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Anthropometric parameters of growth and nutritional status in children aged 6 to 7 years in R. Macedonia

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ABSTRACT

Purpose: Evaluation of age- and sex-specific differences of anthropometric parameters that were used as indicators of growth and nutritional status in children aged 6 and 7 years in R. Macedonia and their comparison with the WHO and NCHS reference values.

Material and Methods: The study included 580 children aged 6 to 7 years from different regions of R. Macedonia. Eighteen anthropometric parameters were measured using standard equipment and measurement technique according to the International Biological Programme. The following nutritional indicators were calculated: BMI, weight-for-height, weight-for-age and height-for-age.

Results: The majority of anthropometric parameters have shown significant age- and sex-specific differences in favour of male subjects, with exception of skin-folds that were apparently higher in female subjects. Values at the 50th percentile in our male subjects for the index weight-for-age were 23 kg and 26.95 kg, respectively, whereas in the female subjects they were 22 kg and 25 kg, respectively. The index height-for-age corresponding to the 50th percentile showed higher values in our male subjects (119.5 cm and 125.55 cm) than in our female subjects (118 cm and 124.5 cm, respectively). 50th percentile in our male subjects for BMI was 16.48 kg/m^2 and 16.75 kg/m^2, whereas in our female subjects it was 15.98 kg/m2 and 16.25 kg/m^2, respectively.

Conclusions: The found values are recommended to be applied for evaluation of deviations in the growth and nutritional status in children aged 6 and 7 years from Macedonian nationality.

Key words: children, anthropometry, growth, nutritional status

INTRODUCTION

One of the most important characteristics in childhood is the continuing process of growth and development. Nutrition is also an important and dynamic ecological phenomenon, which has impact on all stages of growth and development of a human being and its evolution in medical, biological, cultural and social aspects [1]. Unhealthy and imbalanced nutrition as well as sedentary lifestyle contribute to onset of one serious health problem today, named globesity (overweight, obesity). The term itself "globesity" points out to its global spreading all over the world [2]. The World Health Organization (WHO) declares that tendency of overweight is very common in children both in developed and developing countries [3]. Health consequences of obesity are well-known and they include a wide variety of conditions that may affect breathing or muscle-skeleton system, but also life-threatening diseases such as various metabolic, endocrine, coronary-vascular, gastrointestinal and cerebrovascular diseases. Obesity in adult age also presents a health risk for some of the malignant diseases [4]. Health consequences of obesity in childhood are predictors of adult diseases, thus presenting obesity as an exceptionally serious health problem.

In order to prevent and reduce the increasing trend of obesity and its consequences, anthropometric characteristics of growth and nutritional status in children have to be constantly monitored. Some of the anthropometric measures and dimensions are particularly sensitive to changes in food habits and therefore, are sensitive nutritional indicators. On

the other hand, anthropometric measures are rapid, easy-to-perform, economic, non-invasive and are especially important for assessment of growth and nutritional status in children. These indicators can easily be applied in assessment of growth and nutritional status both in individuals and in populations [5].

According to the WHO recommendations the most widely accepted indicators for assessment of nutritional status in childhood, besides BMI (Body Mass Index) obtained by measuring basic anthropometric parameters, the following derived anthropometric indicators are also recommended: height-for-age, weight-for-age, weight-for-height and anthropometry of the upper-arm [6-10].

The primary aim of our study was evaluation of age-and sex-specific differences of anthropometric parameters that were used as indicators of growth and nutritional status in children aged 6 and 7 years in R. Macedonia and their comparison with the WHO and NCHS (National Center of Health Statistics) reference values.

This category of children, at the age of 6 and 7 years, is particularly sensitive since in this age period children start going to school, their lifestyle is noticeably changed and they become vulnerable to various health risks [11-13].

MATERIAL AND METHODS

The study included healthy children from both sexes aged 6 and 7 years of Macedonian nationality living in different regions of R. Macedonia. It excluded children with systemic and metabolic diseases that may affect on growth and development of children, as well as those children with family history of systemic illness. Anthropometric characteristics of the children at the age of 6 and 7 years were obtained from a representative sample of children, selected by previously done stratification, which divided the territory of R. Macedonia into seven statistical regions. According to the State Statistical Office of R. Macedonia children were selected proportionally from each region. The total number of subjects (n=580) was divided into two groups by age: a group of 6-year-old children (range of age from 6 to 6.9 years) and a group of 7-year-old children (range of age from 7 to 7.9 years). Each age group was divided into two subgroups by sex. Six-year-old group of children was divided into 150 boys and 140 girls and seven-year-old group was divided into 150 boys and 140 girls.

Anthropometry

All anthropometric measurements were done in line with the International Biological Programme (IBP) in the period between 5.09.-20.12.2008 [14]. For the purpose of the measurements the subjects were wearing light clothes (T-shirts and shorts), they removed their shoes and their anthropometric points and levels were previously marked. The following anthropometric parameters were measured: weight; height; length of the upper and lower extremity; eight circumferences (circumference of: mid-upper-arm, forearm, head, chest, abdomen, knee, thigh, calf); four bony diameters (diameters of: wrist, elbow, knee and ankle); and two skin-folds (skin-fold above scapula and triceps). The instruments for measuring were standard and were regularly calibrated before measuring; their precision was controlled throughout the entire measurement process. The following standard anthropometric instruments were used: anthropometer by Martin for measuring of height and lengths with reading precision of 1 mm; medical decimal scales for measuring of weight with precision of 0,1 kg; metal tape for measuring of circumferences with precision of 1 mm; "John-Bull" caliper for determination of skin-folds with pressure of 10 g/cm^2 and precision of 0,1 mm; and caliper square for measuring of diameters with reading precision of 1 mm.

According to the WHO recommendations for assessment of nutritional status in children the following indices were taken into consideration: weight-for-age, height-for-age, weight-for-height and BMI (dividing the weight by the square of the height) [3,6,8,10].

Definitions

For the aim of categorization of the anthropometric indices' values, the following percentile cut-off points were used: <5th percentile for the category of extremely low values; from the 5th to 85th percentile for mean values; from the 85th to 95th percentile for the category of above average values; and above the 95th percentile for extremely high values. The index weight-for-age was used for quantitative grading of the nutritional status in 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 the 85th to 95th percentile. If the value of the index weight-for-age was within the range of the 5th and 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 the 95th percentile [6,8,10].

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. Testing of sex and age differences was done with analysis of variance for large, independent samples-ANOVA. Differences for $p < 0.05$ were considered significant.

RESULTS

Mean values and standard deviations of the examined anthropometric parameters in children aged 6-7 years and their sex and age differences are presented in *Tab. 1; Tab. 2.*

Table 1. **Body weight, body height, BMI, lengths and diameters of the extremities in 6 and 7-year-old children from R. Macedonia (mean and standard deviation).**

Sex/age	n	Body weight (kg)	Body height (cm)	BMI (kg/m^2)	Lengths (cm)		Diameters (cm)			
					Arm	Leg	Elbow	Wrist	Knee	Ankle
Male										
6	150	24.48±5.15^b	119.7±5.52^b	16.94±2.61^b	53.26±2.26b	68.11± 3.85^b	5.44±0.82^b	3.95±0.45^b	7.78±0.84^b	5.53±0.49^b
7	150	27.46±5.67^{ab}	125.14±5.11^{ab}	17.45±2.93^{ab}	57.33±2.73^{ab}	72.42±3.53^{ab}	5.78 ±0.62^{ab}	4.14±0.38^{ab}	8.26 ±1.04^{ab}	5.89±0.47^{ab}
Female										
6	140	22.53±4.38	117.9±5.93	16.09±2.14	51.32±2.72	67.23 ±3.78	5.23±0.0.67	3.77±0.42	7.43±0.87	5.29±0.51
7	140	25.68±5.55^a	123.8±5.97^a	16.63±2.59^a	55.41±2.48^a	71.54±3.29^a	5. 52.±0.73^a	3.98±0.44^a	7.87±1.09^a	5.65±0.55^a

^{a} p<0.05 vs 6 year-old children (ANOVA)

^{b}p<0.05 vs female children of the same age (ANOVA)

Table 2. **Circumferences and skin-folds in 6- and 7-year-old children from R. Macedonia (mean and standard deviation).**

Sex/age	n	Circumferences (cm)								Skinfolds (mm^2)	
		Head	Chest	Waist	Hip	Mid upper	Forearm	Thigh	Calf	Scapula	Triceps
Male											
6	150	50.91±1.84^b	59.71±4.72^b	56.08±5.15^b	63.35±6.05	17.57±2.91	15.57±2.23^b	33.46±4.65	23.52±3.17	5.48±1.42^b	8.55±2.09^b
7	150	51.42±1.52^{ab}	62.53±6.14^{ab}	59.42±5.41^{ab}	67.41±6.14^a	18.53±2.37^a	16.63±1.98^{ab}	35.56±4.79^{ab}	25.31±4.01^{ab}	6.11±1.45^{ab}	9.36±2.23^{ab}
Female											
6	140	50.48±1.61	58.13±4.45	54.81±6.08	62.25±6.01	17.92±2.64	15.25±2.13	32.69±3.72	22.94±3.29	6.14±1.54	9.29±2.06
7	140	50.89±1.77^a	61.02.±5.81^a	57.63±6.24^a	66.04±6.11^a	18.95±2.18^a	16.27±2.02^a	34.24±4.87^a	24.33±4.05^a	6.81±1.73^a	9.97 ±2.17^a

^{a} p<0.05 vs 6 -year- old children (ANOVA)

^{b} p<0.05 vs female children of the same age (ANOVA)

Tab. 1 shows mean values and standard deviations for weight, height, BMI, length of the upper and lower extremity as well as of the four diameters (for elbow, wrist, knee and ankle).

Mean values of height, weight and BMI in the 6-7-year-old subjects increased significantly. Six-year-old boys had body height of 119.7 ± 5.5 cm, weight of 24.48 ± 5.2 kg and BMI of 16.94 ± 2.6 kg/m^2. Seven-year-old boys had body height of 125.14 ± 5.1 cm, weight of 27.46 ± 5.7 kg and BMI of 17.45 ± 2.9 kg/m^2. These parameters also increased with age in the female subjects. Body height from 117.9 ± 5.9 cm, weight from 22.53 ± 4.4 kg and BMI from 16.09 ± 2.1 kg/m^2 in the 6-year-old girls increased to 123.8 ± 5.9 cm, 25.68 ± 5.6 kg and 16.63 ± 2.6 kg/m^2, respectively in the 7-year-old girls. Besides height, the remaining linear parameters both in male and female subjects aged 6-7 years increased significantly with age. Comparison of these anthropometric parameters between male and female subjects showed age-specific differences in favour of the male subjects.

Transversal parameters of the skeleton (diameters) demonstrated significant age differences where subjects belonging to younger age category had markedly lower values of these parameters compared to the group of older age subjects.

Mean values, standard deviations as well as sex and age differences in the circular parameters (circumference and skin-folds) are presented in *Tab. 2.* All circumferences showed significant age differences in the children of both sexes. In addition to age difference, head and chest circumferences also showed a substantial sex difference in all examined groups. Significant sex differences were found for forearm circumference and waist circumference in the 6-year-old children. Thigh and calf circumferences revealed significant sex differences in the 7-year-old subjects. Mid-upper-arm circumference and hip circumference showed no important sex differences.

Skin-folds (scapula and triceps), which are indicators for subcutaneous fat component had substantially higher values in girls from both age groups and at the same time age differences were registered for these parameters.

Tab. 3; Tab. 4 give age- and sex-specific percentiles for the anthropometric parameters that are commonly used for assessment of the growth and nutritional status in children, such as: indices weight-for-age, height-for-age, BMI, mid-upper-arm circumference and skin-folds of scapula and triceps.

Six-year-old boys displayed the following cut-off points in the range from the 5th to 85th percentile for the parameters height-for-age from 111.5 to 125.6 cm; weight-for-age from 18 to 31 kg; and for BMI from 13.45 to 19.71 kg/m^2. Female subjects at the same age had the following cut-off values: from 109.4 to 123.6 cm for height-for-age; from 16 to 26.35 kg for weight-for-age; and from 12.88 to 18.72 kg/m^2 for BMI.

Seven-year-old boys presented with the following cut-off values from the 5th to 85th percentiles: from 117.6 to 130 cm for height-for-age; from 20 to 33 kg for weight-for-age; and from 14.25 to 19.8 kg/m^2 for BMI. Girls at the same age presented with these cut-off values: from 114 to 129.65 for height-for-

Table 3. **Percentile values for body weight, body height and BMI by sex and age, in 6- and 7-year-old children from R. Macedonia.**

Sex/age		Percentiles								
Weight-for-age	n	5	10	15	25	50	75	85	90	95
Male										
6	150	18	19.5	20	20	23	28	31	32	33
7	150	20	21	22.12	24	26.95	30	33	35	36.95
Female										
6	140	16	17.1	18	19	22	25	26.35	29.3	30
7	140	18.75	20	20	22	25	28.5	30.5	33	35
Height-for-age										
Male										
6	150	111.5	113	114.4	116	119.5	123.5	125.6	127.2	128.8
7	150	117.6	118.43	119.1	121.42	125.55	128.25	130	131.4	134.19
Female										
6	140	109.4	110.6	111.6	113.2	118	121.5	123.6	125	127.9
7	140	114	117	117.5	119.4	124.5	127.55	129.65	131.1	133.5
BMI										
Male										
6	150	13.45	13.88	14.36	14.89	16.48	18.2	19.71	20.58	22.5
7	150	14.25	14.68	14.93	15.55	16.75	18.44	19.803	20.94	22.97
Female										
6	140	12.88	13.52	13.96	14.43	15.98	17.78	18.72	19.08	19.54
7	140	13.12	13.68	14.26	14.99	16.26	17.82	19.21	19.81	21.68

age; from 18.75 to 30.5 kg for weight-for-age; and from 13.12 to 19.21 kg/m^2 for BMI.

The index weight-for-height shows relationship between weight and height of a child. *Tab. 5* gives mean values, standard deviations and median values for weight of different categories of height in subjects of both ages.

DISCUSSION

We examined several anthropometric parameters in our study, which are used for assessment of growth and nutritional status in children. Age- and sex-specific differences related to certain anthropometric parameters were observed in favour of male subjects, except of skin-folds of scapula and triceps that showed higher values in female subjects. Our results are in agreement with the results reported in other anthropometric studies [15-17].

The obtained values enabled comparison with corresponding anthropometric researches in children from other regions and populations, but from our country as well. Namely, Todorovska et al., in her extensive anthropometric study of 1997 performed anthropometric measurements in children aged 7-15 years and she evaluated the degree of nutrition. This study determined on the cut-off values of anthropometric indicators for the nutritional status with relation to various percentile categories for the examined age groups. Todorovska et al., compared these values with those obtained for the reference NCHS population [1].

The index height-for-age portrays the degree of linear growth of a child in correlation with his/her chronological age [18]. Low values of this parameter, under the 5th percentile, point out to long-term disordered nutrition or health [18,19]. The value of this parameter for the 50th percentile in the 6-year-old boys in our study was 119.5 cm against 119.3 cm found in the NCHS reference population [18,20]. The obtained value for our 7-year-old boys was 125.55 cm, which was insignificantly lower than 126.6 cm for the NCHS reference population and similar to the value reported in the study of Todorovska et al., [1,18,20]. The values obtained for our female subjects are similar with those presented in the WHO reports, but somewhat lower [18]. The values for the 6- and 7-year-olds were 118 cm and 124.5 cm and they were similar with the values found in the NCHS reference population (NHANES - National Health and Nutrition Examination Survey), presented with 117.8 cm for the 6-year-old girls and 124.4 cm for the 7-year-old girls [17]. Anthropometric NCHS values have been accepted by the WHO as international anthropometric standard values 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 for their age that is being detected with the cut-off 5th percentile is used to discover children with impediment to attain the

Table 4. **Percentile values for mid upper circumference and skin-folds by sex and age, in 6- and 7-year-old children from R. Macedonia.**

Sex/age		Percentiles								
Mid upper arm circumference	n	5	10	15	25	50	75	85	90	95
Male										
6	150	14.5	15	15.7	16.2	17.3	18.2	20.2	21	22
7	150	15.	15.8	16.5	17	18.35	20.	21	21.9	22.5
Female										
6	140	14.8	15.5	16	16.6	17.6	18.5	20.5	21.18	22.25
7	140	15.5	16.2	16.8	17.5	18.8	20.	21.2	21.55	22.35
Skin-fold scapula										
Male										
6	150	3.5	3.8	4	4.2	5.2	6.8	7.2	7.5	8
7	150	3.8	4.2	4.5	5.1	5.9	7	7.5	7.8	8.5
Female										
6	140	3.8	4.2	4.5	4.8	5.6	7.25	7.8	8.2	8.5
7	140	4.65	5	5.2	5.7	6	8.2	8.65	9.2	10
Skin-fold triceps										
Male										
6	150	5.2	5.8	6.2	7	8.2	9.8	10.8	11.5	12
7	150	5.89	6.5	7	8	8.8	10.95	11.4	12	13
Female										
6	140	5.8	6.2	6.8	7.7	9	10.5	11.2	12.2	13.
7	140	6.2	7	7.5	8.5	9.7	11.45	12.2	12.5	13.55

Table 5. **Means (x), standard deviations (Sd) and medians (Me) for the index weight-for-height for 6- and 7-year-old children by sex.**

Height (cm)	*n*	Body weight (kg)		
		X	Sd	Me
Male				
102-108.9	4	16.57	2.5	16
109-115.9	26	20.27	2.4	20
116-122.9	110	23.08	2.1	23
123-129.9	125	28.7	5.3	27
130-136.9	35	33.4	4	33
Female				
102-108.9	6	16.25	1.9	15
109-115.9	64	19.7	2.6	19
116-122.9	93	22.7	3.1	22
123-129.9	95	26.4	4.9	26
130-136.9	22	31.6	6.3	30

potential for linear growth as a result of impaired health or undernourishment [19]. In contrast, the category of children with extreme height for their age that corresponds to the cut-off above the 95th percentile indicates the possible risk of endocrine disorders in children, which cause enormous linear growth [19].

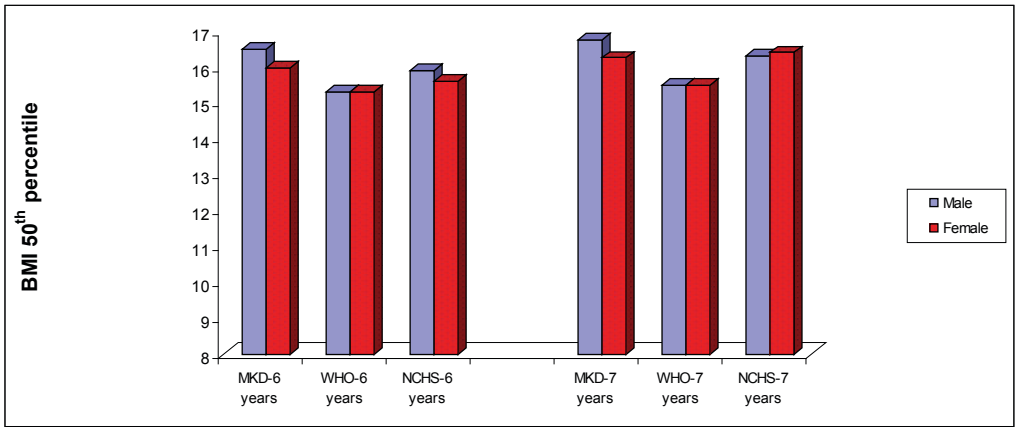
The index of weight-for-age shows the achieved weight for the chronological age of a child [7,18,19]. Values at the 50th percentile for weight-for-age in both male and female subjects aged 6 and 7 years in our study were moderately higher in comparison with those reported in literature [18,20].

Values for the parameter weight-for-age under the 5th percentile imply underweight that does not correspond with the chronological age of a child and might also be a result of the impaired health state or undernourishment. On the contrary, if the value for weight-for-age is above the 85th percentile, it identifies children with risk of overweight, a condition that predicts obesity in children [18].

The parameter weight-for-height shows if the child has reached the adequate weight corresponding to his/her actual height [18]. This parameter is influenced by the height (height-for-age) and weight of the child (weight-for-age) [18]. Low values for weight-for-height, under the 5th percentile reveal weight loss as a result of acute starvation or serious disease whereas overweight with relation to the height of a child also describes the overweight as an indicator for a risk of obesity [18,19].

The index of weight, widely known as BMI, together with the index of weight-for-age are parameters for monitoring the nutritional status [7-10,18-21]. The results from our study referring to, have shown gender-specific differences between male and female subjects at the age of 6 and 7 years. In both

Figure 1. **The values of the 50th percentile of BMI in 6- and 7-years-old children from Macedonian nationality (MKD) and reported values of the same age by WHO and NCHS.**



age groups, the values of BMI were significantly ($p<0.05$) higher in male subjects. There were no big gender-specific differences in the reported values by WHO and NCHS, which is the major difference with the findings in our study (*Fig.1*) [18,20].

Fig.1 gives 50th percentile of BMI in our subjects aged 6-7 years from both sexes in comparison with the reported values of the same age by WHO and NCHS.

Cut-off values of BMI for the 85th and 95th percentile were higher in our subjects at the age of 6 years (19.71 and 22.5 kg/m^2) than in the subjects examined by Cole (17.7 and 20.2 kg/m^2) [22]. BMI values in our female subjects aged 6 years were 18.72 kg/m^2 for the 85th percentile and 19.54 kg/m^2 for the 95th percentile against the Cole's relevant results of 17.5 kg/m^2 for the 85th percentile and 20.1 kg/m^2 for the 95th percentile [22]. BMI values in our 7-year-old subjects had the following values for the 85th percentile and the 95th percentile: 19.8 and 22.97 kg/m^2 for boys and 19.2 and 21.68 kg/m^2 for girls against those reported by Cole: 18.2 and 20.6 kg/m^2 for 7-year-old boys and 18 and 20.5 kg/m^2 for 7-year-old girls [22].

Circumferences are sensitive indicators for the nutritional status, especially the mid-upper-arm circumference. Six and seven-year-old children in our study had lower mean values and values at the 50th percentile for mid-upper-arm circumference than those in the NCHS reference population [20].

Skin-folds are indicators of the size of subcutaneous fat contents, that is, of the energetic reserve in the organism. Skin-fold above triceps is particularly sensitive parameter for detecting changes in the nutritional status. There was a significant sex difference in favour of girls in our study, which coincides with the findings in other anthropometric studies [15-17]. Mean values of skin-folds in our subjects were somewhat lower in comparison with those in the NCHS reference population [20].

Comparing our results with those reported for other populations in other studies are another confirmation for the existence of population differences in anthropometric characteristics, which depend on many internal (genetic) and external exogenous factors [1]. Results obtained in our study have confirmed the WHO recommendation that it is necessary for each country to prepare its own anthropometric standards. They are indispensable for precise classification and detection growth deviations and nutritional status impairment in children of all age stages. Utilization of anthropometric standards of other regions and populations, such as the NCHS standards, is allowed only in cases when one country lacks national anthropometric standards.

CONCLUSIONS

We have determined cut-off points from the 5th to the 95th percentile for anthropometric parameters which are routinely used in assessment of growth and nutritional status in children. These results may be applied as anthropometric criteria for assessment of growth and nutritional status in six and seven-year-old children from Macedonian nationality living in different regions in R. Macedonia. They should also contribute to acknowledgement of the most common disorders in growth and nutritional status as well as to help in more precise selection of individuals who are in need of nutritional intervention and further clinical examinations. Additionally, anthropometric parameters have a practical importance for planning certain preventive measures and activities in the field of children's nutrition in one country.

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