ANTHROPOMETRIC CHARACTERISTICS AND OBESITY INDICATORS AMONG PRESCHOOL CHILDREN IN AN URBAN AREA IN CROATIA

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ABSTRACT

The aim of this research was to determine the growth rate and sex differences in anthropometric characteristics among preschool children in the city of Osijek. The research was based on a sample of 760 preschool children from 10 kindergartens in the territory of the city of Osijek. The measured variables were body height (BH) and weight (BW), which were used for calculating the body mass index (BMI) according to sex and age. The basic descriptive parameters were calculated and a t-test was used to determine possible differences by sex in the observed variables. The average results obtained within the BH and BW variables for sex and age indicate that the rate of growth is in line with the WHO's prescribed values. Observing the BMI values, a very high value was notable in the third year of life (17.59 for boys and 17.62 for girls), following which the values decreased by the age of five and again increased after the age of five. The sex difference in terms of BH was proven to be statistically significant at the ages of four (p=0.03), five (p=0.029) and seven (p=0.037), while in terms of BW there was a statistically significant difference only at the age of four. No statistically significant sex difference in the BMI was found. Since there is a constant increase in the numbers, i.e. percentages, of overweight and obese children with age, it is recommended to take preventive and obesity reduction measures in the form of parent education on the risks that come with obesity, on the importance of a healthy diet and everyday physical activity, and on motivating and encouraging children to move through active play, as well as to continue with the constant monitoring of children's current anthropometric status.

Keywords*:* preschool children, growth, anthropometry, BMI, percentile

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INTRODUCTION

Anthropometric measurements can be indicators of a population's health status, quality of nutrition and nutritional status, giving rise to increasingly widespread studies of anthropometric characteristics among researchers (Cole et al., 2005), not only for monitoring children's growth and development, but also for an early detection of overweight and risk of obesity. In the last several decades, obesity has become one of the leading direct and indirect causes of morbidity and mortality in all parts of the world. There is evidence that childhood obesity is widely related to serious health complications and increased early death risk (Dietz, 1998). It is known that obesity is one of the key risk factors for the development of some cardiovascular and cerebrovascular diseases which are among the three leading causes of mortality today (Baklaic et al., 2007). According to the Croatian Bureau of Statistics, the leading causes of death in 2006 in Croatia were circulatory system diseases, from which 577.2/100,000 citizens died (Baklaic et al., 2007). The top three positions in the ranking of the ten leading causes of mortality are occupied by ischaemic heart disease (19.5%), cerebrovascular diseases (16.03%) and heart failure (5.87%) (Baklaic et al., 2007). This is precisely the reason why obesity has become a public health issue and why it is given such importance and frequency in research today.

Obesity is essentially determined by a disproportion between increased energy intake and reduced energy consumption, where a positive energy balance results in storing excess energy in adipose tissue (Kumanyika et al., 2002). Nevertheless, various surveys have shown there are other factors creating predisposition for its development, i.e., inheritance, birth weight, duration of breastfeeding, age at which complementary foods were introduced, different socioeconomic factors, such as diet, sedentary lifestyle and various habits (Gillman et al., 2001; Stettler et al., 2002; Faith et al., 2003; Whitaker, 2004; Bralic et al., 2005; Zimmerman et al., 2010).

A major concern is the increased incidence of obesity in preschool age, precisely because it is related to obesity occurring later in life (Nader et al., 2006). According to the World Health Organization's (WHO) research, the prevalence of obesity among preschool children grew from 4.2% in 1990 to 6.7% in 2010, and this trend is expected to continue, rising up to 9.1% in 2020 (De Onis et al., 2010). The occurrence of obesity in early childhood can directly harm the kidneys, because chronic liver diseases affect the locomotor system contributing to the development of deformations such as Blount's disease, as well as osteoarthritis, precocious puberty and polycystic ovary syndrome. Obesity occurring in childhood is also associated with a series of psychosocial problems, loss of self-confidence, depression, which in turn have an indirect impact on future professional performance (Bralic et al., 2010).

For an early detection of being overweight in childhood, it is necessary to constantly monitor the growth and development of children and take their anthropometric measurements (Cole et al., 2000). In the course of constant monitoring of growth and development, growth dynamics, should be taken into account as well. Since anthropometric measurements can be indicators of a population's health status, quality of nutrition and nutritional status, studies of anthropometric characteristics have become increasingly widespread among researchers (Cole et al., 2005). In kinesiology research, knowledge of children's anthropological status is required for quality planning and programming of physical activity (Findak, 1997), as well as for

the choice of contents that should facilitate growth and development, and which also fall into the category of primary prevention of obesity. It is precisely for these reasons that this research was undertaken, as a contribution to determine the growth and development dynamics and obesity indicators among preschool children in the territory of the city of Osijek. Although the sample of participants is representative, the greatest limitation of this survey is that it only covers the urban part of the region. Therefore, future studies should include more regions and rural areas in order to get the whole picture and to be able to generalize the results.

The WHO has adopted a new approach to monitoring children's growth, including the development of new growth curves in 2007 which encompass values for ages from birth until 20 years − length/height-for-age, weight-for-age, weight-for-length (45−110 cm), weight-for-height (65−120 cm), body mass index-for-age, head circumference-for-age, mid upper-arm circumference-for-age, subscapular skinfold-for-age, triceps skinfold-for-age and motor development milestones (Nenadic et al., 2008). These were constructed by the National Center for Health Statistics/Center for Disease Control and Prevention (NCHS/CDC), and have been recommended by the WHO. As Croatia previously did not have its own national reference values for preschool children, after the publication of the WHO's new standard charts the country joined the implementation of new anthropometric standards in children's growth and development monitoring (Nenadic et al. 2008).

AIM

The aims of this paper were to a) determine if BH, BW and BMI differed by age and sex in a sample of children from an urban area of Croatia, and b) compare these anthropometric characteristics against WHO reference values.

METHODS

Participants

The sample of participants consisted of 760 preschool age children from 10 kindergartens located in the city of Osijek and was divided according to sex into boys and girls (385 girls and 375 boys). The boys sample was composed of 31 boys aged 3 (mean 2.96; SD= 0.29/ 35.5 months), 64 boys aged 4 (47.2 months; mean 3.87 years ± 0.53 years), 72 boys aged 5 (58.6 months; mean 4.87 years ± 0.28 years), 96 boys aged 6 (70.5 months; mean 5.87 years ± 0.31 years) and 112 boys aged 7 years (82.4 months, mean 6.86 years ± 0.26 years). The girls sample was comprised of 34 girls aged 3 (35.1 months; mean 2.92 years ± 0.31 years), 64 girls aged 4 (46.9 months; mean 3.91 years ± 0.26 years), 102 girls aged 5 (58.7 months; mean 4.89 years ± 0.29 years), 97 girls aged 6 (71.5 months; mean 5.96 years ± 0.28 years) and 88 girls aged 7 years (81.3 months; mean 6.78 years ± 0.28 years). Our sample was convenient and consisted of 10 out of 23 public kindergartens in the city. The measurements were conducted with the children whose parents signed a written permission form and who attended the kindergarten on the day of data collection. The research was carried out in accordance with the Code of Ethics prepared by the Council for Children as an advisory body of the government.

Variables
The sample of variables was composed of two anthropometric measurements of BH, BW and BMI. The measurements of height and weight were taken according to the International Biological Programme, and BMI was calculated from the BH and BW for each individual participant and according to age and sex. Body height was measured by employing the stadiometer SECA 2013, whereas the Omron digital scale BF 511 was used to measure body mass. Measurements were taken on barefoot children in the early morning hours of kindergarten attendance.

In this research, the measurements used were height-for-age, weight-for-age and body mass index-for-age. BMI for age and sex is an anthropometric index describing the ratio of BW expressed in kilograms and BH expressed in square metres $BMI=BW/(BH)^2$ (kg/m^2). BMI values are used for the classification of children and adolescents in terms of malnutrition, obesity and risk from developing obesity (developed by the NCHS/CDC Prevention and Health Promotion (2000) 2 to 20 years; Boys, Girls, Body mass index-for-age percentiles (http:// www.cdc.gov/growthcharts) (WHO).

Data Processing Methods
For the stated variables BH, BW and BMI basic descriptive parameters were calculated (the mean, standard deviation, percentiles) and reference values and percentile curves prescribed by the WHO were used for the comparison of the obtained data. The Kolmogorov-Smirnov test was used to examine the normality of distribution, and a t-test was used to examine the difference according to sex in the BH, BW and BMI variables, at a significance level of p=0.05. Statistical software *Statistica 12* was used to analyse the data.

RESULTS

The results obtained in the BH variable for age and sex on average show that the growth rate is in line with the prescribed WHO values, which means they do not go beyond the limits of the 5^{th} and 95^{th} percentile (Chart 1 for boys and Chart 2 for girls). It was observed that the boys grew between the ages of three and seven by a total of 35.56 cm in height, which amounted to 3.84 cm per year on average, while the girls gained somewhat less in height than boys between the ages of three and seven − a total of 33.92 cm, which is 3.45 cm per year on average. There is a difference in height with regard to age between boys and girls, specifically at the ages of four, five and seven years, where the boys are somewhat taller, while at the ages of three and six there were no differences between the boys and girls. The observed sex difference was examined using a t-test and a statistically significant difference was found at the ages of four, five and seven years (Table 1).

Table 1: Descriptive statistics of anthropometric measurements of BW, BH and BMI and differences between boys and girls according to age

			n	Months	Median (cm)	Mean (cm)	SD (cm)	t-test	p
Body height	3 years	boys	31	35.5	97.00	95.35	9.35	-0.86	0.93
		girls	34	35.1	96.00	95.55	11.87		
	4 years	boys	64	46.5	107.25	107.43	6.69	2.16	0.03*
		girls	64	46.9	105.00	104.92	5.12		
	5 years	boys	72	58.4	114.00	113.55	4.68	2.19	0.029*
		girls	102	58.7	111.00	110.56	10.86		
	6 years	boys	96	70.5	120.25	120.56	6.27	-0.70	0.48
		girls	97	71.5	122.00	121.17	5.87		
	7 years	boys	112	82.4	126.75	127.17	8.41	2.09	0.037*
		girls	88	81.4	124.00	124.93	6.07		
			n	**Months**	**Median (kg)**	**M (kg)**	**SD (kg)**	**t-test**	**p**
Body height	3 years	boys	31	35.5	15.60	15.65	1.91	-0.86	0.93
		girls	34	35.1	15.00	15.70	2.76		
	4 years	boys	64	46.5	18.00	18.26	2.94	2.09	0.04*
		girls	64	46.9	17.25	17.34	2.09		
	5 years	boys	72	58.4	20.00	20.30	2.64	1.50	0.13
		girls	102	58.7	19.00	19.58	3.42		
	6 years	boys	96	70.5	23.00	23.42	4.05	0.30	0.76
		girls	97	71.5	23.00	23.24	4.19		

	7 years	boys	112	82.4	25.10	26.52	5.29	1.51	0.13
		girls	88	81.4	24.20	25.44	4.49		
			n	**Months**	**Median (bmi)**	**M (bmi)**	**SD (bmi)**	**t-test**	**p**
BMI	3 years	boys	31	35.5	15.81	17.59	3.67	-0.34	0.97
		girls	34	35.1	16.76	17.62	3.84		
	4 years	boys	64	46.5	15.48	15.79	1.40	0.14	0.88
		girls	64	46.9	15.31	15.75	1.80		
	5 years	boys	72	58.4	15.60	15.71	1.41	0.15	0.87
		girls	102	58.7	15.41	15.67	2.10		
	6 years	boys	96	70.5	15.55	16.07	2.16	1.00	0.31
		girls	97	71.5	15.54	15.76	2.12		
	7 years	boys	112	82.4	15.76	16.32	2.42	0.14	0.88
		girls	88	81.4	15.81	16.27	2.50		

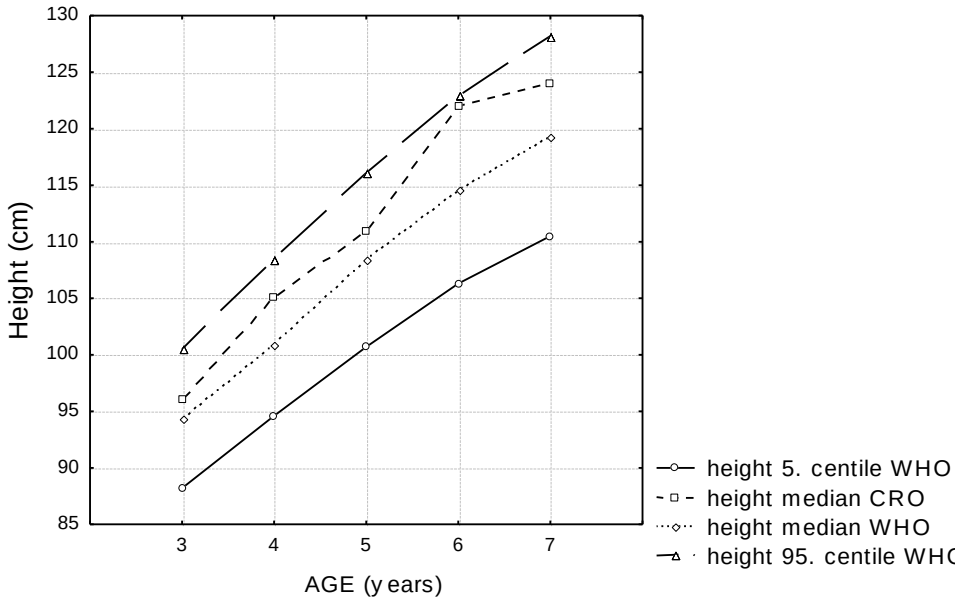


Chart 1: Average values of boys height with regard to age in comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

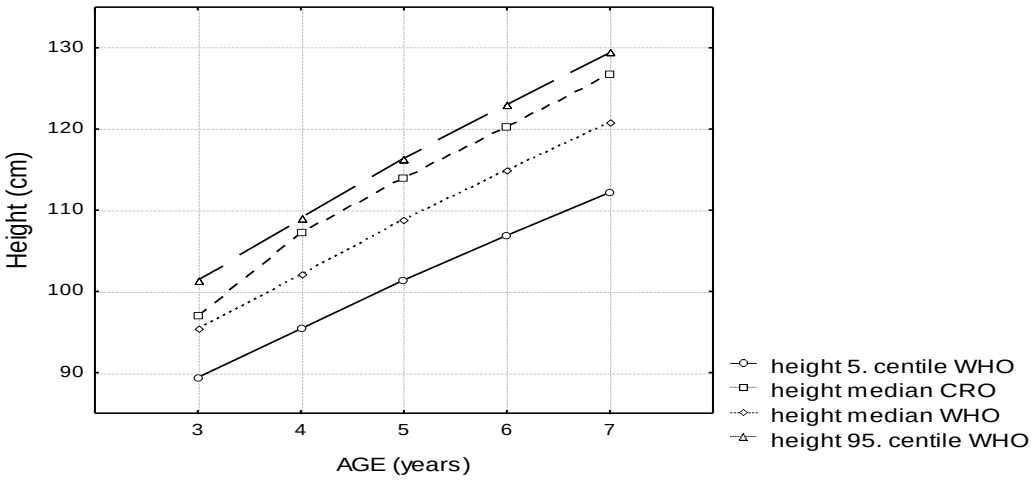


Chart 2: Average values of girls height with regard to age and comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

The results obtained in the BW variable for sex and age on average show that the growth rate is also in line with the prescribed WHO value, which means they do not go beyond the limits of the 5th and 95th percentile (Charts 3 and 4). Although the children's average results are within recommended values, a certain percentage of children show values beyond those limits. The greatest percentage of boys who were beyond the 5th centile at age three is (6.5%), age seven (6.25%) and age four (4.7%); for girls beyond the 5th centile at the age five (3.9%), three (2.9%) and six (1.03%). The greatest percentage of boys who were above the 95th centile are at ages seven (7.25%), four (17%) and three (16.1%), and for girls at the age of three (20.6%), seven (14.8%) and six (14.4%).

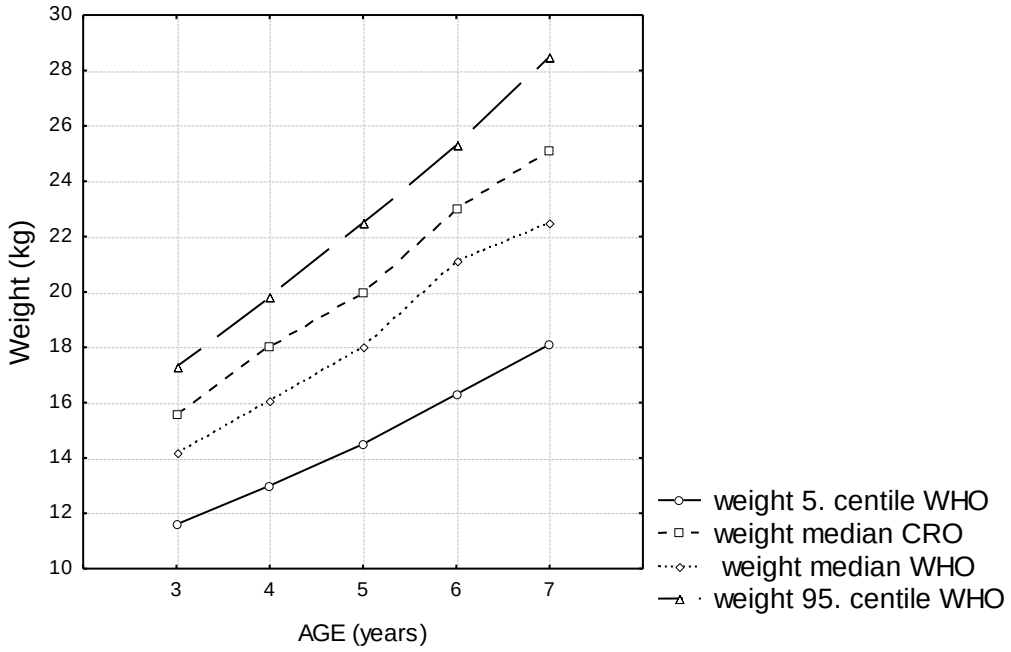


Chart 3: Average values of boys weight with regard to age and comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

It was observed that the boys between the ages of three and seven gained a total of 11.93 kg in weight, which made an annual average of 1.48 kg, while the girls gained slightly less weight compared with the boys, 11.11 kg in total, which made an annual average of 1.37 kg. The difference in weight with regard to age between the boys and girls, specifically at the ages of four, five and seven, where the boys were somewhat heavier, while at the ages of three and six there was no difference between the boys and girls. The observed sex difference was examined using a t-test and a statistically significant difference was found at age four (Table 1).

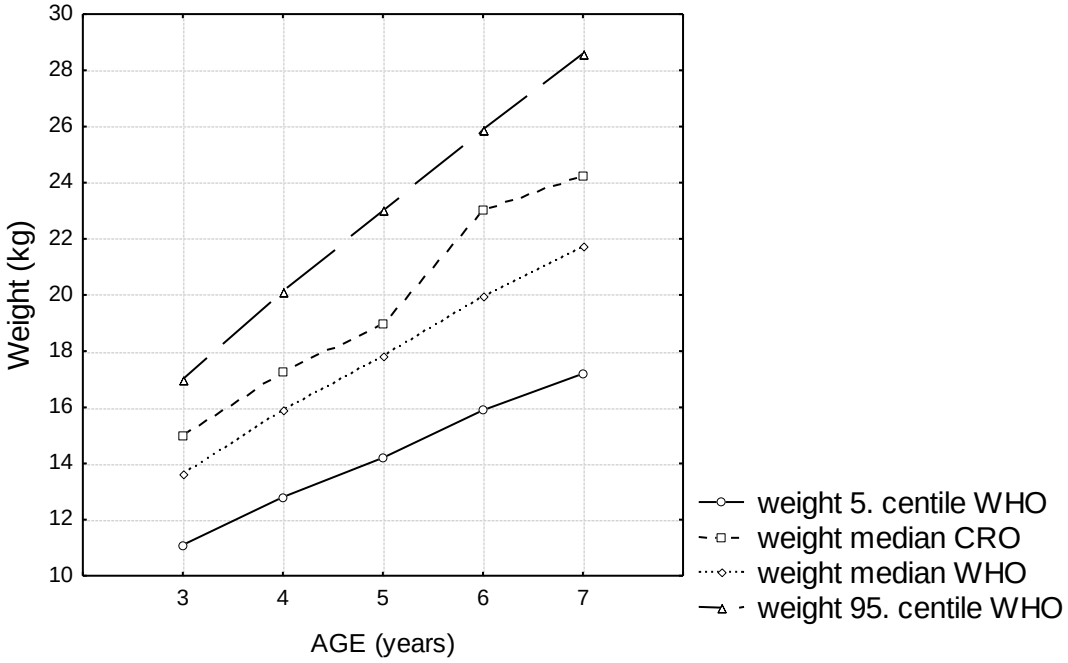


Chart 4: Average values of girls weight with regard to age and comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

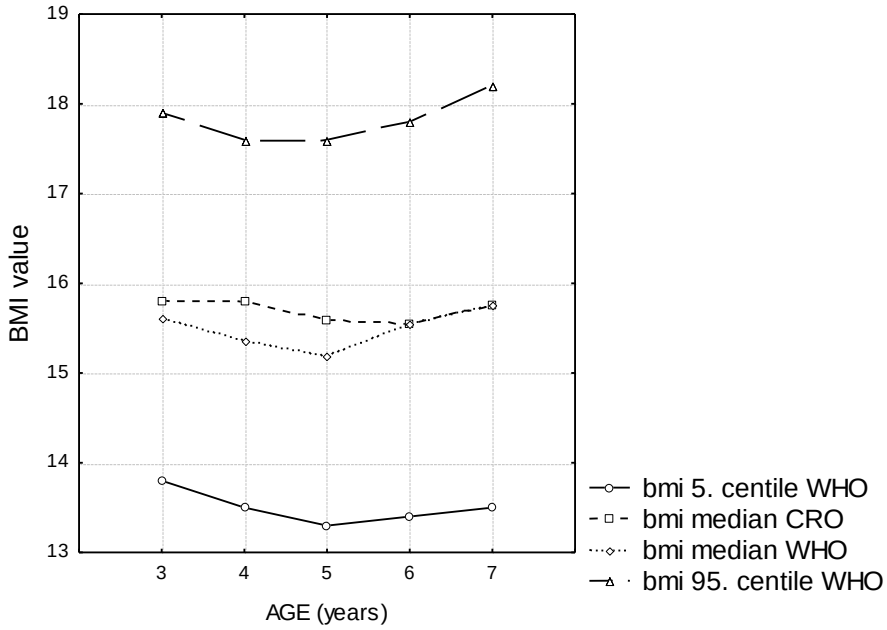


Chart 5: Values of BMI (kg/m^2) for boys and their comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

In the BMI variable, no significant deviation was found either among the boys or girls, although an increased median BMI value was found at the age of three, however, without exceeding the 95th percentile (Charts 5 and 6). Testing the difference between body mass indices according to sex, no statistically significant difference was observed (Table 1).

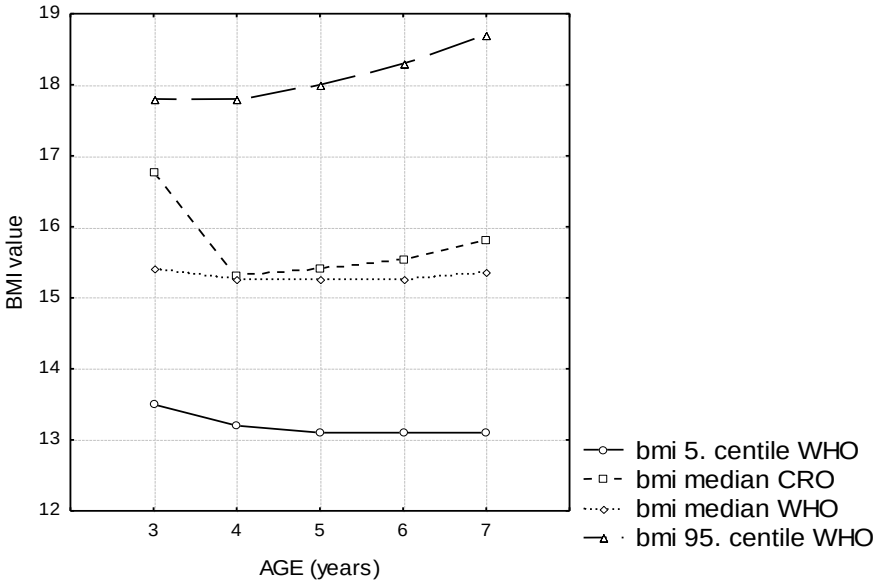
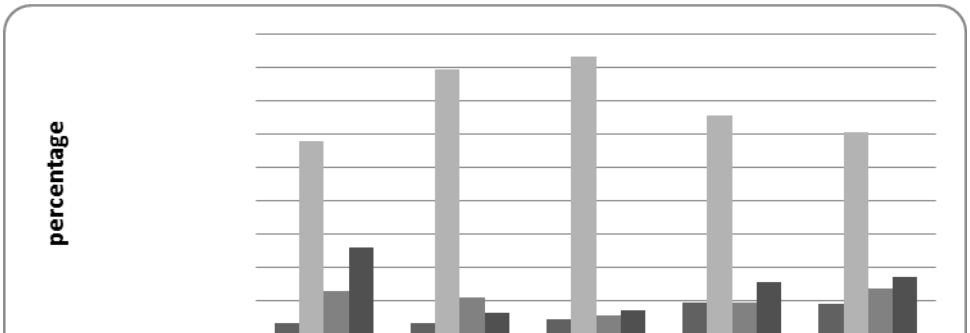


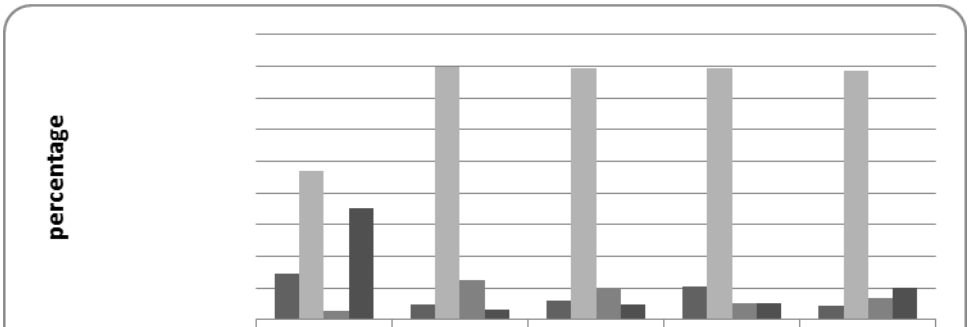
Chart 6: Values of BMI (kg/m^2) for girls and comparison with the lowest (5th centile) and highest (95th centile) reference values prescribed by the WHO

Charts 7 and 8 show the percentage of children categorized according to percentiles in the following groups: underweight (below the 5th percentile), normal weight (5th–85th percentile), overweight (85th–95th percentile) and obese (above the 95th percentile). The BMI results shown in percentages indicate that the majority of the children fall into the group of normal weight, but the fact that the percentages of the overweight and obese increase with age, more so among the boys than among the girls, is a cause for concern. Out of the entire sample, no less than 24% of the boys and 16.36% of the girls fall into the overweight and obese groups.



	3 years	4 years	5 years	6 years	7 years
malnourished%	3.23	3.12	4.16	9.36	8.92
normal%	58.06	79.69	83.33	65.63	60.71
obesity risk%	12.9	10.94	5.55	9.38	13.4
obesity%	25.81	6.25	6.96	15.63	16.97

Chart 7: Percentage (%) of boys categorized according to BMI percentiles



	3 years	4 years	5 years	6 years	7 years
malnourished%	14.7	4.69	5.89	10.32	4.54
normal%	47.06	79.69	79.41	79.38	78.41
obesity risk%	2.95	12.5	9.8	5.15	6.82
obesity%	35.29	3.12	4.9	5.15	10.23

Chart 8: Percentage (%) of girls categorized according to BMI percentiles

DISCUSSION

The aim of this paper was to determine the BH, BW and BMI by age and sex, and examine the sex differences in anthropometric characteristics among preschool children in an urban area in Croatia, with regard to the reference values as prescribed by the WHO. The results obtained through this research indicate that the growth and development of preschool children between the ages of three and seven in the territory of the city of Osijek is in line with the natural growth and development occurring at these ages according to the WHO's standards, i.e., all the observed children in both variables are within the recommended 5^{th} and 95^{th} percentile limits. The annual weight and height increases are stable in both sexes and amount to approximately 4 cm within a period of 9 months, which is in accordance with the recommendations for this stage of development, i.e., 5 cm per year (Misigoj–

Durakovic, 2008). However, observing the annual growth from two points of height measurement, it was noted that the boys showed somewhat higher growth rates at the ages of three, six and seven, and the same was found among the girls at the ages of three and six. In terms of BW, somewhat higher growth rates were observed at the ages of five and six among the boys and at the ages of three, six and seven among the girls. Similar results were obtained by Popovic (2008), who measured children between the ages of four and eleven in the territory of Vojvodina, whereby a statistically significant increase in all the measurements for body volume estimation was found among boys at the ages of six, seven and eight, i.e., a significant increase in BW, BH and skinfold values. The same was established among girls at the ages of five and a half, six and a half, and seven and a half years. Zafirova & Todorovska (2009) also found a significant increase in BH and BW between the two age groups of 6- and 7-year-old children both for boys and girls, as well as sex differences in anthropometric parameters, where the boys were more dominant, except in the skinfold measures. Oja & Jürimäe (2002) established a significant increase in BH both for boys and girls, and BW only for girls during a two-year development, at the age of 6 and 7.

As in many animal species, humans show significant average sex differences in body size, though the magnitude of these differences varies with the population (Wells, 2007). These sex differences or sexual dimorphism in body size exists already at birth. Girls are born with less body length and body weight compared with boys, but newborn girls already have more subcutaneous fat than boys (Greil, 2006). According to Greil (2006), in comparison to boys, girls on an average grow and develop faster, they follow the typical human growth curve with a higher tempo and finish their length growth earlier. This leads to a first minor female growth advantage in some measurements around the age of 6 or 7, because already at this age girls may be biologically older compared with boys of the same chronological age and thus may undergo their mid-growth spurt earlier.

The results obtained for the BMI variable show that the median BMI value exceeds neither the 5^{th} nor the 95^{th} percentile for both boys and girls. Although a somewhat higher BMI was observed among the girls, it is followed by a decline and then increase from the age of four until the age of seven. Similar results were obtained by Popovic (2008). He also found a decline in the back and abdomen skinfold values until the age of five, followed by an increase until the age of seven for girls and the age of eight for boys. Horvat (2009) also determined a growing trend in the fat component for both sexes among preschool children (6.5−8 years old), as well as a decrease in the non-fat component among girls. According to Greil (2006), sexual dimorphism of weight and BMI decreases in the elderly. Body fat differs from all other measurements. Females have more subcutaneous fat and higher total body fat content compared with males at all ages. According to Wells (2007), both genders show a relative decrease in body fat between one and six years of age, whereas girls then begin to increase in fatness again, increases in weight in boys are primarily attributable to lean mass.

While most preschool children in the territory of the city of Osijek fall into the range between the 5^{th} and 95^{th} percentile, which denotes a normal nutritional status, the BMI results shown in percentages indicate that a rather large percentage is in the categories of overweight (85−95^{th} percentile) and obese (>95^{th} percentile), as much

as 24% of the boys and 16.36% of the girls, and that there is a continual growing trend in the percentages of children in these categories according to age and sex. Cattaneo et al. (2009) in their review paper determined that the countries in the Mediterranean region and the British Isles report the highest rates of overweight and obesity in preschool children, while countries in middle, eastern and northern Europe report the lowest − Spain reports the highest prevalence, followed by Ireland and Greece, while the Czech Republic and Romania report the lowest prevalence. They also found that the rates are generally higher in girls than in boys.

The research was carried out on a sample of children between the ages of three and seven attending preschool institutions in an urban area in Croatia, and it is therefore proposed that future research should include children who are not enrolled in kindergartens in the same area. Given that the new WHO standards for monitoring children's growth and development in addition to the variables used in this paper include measuring head circumference-for-age, mid upper-arm circumference-for-age, subscapular skinfold-for-age and triceps skinfold-for-age, another suggestion is to increase the number of variables. As stated above, the sample of participants is representative; the greatest limitation of this survey is that it only covers the urban part of the region. Therefore, future studies should include more regions and rural areas in order to get the whole picture and to be able to generalize the results.

CONCLUSION

The aim of this research was to determine the growth rate and sex differences in anthropometric characteristics among preschool children in the city of Osijek. The results show that the BH and BW variables for sex and age indicate that the rate of growth is in line with the WHO's prescribed values. Observing the BMI values, a very high value was notable in the third year of life, following which the values decreased by the age of five and again increased after the age of five. The sex difference in terms of BH was proven to be statistically significant at the ages of four, five and seven, while in terms of BW there was a statistically significant difference only at the age of four. No statistically significant sex difference in the BMI was found. Since there is a constant increase in the numbers, i.e., percentages, of overweight and obese children with age, it is recommended to take preventive and obesity reduction measures in the form of parent education on the risks that come with obesity, on the importance of a healthy diet and everyday physical activity, and on motivating and encouraging children to move through active play, as well as to continue with the constant monitoring of children's current anthropometric status.

FIRST AUTHOR'S BIOGRAPHY

Daria Farkaš is a third year student of postgraduate doctoral studies at the Faculty of Kinesiology. For the last three years she has been working in a primary school, F. F. Frankopan, as a teacher of physical education. This research was conducted as part her research dissertation with the second author of this paper, Prof. Zvonimir Tomac. The work contributes to a better understanding of the growth and development of preschool children in preschool education in the city of Osijek, Croatia. Data collection took place in the autumn of 2011.

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