*JMS 2021;4(1):130-137*
*UDC:572.087.1-053.2(497.7)*

# ANTHROPOMETRIC PARAMETERS AND INDEXES IN 9 YEAR-OLD-CHILDREN FROM R. NORTH MACEDONIA

Zafirova Biljana[1], Chadikovska E[1], Trpkovska B[1], Bojadgieva B[1], Dodevski A[1], Petkovska L[2].

[1]Institute of Anatomy, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, R of North Macedonia,

[2]University Clinic of Toxicology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, R of North Macedonia,

**Abstract**

The aim of the study was the detection of sex-specific differences of anthropometric parameters and indexes that were used as indicators of growth and nutritional status in the 9-year-old-children from R.North Macedonia.

The study included 280 healthy children aged 9 (140 boys, 140 girls) from R.North Macedonia. Fourteen anthropometric parameters were measured which define longitudinal, circular and transversal measures of skeleton using standard equipment and measurement technique. The following indicators were calculated: weight-for-age (BW), height-for-age (BH), BMI, mid-upper circumference-for-age (MUAC) and skinfolds thickness (scapula SFSc and triceps SFTr)-for-age.

The results have shown significant sex-specific differences in favour of boys for the height, four transversal and three circular parameters, with exception of mid-upper-arm circumference and skinfolds that were apparently higer in girls. Values of the 50$^{th}$ percentile in boys were as follows: 33 kg for BW, 136 cm for BH and 17.65 kg/m$^2$ for BMI, 19.8 cm for MUAC and for skinfolds: SFSc 8 mm and 12 mm for SFTr.The values of these parameters in girls were: 32 kg for BW, 135cm for BH and 17.47 kg/m$^2$ for BMI. 20.8 cm for MUAC and for SFSc 9.8 mm and 12.8 mm for SFTr.

These results can be used as criteria for the assessment of the morphological characteristics and detection of deviations in the growth and nutritional status in children aged 9.

***Key words***: children, anthropometry,growth, nutritional status

## Introduction

Growth is integral part of childhood and growth monitoring is critical for the assessment of health and disease in an individual child and the community as a whole [1]. Anthropometrics are a set of non-invasive, quantitative body measurements used to assess growth, development, and health parameters[2]. Anthropometric measurements, including parameters that define the longitudinal, circular and transversal dimensions of the body help providers determine if a child is growing properly and can indicate when the child's health and well-being are at risk [3]. Additionally, anthropometric measurements assist providers in selecting appropriate treatment options for children and adolescents [4]. Two of the most important health indicators for children are their individual growth pattern and their weight and height relationship, which are determined by accurate serial anthropometric measurements [4]. In the anthropometric assessment of children's nutritional status, the variables weight, height, sex, and age are combined to form anthropometric indices [5,6].

According to the WHO recommendations the most widely accepted indicators for assessment of nutritional status in childhood, besides BMI obtained by measuring basic anthropometric parameters, the following derived anthropometric indicators are also recommended: height-for-age, weight-for-age, anthropometry of the upper-arm-for-age (MUAC) and skinfolds thikness (over scapula SFSc-for-age and triceps SFTr-for-age) [7-11].

Since growth is an indicator of child's health and nutrition, updated population-specific reference growth charts are needed [11]. For this reason, in order to prevent and reduce the increasing

trend of obesity and its consequences, anthropometric variables of growth and nutritional status in children have to be constantly monitored [12].

Some of the anthropometric variables are particularly sensitive to changes in food habits and therefore, are sensitive nutritional indicators [5]. The body-composition assessment based on anthropometric measurements are still an important method of choice in clinical investigations [13]. Moreover, anthropometric measures are rapid, easy-to-perform, economic and are especially important for assessment of growth and nutritional status in children[2,4].

In according with these the aim of the study was the evaluation of sex-specific differences of anthropometric parameters and indexes that were used as indicators of growth and nutritional status of the 9-year-old-children in the R. North Macedonia.

**Materials and methods**

Subjects

The study included healthy children from both sexes aged 9 years from living in different regions of R.North 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. The total number of subjects (n=280) was divided into two subgroups by sex: 140 boys and 140 girls.

Anthropometry

All anthropometric measurements were done in line with the International Biological Programme (IBP)[2,4,9]. 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: For assessment of longitudinal skeleton dimensionality: body height, length of (arm and leg); for assessment of transversal skeleton dimensionality: diameters for (elbow, wrist, knee and ankle); for assessment of body mass and circular dimensionality, i.e. body volume: body weight, circumferences of (mid-upper-arm, head, chest, waist) and two skin-folds thickness (above scapula and triceps) which are indicators for subcutaneous fat componet. 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 gr/cm$^2$ and precision of 0,1 mm, and caliper square for measuring of diameters with reading precision of 1mm. According to the WHO recommendations for assessment of nutritional status in children the following indices were taken into consideration: weight-for-age (BW), height-for-age BH), BMI (dividing the weight by the square of the height, mid-upper-arm-circumference-for-age (MUAC) and skinfolds-for-age: above scapula-for-age (SFSc) and triceps (SFTr).

Definitions

For the aim of categorization of the anthropometric indices' values, the following percentile cut-off points were used: <5$^{th}$ percentile for the category of extremely low values or underweight; from the 5$^{th}$ to less than the 85$^{th}$ percentile for mean values normal or healthy weight; from the 85$^{th}$ to lees than the 95$^{th}$ percentile for the category of overweight or category of above average values; and 95$^{th}$ percentile or grater for obese and for extremly high values, and for skinfold thickness-for-age > =90 $^{th}$ percentiles for the obesity [10-11,13-15].

Statistics

The gathered data for the relevant variables were analyzed with a descriptive statistics represented by central tendency and its deviation (arithmetic mean ± standard deviation) along with ranges expressed in percentiles. Testing of sex-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 9 years and their sex differences (ANOVA- test) are presented in Table 1and Table 2.

Table 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).

**Table 1**. Body weight, height, BMI, lengths and diameters of the extremities in 9- old -children from R.North Macedonia (mean and standard deviation).

| Sex | n | Body weight (kg) | Body height (cm) | BMI ($kg/m^2$) | Lengths (cm) | | Diameters (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Arm | Leg | Elbow | Wrist | Knee | Ankle |
| **Boys** | 140 | 33.59±6.75 | 136.1±6.27[a] | 18±2.73 | 59.5±3.26 | 77.58±2.33 | 6.07±0.8[a] | 4.3±0.4[a] | 8.6±1.3[a] | 6.2±0.6[a] |
| **Girls** | 140 | 32.5.±4.56 | 134.5±5.63 | 17.9±2.54 | 59.1±3.6 | 77.27±2.51 | 5.86±0.88 | 4.2±0.46 | 8.29±1.5 | 6.1±0.7 |

[a]$p<0.05$ vs female children (ANOVA)

Nine years old boys had body height of 136.1. ±6.27 cm, weight of 33.59 ± 6.75 kg, BMI of 18.02±2.73 $kg/m^2$, length of arm 59.53±3.26 cm, length of leg 77.58±2.33 cm and for transversal parameters of the skeleton (diameters):elbow of 6.07±0.83cm, wrist of 4.35 ±0.44cm, for knee of 8.62±1.31cm and for ankle of 6.25±0.66cm.

Girls at the same age have the following values for the same parameters: body height of 134.51. ±5.63 cm, weight of 32.54 ±5.92 kg, BMI of 17.91±2.54 $kg/m^2$, length of arm 59.12±3.63 cm, length of leg 77.27±2.51 cm and for transversal parameters of the skeleton (diameters): elbow of 5.86±0.88cm, wrist of 4.21 ±0.46cm, for knee of 8.29±1.52cm and for ankle of 6.12±0.7 cm.

The results of the comparative examinations of these parameters showed the existence of sex-specific differences for height and all four diametres in favour of boys. Mean values of the other parameter were slightly higher in boys, but the sex-specific difference turned out to be insignificant.

Mean values and standard deviations as well as sex differences in the circular parameters (circumference and skin folds thikness) are presented in Table 2.

Values of the circular parameters-four circumferences in our nine year old boys were (52.11±1.22 cm for head, 64.64±5.94cm for chest, 63.96±7.25cm for waist and for MUAC of 20.06 ±3.14cm.) and values for the skinfolds thikness were (SFTr of 12.02±4mm and SFSc of 9±3.66mm). Values for the same parameters in our nine year old girls were of 51.57±1.44cm for head, 62.91±5.88cm for cheast, 62.03±7.23cm for waist and for MUAC of 20.87±2.82 cm and for SFTr of 12.89±3.15mm and SFSc of 10.26±3mm.

Circular parameters circumferences of (head, chest, waist) showed sex-specific difference also in favour of boys. Significant difference in favour of girls was noticed in the mid-upper-arm cirucumference and in the skinfolds (over scapula nad triceps).

**Table 2**. Circumferences and skinfolds of 9 year-old children from R. North Macedonia (mean and standard deviation).

| Sex | n | Circumferences (cm) | | | | Skinfolds (mm) | |
|---|---|---|---|---|---|---|---|
| | | Head | Chest | Mid upper | Waist | Scapula | Triceps |
| **Boys** | 140 | 52.11±1.22[a] | 64.64±5.94[a] | 20.06±3.14 | 63.96±7.25[a] | 9±3.66 | 12.02±4 |
| **Girls** | 140 | 51.57±1.44 | 62.91±5.88 | 20.87±2.82[a] | 62.03±7.23 | 10.26±3[a] | 12.89±3.15[a] |

[a]$p<0.05$ vs female children (ANOVA)

Table 3 give 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-for-age and skin-folds thikness (scapular and triceps)-for-age.

Boys displayed the following cut-off points in the range from the $5^{th}$ to $85^{th}$ percentile for the parameters height-for-age from 126.5 to 143.4 cm; weight-for-age from 25 to 40 kg; BMI from 14.61 to 20.44 kg/m$^2$, muac-for-age from 15.68 to 23.5 cm, SFTr-for-age from $5^{th}$ to $75^{th}$ percentile from 6.5 to 14.8 and for SFSc-for-age from 5 to 11.5. Girls at the same age had the following cut-off values: from 105.83 to 118.38 cm for height-for-age; from 15 to 22 kg for weight-for-age; from 12.38 to 20.56 kg/m$^2$ for BMI, muac-for-age from 16.5 to 22.8cm, SFTr-for-age from 8 to 15 mm and for SFSc-for-age from 5.9 to 12.5 mm.

**Table 3.** Sex-specific percentiles of the indexes: Weight-for-age, Height-for-age, Body Mass Index, MUAC-for-age, SFTr-for-age, and SFSc-for-age in 9 year-old children from R. North Macedonia

| | PERCENTILES | | | | |
|---|---|---|---|---|---|
| **BOYS** | **5** | **50** | **85** | **90** | **95** |
| Weight-for-age | 25 | 33 | 40 | 43 | 45 |
| Height-for-age | 126.5 | 136 | 143.4 | 144.8 | 146.4 |
| BMI-for-age | 14.61 | 17.65 | 20.44 | 21.34 | 24.04 |
| MUAC-for-age | 15.68 | 19.8 | 23.5 | 24.8 | 26 |
| SFTr-for-age | 6.5 | 12 | 16.5 | 17.2 | 18 |
| SFSc-for-age | 5 | 8 | 13.6 | 14.5 | 16.3 |
| **GIRLS** | | | | | |
| Weight-for-age | 24 | 32 | 38 | 40 | 44 |
| Height-for-age | 124.75 | 135 | 140.15 | 141.3 | 143.2 |
| BMI-for-age | 14.39 | 17.47 | 20.5 | 21.6 | 23.1 |
| MUAC-for-age | 16.5 | 20.8 | 24 | 24.5 | 25.2 |
| SFTr-for-age | 8 | 12.8 | 16 | 17 | 18.5 |
| SFSc-for-age | 5.9 | 9.8 | 13.8 | 14 | 15.5 |

**Discussion**

We examined fourteen anthropometric variabless, which define longitudinal, circular and transversal measures of skeleton. Also these results can be used as criteria for the assessment of the morphological characteristics and detection of deviations in the growth and nutritional status in children.

Our results are in agreement with the results reported in other anthropometric studies [6,15-21].The obtained values enabled comparison with corresponding anthropometric researches in children from other regions and populations. The index height-for-age portrays the degree of linear growth of a child in correlation with his/her chronological age [22]. Low values of this parameter, under the $5^{th}$ percentile, point out to long-term disordered nutrition or health [6]. The value of this parameter for the $50^{th}$ percentile in the 9-year-old boys/ grils in our study was for boys of 136 cm and 135cm for girls respectively, against 137.5 cm for boys and 137 cm for girls found in the NCHS reference population [10,11,13-14]. The category of children with small body height for their age that is being detected with the cut-off $5^{th}$ percentile is used to discover children with impediment to attain the potential for linear growth as a result of impaired health or undernourishment [5,6,19]. In contrast, the category of children with extreme height for their age that corresponds to the cut-off above the $95^{th}$ percentile indicates the possible risk of endocrine disorders in children, which cause enormous linear growth [5-6,17,19,21,].

The index of weight-for-age shows the achieved weight for the chronological age of a child. Values at the $50^{th}$ percentile for weight-for-age in boys and girls in our study were moderately higher in comparison with those reported in literature [6,10-11,13-16,17,19].

Values for the parameter weight-for-age under the $5^{th}$ 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 $85^{th}$ percentile, it identifies children with risk of overweight, a condition that predicts obesity in children. The index of weight, widely known as BMI, together with the index of weight-for-age are parameters for monitoring the nutritional status [15]

Cut-off values of BMI for the $85^{th}$ and $95^{th}$ percentile were higher in our boys at the age of 9 years (20.44 and 24.04 $kg/m^2$) than in the subjects examined by Cole (19.46 and 23.39 $kg/m^2$) [23]. BMI values

in our girls were 20.56 kg/m$^2$ for the 85$^{th}$ percentile and 23.1 kg/m$^2$ for the 95$^{th}$ percentile against the Cole's relevant results of 19.46 kg/m$^2$ for the 85$^{th}$ percentile and 23.46 kg/m$^2$ for the 95$^{th}$ percentile [23]. Circumferences are sensitive indicators for the nutritional status, especially upper-arm anthropometry seems to be an important technique to determine body-composition and nutritional status [18]. Children in our study had easily lower mean values and values at the 50$^{th}$ percentile for mid-upper-arm circumference than those in the NCHS reference population [10-11-13,14,18].

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 [18].

The differences among the children in this and other studies are another confirmation for the existence of population differences in anthropometric characteristics, which are under the influence of many endogenous and environmental factors [24]. These values are just another confirmation of the WHO request for creating our own, clearly defined and precise anthropometric criteria for classification and detection of growth, nutritional problems in children of all age groups, criteria which should arise from measurements conducted in our own population [25].

**Conclusion**

Based on the results of this study, the following conclusions can be drawn:

- 9 year boys in Macedonia have higher mean values for longitudinal, transversal and circular anthropometric variables compared with the girls. MUAC and skinfolds are exception to this.

- Statistically significant sex-specific differences were registered for height, four transversal and three circular parameters again in favour of boys. For the other longitudinal parameters (lengts of arm and leg) there were no statistically significant differences, even though the mean values were slightly higher in boys.

- There were also statistically significant sex-specific differences for MUAC and skinfolds (scapula and triceps), but in favour of girls.

We have determined cut-off points from the 5$^{th}$ to the 95$^{th}$ percentile for anthropometric variables which are routinely used in assessment of growth and nutritional status in children.

It is recommended to apply these results in everyday routine practice as anthropometric criteria for assessment and evaluation of nutritional status. They can also indicate certain misbalance as criteria for selection of individuals for further clinical research. Additionally, anthropometric varibales have a practical importance for planning certain preventive measures and activities in the field of children's nutrition in one country.

**References**

1. J. Fudvoye and A.-S. Parent. Secular trends in growth. Annales d'Endocrinologie 2017; 78, (2): 88–91.
2. Kristen Cashin and Lesley Oot .Guide to anthropometry. A Practical Tool for Program Planners, Managers, and Implementers.2018. https://www.fantaproject.org/sites/default/files/resources/FANTA-Anthropometry-Guide-May2018.pdf
3. Zafirova B, Todorovska L. Anthropometric parameters of growth and nutritional status in children aged 6 to 7 years in R. Macedonia. Adv med Sci 2009;54(20):289-95.

4. California Department of Health Care Services, Systems of Care Division Child Health and Disability Prevention Program, Health Assessment Anthropometric mesaurements Guidelines Mar 2016 https://www.dhcs.ca.gov/services/chdp/Documents/HAG/4AnthropometricMeasure.pdf
5. Haroldo da Silva Ferreira et all.Antropometric assessment of childs nutritional status:a new approach based on adaption of Watrelow classification. BMC Pediatr.2020; (20):65.
6. Vaman Khadilkar, Sangeeta Yadav et all. IAP Growth Charts for Height, Weight and Body Mass Index for 5- to 18-year-old Indian Children.Indian Pediatr 2015; 20 (52): 47-55.
7. de Onis M, Onyango AW, Borghi E, Nishida AS, Siekman J. Development of a WHO growth reference for school-aged children and adolescents. Bull WHO. 2007;85(9):649-732.
8. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J, for the WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. Food Nutr Bull 2006; 25(suppl 1):S15–26.
9. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Technical Report Series No. 854. Geneva: World Health Organization, 1995nning, study design, and methodology. Food Nutr Bull 2004;25(1)(supplWHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatr Suppl. 2006; 95 (S450):76–85.
10. World Health Organisation. Obesity. In: World Health Organisation; 2016. http://www.who.int/topics/obesity/en.
11. World Health Organisation. Child Growth Standards Geneva: WHO 2007; Available from: http://www.who.int/childgrowth/en/
12. Lobstein T. Prevalence And Trends Across The World. In M.L. Frelut (Ed.), The ECOG's eBook on Child and Adolescent Obesity. 2015; Retrieved from ebook.ecog-obesity.eu
13. U.S. Centers for Disease Control and Prevention (CDC). National Health and Nutrition Examination Survey (NHANES):Anthropometry Procedures Manual. 2016; Available at: https://www.cdc.gov/nchs/data/nhanes/ nhanes_07_08/manual_an.pd
14. CDC table for calculated BMI values for selected heights and weights for ages 2–20 years. National Health and Nutrition Examination Survey. 2000; Available from: http://www.cdc.gov/
15. Using the BMI-for-Age Growth Charts CDC https://www.cdc.gov/nccdphp/ dnpa/growthcharts/ training/modules/module1/text/module1print.pdf.
16. Mc Dowell AM, Fryar DC, Hirsch R, Ogden SL. Anthropometric references data for children and adults: US Population, 1999-2002. Adv Data 2005; 361:1-5.
17. Olcay Neyzi Ruvede Bundak Gublin Gokcay et all.Reference Values for Weight, Height, Head Circumference, and Body Mass Index in Turkish Children. J Clin Res Endocrinol 2015D; 7(4):280-293
18. Velez RR, Cifuentes MF, Correa- Bantista JE, et al. Tricepsand subscapular thickness percentiles and cut-off for overweigt and obesity in a population based sample of schoolchildren and adolescents in Bogota, Columbia. Nutrients, 2016;8(10):595.
19. Lazarus Mramba, Moses N et all. A growth reference for mid upperarm circumference for age among schoolage children and adolescents, and validation for mortality: growth curve construction and lomgitudinal cohort study. BMJ 2017;358;j3423.
20. Jeanette Tinggaard , Lise Aksglaede et all.The 2014 Danish references from birth to 20 years for height, weight and body mass index**.** Acta Paediatrica.2014;103(2):214-24
21. Juliusson PB, Roelantes M, Nordal E, Furevik L, Eide GE, Moster D, Hauspie R, Bjerknes R. Growth references for 0-19 year old Norwegian children for length/height, weight, body mass index and head circumference. Ann Hum Biol. 2013;40:220-7.
22. Kherkheulidze M, Nemsadze K, Kavlashvili N, Kandelaki E, Adamia N. The parameters of physical growth in 5-6 years old children in Tbilisi. Georgian Med News. 2010;(178):52-6
23. Cole TJ, Bellizzi CM, Flegal MK, Dietz HW. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1240-6

24. Zafirova B et all.Evaluation of Sex-Specific Differences of Anthropometric Variables That Were Used as Indicators of Nutritional Status in Macedonian Children. JMS. 2018; 1 (1): 25-30.
25. de Onis M, Habict JP. Anthropometric reference data for international use: recommendations from a WHO Expert Committee. Am J Clin Nutr. 1996; 64(4):650-8.