BODY MASS INDEX, UNDERWEIGHT AND OVERWEIGHT IN CHILDREN 3 TO 5 YEARS OF AGE FROM SKOPJE

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Abstract

The aim of this research is to present body mass index (BMI) data in children 3–5 years of age from Skopje and provide the information on the prevalence of different categories of nutritional status during the early childhood.

Material and methods: The study included 420 preschool children (210 boys and 210 girls). Stature and body weight were measured, and the BMI value was calculated. Twelve anthropometric parameters were measured using standard equipment and measurement technique according to the International Biological Programme.

Results: The majority of anthropometrical parameters have shown significant age and sex specific differences in favor of male subjects. Values at the 50th percentile in our male subjects aged 3, 4 and 5 years for the weight-for-age index were 19 kg, 19.1 and 21 kg, respectively whereas in the female subjects the corresponding values were 16.8 kg, 20 kg and 21 kg. The height-for-age index values corresponding to the 50th percentile showed slightly higher values in our male subjects (100 cm, 109.5 cm and 116 cm) than those in our female subjects (102 cm, 108.5 cm and 116 cm). The values of 50th percentile of BMI in our males subjects were 18.1 kg/m², 16.2 kg/m² and 16 kg/m² whereas in our females were 16.5 kg/m², 16.7 kg/m² and 16.4 kg/m².

Conclusion: These results show that underweight is a health problem of the rising generation in Skopje and needs to be considered along with the problem of overweight. It is recommended that the detected values could be applied for evaluation of deviations in growth and nutritional status in children aged 3–5.

Key words: anthropometry, preschool children, underweight, overweight.

Introduction

Globally, obesity is a significant public health problem [1–2] and a number of studies reporting an increasing prevalence of overweight and obese children in Europe, USA, Canada etc. [3–5]. The health risks associated with the excess body weight are well documented. The age and sex specific body mass index (in kg/m²) or BMI is the most common method for assessing weight status and health risks in children [6–7]. The improvement in the economic situation and the 'modernization' of the society has led to an increase in the consumption of high-energy foods and an alarming increase in sedentary behavior. These are probably the main reasons why obesity rates in preschool and schoolchildren more than doubled over the past decade [8–9].

The terms *overweight* and *obesity* are often used interchangeably, despite the fact that they are not identical. Namely, overweight is defined as an increased weight (not necessarily excess fat) for a certain height, while obesity indicates an excess in fat mass. Even though the long-term effect of overweight and obesity on morbidity and mortality in children has not

yet been as well documented as in adults, multiple studies have shown that adiposity in childhood is correlated with the rising incidence of diabetes, hypertension and atherosclerosis observed in this age group [10]. The consequences of overweight and obesity imply that the definition of who is overweight, and especially who is obese, is of utmost importance. Macedonian Ministry of health adopted the World Health Organization's international reference and the weight-for-height index as the official criterion to evaluate the nutriational status of preschool children both in terms of undernutrition and overnutrition.

Usually there are three sets of growth references commonly used to assess a child's weight status and health risk; BMI cut-points published by the Center for Disease Control (CDC), International Obesity Task Force (IOTF) and those published by the World Health Organization (WHO). Inconsistent prevalence estimates of childhood overweight and obesity based on variant growth references pose a challenge in defining the burden of childhood obesity at a population level. Recommendations are inconsistent depending on what method was used [11].

Material and methods

The study included 420 healthy preschool children at age 3–5, from both sexes. It excluded children with systemic and metabolic diseases that may affect the growth development of children, as well as those children with family history of systemic illness.

Anthropometric characteristics of the children at the age of 3–5 years were obtained from a representative sample of children from kindergartens in Skopje. The total number of subjects ($n = 420$) was divided into three groups by age: a group ($n = 100$) of 3 years old children (range of age from 3 to 3.9 years); a group ($n = 120$) of 4 years old children (range of age from 4 to 4.9 years) and a group ($n = 200$) of 5 years old children (range of age from 5 to 5.9 years). Each age group was divided into two subgroups by sex (boys and girls).

Anthropometry

Anthropometrical measures were taken in line with the International Biological Programme (IBP). Children were asked to take off their shoes for the height measuring and to take off any over-clothing for the weight measuring and their anthropometric points and levels were marked on the body of the child. The following parameters were measured: body weight, body height, BMI, arm length, leg length, circumferences of the upper arm, forearm, thigh and calf, diameters of elbow and knee.

The instruments for measuring were standard and were regularly calibrated before measuring. The following standard anthropometric instruments were used: anthropometer by Martin for measuring of height and lengths with reading precision of 1 mm; and medical weighing scale for measuring of weight with precision of 0.1 kg; metal tape for measuring of circumferences with precision of 1 mm.

According to the WHO recommendations for assessment of nutritional status in preschool children the following indices were calculated: weight-for-age; height-for-age and BMI.

Definitions

For categorization of the values of the anthropometric indices, the following percentile cutoff points were used; below 5th percentile for the category of extremely low values; from 5th to 85th percentile for mean values; from 85th to 95th percentile for the category of above average values; and above 95th percentile for extremely high values. The index weight-for-age was used for quantitative grading of the nutritional status in preschool children. Children with the weight-for-age index under the 5th percentile were considered as underweight for their age, while overweight children were those with the weight-for-age index from 85th to 95th percentile. If the values of the weight-for-age index were within the range of 5th to 85th percentile, these children were considered to be with normal weight for their age. The category of children with a risk of obesity comprised those who had the weight-for-age index above 95th percentile [12, 13].

Statistics

The obtained data for the relevant variables were analyzed with descriptive statistics presented with measures of central tendency and its deviation (arithmetic mean ± standard deviation) along with ranges expressed in percentiles. Sex-specific differences were estimated with the independent-samples t-test. The differences with $p < 0.05$ were considered significant.

Results

The mean values and standard deviations of the examined anthropometric parameters in children aged 3–5 years and their sex and age differences are presented in Tables 1–3. They contain the mean values and standard deviations for weight, height, BMI, length of the upper and lower extremities as well as of the four circumferences (upper arm, fore arm, thigh and calf).

Mean values of weight, height and BMI in the 3–5 years old children increased significantly with age. Three-year old boys had body weight of 18.7 ± 2.8 kg, height of 101.1 ± 5.2 cm and BMI of 18.3 ± 2.5 kg/m². Four-year old boys had body weight of 19.4 ± 3.0 kg, height of 108.5 ± 4.9 cm and BMI of 16.5 ± 2.2 kg/m². Five-year old boys had body weight of 21.5 ± 3.0 kg, height of 115.5 ± 5.8 cm and BMI of 16.1 ± 1.8 kg/m².

The above mentioned parameters also increased with age in girls. The body weight of 18.4 ± 4.4 kg, height of 103.3 ± 6.6 cm and BMI of 17.3 ± 3.3 kg/m² was found in 3-years old girls and increased to 19.9 ± 3.1 kg, height to 108.25 ± 6.3 cm and BMI to 16.9 ± 1.5 kg/m² in 4-years old girls. In 5-years old girls the corresponding values were: body weight of 21.7 ± 3.5 kg, height of 114.0 ± 6.4 cm and BMI of 16.6 ± 1.9 kg/m².

Table 1

Body weight, body height, BMI, lengths and circumferences of the extremities in 3 year-old -children (mean and standard deviation)

Sex	n	Body weight (kg)	Body height (cm)	BMI (kg/m²)	Lengths (cm)		Circumferences (cm)			
					Arm	Leg	Upper arm	Fore arm	Thigh	Calf
Boys	50	18.7 ± 2.8	101.1 ± 5.2	18.3 ± 2.5	40.6 ± 2.3	51.8 ± 4.4	15.6 ± 1.6	15.3 ± 1.5	24.7 ± 3.5	20.8 ± 2.4
Girls	50	18.4 ± 4.4	103.3 ± 6.6	17.3 ± 3.3	40.4 ± 3.4	53.3 ± 5.4	15.0 ± 1.9	14.9 ± 2.8	25.9 ± 3.8	20.6 ± 3.1

Table 2

Body weight, body height, BMI, lengths and circumferences of the extremities in 4 year-old -children (mean and standard deviation)

Sex	n	Body weight (kg)	Body height (cm)	BMI (kg/m²)	Lengths (cm)		Circumferences (cm)			
					Arm	Leg	Upper arm	Fore arm	Thigh	Calf
Boys	60	19.4 ± 3.0	108.5 ± 4.9	16.5 ± 2.2	42.3 ± 2.6	55.7 ± 4.2	15.4 ± 1.6	14.6 ± 1.5	25.9 ± 3.2	21.1 ± 2.0
Girls	60	19.9 ± 3.1	108.2 ± 6.3	16.9 ± 1.5	42.9 ± 3.3	57.3 ± 4.4	15.5 ± 1.4	15 ± 1.3	27.2 ± 3.2	21.9 ± 1.6

Table 3

Body weight, body height, BMI, lengths and circumferences of the extremities in 5 year-old -children (mean and standard deviation)

Sex	n	Body weight (kg)	Body height (cm)	BMI (kg/m²)	Lengths (cm)		Circumferences (cm)			
					Arm	Leg	Upper arm	Fore arm	Thigh	Calf
Boys	100	21.5 ± 3.0	115.5 ± 5.8	16.1 ± 1.8	45.9 ± 3.7	58.8 ± 5.7	15.6 ± 1.8	15.1 ± 1.7	28.1 ± 3.8	21.4 ± 2.9
Girls	100	21.7 ± 3.5	114.0 ± 6.4	16.6 ± 1.9	45.5 ± 2.9	59.4 ± 5.4	16.0 ± 1.7	15.3 ± 1.6	27.3 ± 4.8	22.0 ± 2.8

The remaining linear parameters both of boys and girls aged 3–5 also increased significantly with age. The comparison of these anthropometric parameters between boys and girls aged 3–5 showed age-specific differences in favor of the girls. Transversal parameters (diame-

ters) of the elbow and knee did not show significant differences in all examined groups.

All circumferences showed significant age-differences in children of both sexes ($p < 0.05$). Significant sex differences were found for forearm circumference and thigh circumference in 3-years old children in both sexes. The body weight, height, BMI and length of the upper extremity were significant in both sexes in 3-years old children. There were significant differences in boys age 4 for thigh circumferences and in girls age 4 for calf circumferences. In girls age 4 there were significant differences in length of lower extremity. In children aged 5 the measured parameters showed no important sex differences. Table 4 give age and sex specific percentiles for the anthropometric parameters that are commonly used for assessment of growth and nutritional status in children such as the weight-for-age; height-for-age and BMI indices.

Three-year-old boys have the following cutoff points in the range from the 5th to 85th percentiles for the three studied parameters: weight-for-age from 14 to 21 kg; height-for-age from 95 to 105.5 cm and BMI from 15.3 to 20.1 kg/m². The girls of the same age had the following cutoff points: from 14 to 23.7 kg for the weight-for-age parameter; 95.5 to 109 cm for the height-for age parameter and from 13.7 to 20.4 kg/m² for the BMI parameter.

Four-year-old boys had the following cutoff points in the range from 5th to 85th percentiles: from 15 to 23 kg for the weight-for-age parameter; from 101 to 114 cm for the height--for-age parameter and from 13.6 to 18.3 kg/m² for the BMI parameter. Girls of the same age had the following cutoff points: from 15 to 23 kg for the weight-for-age parameter; from 98.9 to 114 cm for the height-for-age parameter and from 14.5 to 18 kg/m² for the BMI parameter.

Five-years-old boys in the range from the 5th to the 85th percentiles had the following cutoff points: from 17 to 25 kg for the weight-for-age parameter; from 106 to 122 cm for the height-for-age parameter and from 13 to 17.9 kg/m² for the BMI parameter. Girls of the same age had the following cutoff points for the parameters considered above: from 16 to 26.7 kg for the weight-for-age parameter; from 100 to 120 cm for the height-for-age parameter and from 14.3 to 18.6 kg/m² for the BMI parameter.

Table 4a

Sex-specific percentiles of the indices: weight-for-age, height-for-age and BMI in 3 year-old-children

	PERCENTILES								
MALE	**5**	**10**	**15**	**25**	**50**	**75**	**85**	**90**	**95**
Weight-for-age	14	14.9	15.4	17	19	20	21	21	23.1
Height-for-age	95	96	96.8	97.3	100	104.8	105.5	107.3	110.4
BMI	15.3	15.5	16.1	16.7	18.1	19.2	20.1	21.2	23.1
FEMALE									
Weight-for-age	14	14.9	15	15	16.8	20	23.7	25	27.1
Height-for-age	95.5	96	97	98.5	102	107.5	109	110.1	111.8
BMI	13.7	14	14.4	15.3	16.5	18.8	20.4	20.8	23.6

Table 4b

Sex-specific percentiles of the indices: weight-for-age, height-for-age and BMI in 4 year-old-children

	PERCENTILES								
MALE	**5**	**10**	**15**	**25**	**50**	**75**	**85**	**90**	**95**
Weight-for-age	15	15	16	17.8	19.5	21.3	23	23	24
Height-for-age	101	102	102.4	105	109.5	112.1	114	114	115
BMI	13.6	14.4	14.4	15.1	16.2	17.4	18.3	18.6	20.1
FEMALE									
Weight-for-age	15	15.9	16	18	20	21	23	23	25
Height-for-age	98.9	100	101.8	105	108.6	112	114	116.1	119

| BMI | 14.5 | 15 | 15.4 | 16 | 16.7 | 17.8 | 18 | 18.4 | 19.4 |

Table 4c

Sex-specific percentiles of the indices: weight-for-age, height-for-age and BMI in 5 year-old-children

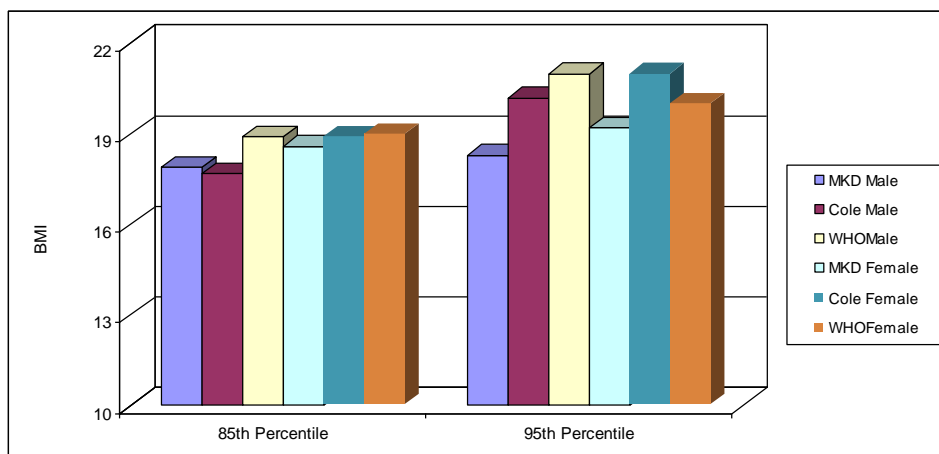|	PERCENTILES								
MALE	**5**	**10**	**15**	**25**	**50**	**75**	**85**	**90**	**95**
Weight-for-age	17	18	19	20	21	24	25	25	26
Height-for-age	106	108	109.1	112.2	116	119	122	123	124
BMI	13.0	13.7	14.1	14.9	16.0	17.2	17.9	18.3	18.8
FEMALE									
Weight-for-age	16	18	18.8	19	21	24	26	26	28
Height-for-age	100	102.3	109	112	115	119	120	121.5	121.45
BMI	14.3	14.5	14.8	15.3	16.4	18	18.6	19.2	20

Discussion

Several anthropometric parameters which are generally used for assessment of the growth and nutritional status in preschool children were examined in our study. Girls showed higher values than boys regarding weight, height and BMI. Our results are in agreement with the results reported in other anthropometric studies [14, 15]. The height-for-age index of the children and their chronological age are linearly related. Low values of this index, below the 5th percentile, point out to long-term disordered nutriation or health.

For 3-years-old boys the values of this parameter for the 50th percentile in our study was 100 cm, against 95cm found in the CDC reference population [15] and the values for the weight-for-age parameter in our study was 19 kg, which was higher than 15 kg for the CDC reference population.

The obtained values for our 4-years-old boys for the parameters considered above were 109 cm against 103 cm for the CDC reference population and 19 kg against 17 kg for the CDC reference, whereas 5-years-old boys had values for height-for-age 116 cm against 111 cm for the CDC reference, and the value for the weight-for-age parameter (21 kg) was higher in our study than the 19 kg value for the CDC reference. Girls in all three groups showed slightly higher values in our study than the values for the CDC references.

Anthropometric CDC and NCHS values have been accepted by the WHO as international standard for estimation of the growth and nutritional status and they comprise age categories from 1 to 77 years. The category of children with small body height and weight for their age being detected with the cutoff 5th percentile are considered as children underweight for their age. Fig. 1 gives 85th and 95th percentile of BMI in boys and girls aged 5 in comparison with the values for the same age reported by WHO and Cole at al. [16].

Fig. 1 – The values of the 85 and 95 percentile in 5 years old children and reported values of the same age by WHO and Cole T

Circumferences are sensitive indicators for the nutritional status, especially the upper arm and thigh circumferences.

The comparison of our results with those reported for other population in other studies [17– 20] is another confirmation for the existence of population differences in anthropometric characteristics, which depend on many internal genetics and external exogenous factors [21].

There is a high prevalence of childhood overweight or obesity in this preschool population, regardless of growth references used. Similar statistics are being reported in other developed countries [22, 23]. The short and long term physical health risks for children associated with excess weight include hypertension, hyperinsulinemia, glucose intolerance, type II diabetes, increased risk of early cardiac disease and psychosocial difficulties. Childhood obesity is a significant public health concern and accurate measurement and classification is crucial in determining the degree of this health problem [24].

Conclusion

We have determined cutoff points from the 5 to 95 percentile for anthropometric parameters which are routinely used in assessment of growth and nutritional status in preschool children. These results may be applied as criteria for assessment of growth and nutritional status in 3–5 years old children not only from kindergartens in Skopje but more generally. Additionally, anthropometric parameters have practical importance for planning certain preventive measures and activities in the field of children nutrition in one country.

Childhood obesity is a public health problem and is associated with increased morbidity and mortality. Obesity tracks through the life cycle suggesting that early identification and primary prevention is a key to reversing and preventing the upward trend into adult obesity and its potential future burden of illness. A consensus is urgently needed on the most valid and reliable growth references to use to measure and monitor a child's growth for both clinical and research purposes.

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Р е з и м е

ИНДЕКС НА ТЕЛЕСНАТА ТЕЖИНА, НЕИСХРАНЕТОСТ И ПРЕКУМЕРНА ИСХРАНЕТОСТ КАЈ ДЕЦА НА 3–5 ГОДИНИ ОД СКОПЈЕ

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Цел: Презентирање на индексот на телесната тежина (БМИ) кај деца на возраст од 3 до 5 години од Скопје и обезбедување информација за преваленцијата на различни категории на нутритивниот статус во тек на раното детство.

Материјал и методи: Студијата вклучува 420 претшколски деца (210 момчиња и 210 девојчиња). Беа мерени растот и телесната тежина, и беше пресметан БМИ. Беа измерени 12 антропометриски параметри со стандардна опрема и техника на мерење согласно со Интернационалната биолошка програма (ИБП).

Резултати: Беа детектирани специфични полови разлики скоро кај сите антропометриски параметри, при што момчињата покажаа малку повисоки вредности во однос на тежината, висината и БМИ кај децата на возраст од 3 до 5 години. Вредностите на 50. перцентил кај момчињата на возраст од 3 години за индексот тежина за возраст беа 19, 19,1 и 21 kg, а кај девојчињата тие беа 16,8, 20 и 21 kg. Вредностите за индексот висина за тежина за 50. перцентил кај момчињата покажаа малку повисоки вредности (100, 109,5 и 116 cm) во однос на девојчињата кај кои вредностите изнесуваа 102, 108,5 и 116 cm. Вредностите на 50. перцентил за БМИ кај момчињата изнесуваа 18,1, 16,2 и 16 kg/m², а кај девојчињата тие беа 16,5, 16,7 и 16,4 kg/m² за трите возрасни групи.

Заклучок: Добиените резултати покажаа дека неисхранетоста е главен проблем кај децата во раст и треба да се следи како проблем заедно со прекумерната исхранетост. Резултатите може да се користат како критериуми за процена и детекција на растот и нутритивниот статус кај претшколски деца на возраст од 3 до 5 години.

Клучни зборови: антропометрија, претшколски деца, неисхранетост, прекумерна исхранетост.