can be seen that these values were higher in girls from Novi Sad only in relation to girls from India, which can be accounted for by genetic predispositions [18–23].

Since the BW parameter is in a close association with background, habits, lifestyle [24, 25], it can be assumed that the differences found in average BW values in relation to boys and girls from other studies can be attributed to these factors.

Having analyzed the morphologic and anthropometric characteristics by age groups in primary school children aged from six to 15 years in the territory of the city of Novi Sad, the authors assessed the significance of the differences in the study parameters in order to determine the increase in the analyzed anthropometric parameters by age groups.

Significant differences in all age groups were determined by analyzing the relation between BW and BH in the boys' sample, particularly in boys aged from 11 to 13 years, which suggests that the highest increase was in these parameters. Contrary to that, less significant differences in BW and BH were observed in six- and seven-year-old boys, which indicated lower increase in these parameters.

The highest increase in these two parameters was observed in girls aged from nine to 12 years, whereas 14- and 15-year-old girls had similar values of these two parameters.

The results obtained in this research are in conformity with the data found in literature. Adolescence is the period of sudden growth and development. Girls enter the period of adolescence after the age of 10, while boys enter early adolescence two years later on average. Sudden skeletal growth, which depends on secretion of the growth hormone regulated by the hypothalamus and the thyroid gland, occurs first in girls and about two years later in boys [26, 27].

Limitation of the study is that it is cross-sectional. It would be of great importance to longitudinally monitor the anthropometric characteristics of pupils.

CONCLUSION

The analysis of the obtained results suggests the conclusion that lately there has been a significant increase in average values of BH and BW in children and adolescents in relation to results from previous studies. These changes in the somatometric indicators and physical appearance of schoolchildren have probably resulted from the population migrations happening in this region in recent decades.

In addition, this research has shown that the sudden ponderal and statural growth began earlier in the girls' than in the boys' sample.

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Антропометријске карактеристике и карактеристике раста школске деце у Новом Саду

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САЖЕТАК
Увод/Циљ Раст, развој и матурација представљају периоде са индивидуалним телесним карактеристикама које, осим антропометријских показатеља и телесног изгледа појединца, дају увид здравственог стања.
Циљ је био да се утврде телесна висина (ТВ) и телесна маса (ТМ) репрезентативног узорка ученика основношколског узраста из Новог Сада, да се направи упоредна анализа у односу на узраст и пол, као и да се утврди у ком узрасту је започет убрзан раст.
Методе Основне антропометријске карактеристике деце основношколског узраста у Новом Саду су утврђене у узорку од 11.676 ученика, узраста 6–15 година. Истраживање је обухватило мерење ТВ и ТМ по прописаној методологији.
Резултати Просечне вредности ТВ у узорку дечака кретале су се од 125,39 *cm* у узрасту од шест година до 175,09 *cm* у узорку од 15 година. У узорку девојчица вредности су се кретале од 124,07 *cm* код најмлађих до 165,77 *cm* у узрасту

од 15 година. Измерене просечне вредности ТМ код дечака кретале су се од 25,58 *kg* код најмлађих до 61,38 *kg* у узрасту од 15 година, а код девојчица од 23,94 *kg* у узрасту од шест година до 54,46 *kg* код најстаријих ученица. Анализом односа ТМ и ТВ у узорку дечака и девојчица утврђене су значајне разлике у свим узрастима. Највеће разлике су уочене код дечака у узрасту 11–13 година, а код девојчица у узрасту 9–12, што означава период кад је започет убрзан раст.
Закључак Анализом две основне антропометријске карактеристике ТВ и ТМ утврђено је да постоје значајне разлике у порасту наведених особина међу узрасним групама посматраног узорка. Такође, слично наводима стручне литературе, и у овом истраживању је утврђено да је нагли пондерални и статурални раст раније започет у узорку девојчица у односу на узорак дечака.

Кључне речи: антропометријска мерења; раст и развој; школска деца