AGE AND SEX-RELATED DIFFERENCES IN ANTHROPOMETRIC CHARACTERISTICS AND BODY COMPOSITION IN PRIMARY SCHOOL-AGE CHILDREN

STAROSNE I POLNE RAZLIKE U ANTROPOMETRIJSKIM KARAKTERISTIKAMA I TJELESNOJ KOMPOZICIJI OSNOVNOŠKOLSKE DJECE

ABSTRACT

This study addressed the assessment of anthropometric characteristics and body composition of primary school children. The study aimed to determine age and sex related differences in children aged 7 and 8 years, which could be used to assess the health status of children and monitor the trend of their growth and development. The study included 1520 students (814 second-grade students and 706 third-grade students; 772 boys and 748 girls). The participants were measured for body height and weight, body mass index, body fat percentage, fat mass, and fat-free mass. The results indicated that there were significant differences between boys and girls in body height and weight, fat percentage, body mass index, and fat-free mass (p <.05), whereas there was no difference in fat mass. Apart from the fat percentage, there are significant differences between seven- and eight-year-old children in all other measured variables. The obtained values of anthropometric characteristics and body composition of children are in accordance with the world trends. The differences between the sexes and the generations of children that have been identified are probably due to genetic predisposition, but also to the conditions in which they grow up.

Key words: health status of children, fat in children
INTRODUCTION

Obesity among children, adolescents and adults has emerged as one of the most serious public health concerns in the 21st century. According to the World Health Organization (WHO), obesity occurs in one of ten people worldwide (WHO, 2015; van Vliet-Ostaptchouk, Nuotio, Slagter, Doiron, Fischer, Foco, & Joensuu, 2014). Secular trends in increasing body fatness are occurring rapidly and especially sensitive period that can be influenced by this changes are childhood and preadolescents (Ng, Fleming, Robinson, Thomson, Graetz, et al., 2014). Measurement of body composition in childhood, as a key component of individual's health and physical fitness profile, is of considerable importance for creating national health strategies and provide a better environment for healthy growing up. The ability to quantify body composition parameters such as fat mass, fat percentage, free fat mass and body mass index and compare them according age and sex may enable better insight of future health hazards associated with obesity. According to some research sexual dimorphism in body composition is considered to be slight before puberty (Forbes, 1987), but increase of body weight begins at about the age of 8 and this persistence continues until the end of the growing process. (Kędzior, Jakubek-Kipa, Brzuszek, & Mazur, 2017).

Thus, the aim of this study was to compare anthropometrics and body composition parameters in primary school-age children depending on sex and age. In addition, these obtained values of age and sex differences can be used to provide important data on body composition in healthy children from municipality of Banja Luka (region in Bosnia and Herzegovina; ~200,000 inhabitants).

METHODS

The study included second- and third-grade students aged 7 and 8 from Banja Luka (Republic of Srpska, Bosnia and Herzegovina). Stratified random sampling was used in this study. Nine primary schools were identified and randomly selected by the author. Consent to participate in the study was obtained from the parents of the children. A total of 1520 students participated, of which 814 were second-grade students and 706 were third-grade students.

Body weight and height, as the most representative measures of physical growth and development, were measured by standard measurement methods: 1) body height (cm) was measured by a Martin anthropometer; 2) body weight (0.1 kg) was measured by a body composition analyzer (BC-418 "TANITA", Japan). The same apparatus calculated 4 additional parameters: Body Mass Index (BMI), Body Fat Percentage (FatP), Fat Mass (FatM), and Fat-Free Mass (FFM). Bioelectric impedance analyzers can be an accurate device for measuring FatP, FatM and FFM in children (Lim et al., 2009).

All body parameters were measured by using a multifrequency bioelectrical impedance analyser (TANITA BC-418MA III). Examinees were tested barefoot, in pants and shirts. During the data collection they were standing on the bottom of body analyser and held electrodes in both arms. The surface of the hand electrode was
placed in contact with each of the five fingers. Data input contains body height and age, and for the testing of recreationists’ categories were selected. After signal reports the direct current goes throw the body and analysed necessary body parameters: Body Mass Index, Fat Free Mass, Fat Percentage, and Fat Mass. The BIA assessment was performed between 10.00 AM and 4.00 PM. Height was, also, measured barefoot to the nearest 0.1 cm, respectively.

Descriptive statistics were calculated for all variables. A T-test for independent samples was used to determine differences between groups. Also, as an effect size statistic, Partial Eta squared ($\eta^2$) was calculated. Statistical significance was determined at the level .05. All analyses were performed using SPSS version 20.0.(IBM, Armonk, NY).

**RESULTS**

The collected anthropometric and body composition characteristics of the study are reported in Table 1 stratified by sex, and Table 2 stratified by age.

### Table 1. Sex-related difference in body composition in healthy early age school children

|            | N (n=1520) | Mean | Std. Dev. | Std. Error Mean | t     | df   | p   | Par. Eta Squared |
|------------|------------|------|-----------|-----------------|-------|------|-----|------------------|
| **Height** |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 131.20 | 6.67      | .24             | 5.73  | 1518 | .00 | .02              |
| girls      | 748        | 129.27 | 6.43      | .23             |       |      |     |                  |
| **Weight** |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 30.09 | 6.86      | .24             | 3.90  | 1518 | .00 | .01              |
| girls      | 748        | 28.74 | 6.61      | .24             |       |      |     |                  |
| **BMI**    |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 17.33 | 2.86      | .10             | 2.00  | 1518 | .04 | .00              |
| girls      | 748        | 17.04 | 2.82      | .10             |       |      |     |                  |
| **FatP**   |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 21.95 | 8.47      | .30             | -5.17 | 1518 | .00 | .00              |
| girls      | 748        | 23.78 | 4.77      | .17             |       |      |     |                  |
| **FatM**   |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 6.85  | 3.40      | .12             | -1.46 | 1518 | .14 | .00              |
| girls      | 748        | 7.09  | 3.13      | .11             |       |      |     |                  |
| **FFM**    |            |      |           |                 |       |      |     |                  |
| boys       | 772        | 23.51 | 8.26      | .29             | 5.64  | 1518 | .00 | .02              |
| girls      | 748        | 21.64 | 3.80      | .13             |       |      |     |                  |

**Legend:** FatP-fat mass percentage, FatM-fat mass (kg), BMI-body mass index, FFM-fat free mass (kg). Mean – the value of arithmetic means; StdDev. (Standard Deviation) – Average deviation of the obtained results from their arithmetic mean; p – coefficient of significance p<.05. Partial Eta squared-effect size statistics.
Table 2. Age-related differences in Body Composition in healthy Early Age School Children

|        | N (n=1520) | Mean | Std. Dev. | Std. Error Mean | t     | df  | p   | Par. Eta Squared |
|--------|------------|------|-----------|-----------------|-------|-----|-----|-----------------|
| **Height** |            |      |           |                 |       |     |     |                 |
| seven-year | 814        | 127.378 | 5.63      | -.19            | -20.55 | 1518 | .00 | .21             |
| eight-year  | 706        | 133.57  | 6.11      | .23             |        |     |     |                 |
| **Weight** |            |      |           |                 |       |     |     |                 |
| seven-year | 814        | 27.52  | 6.02      | .21             | -12.35 | 1518 | .00 | .09             |
| eight-year | 706        | 31.62  | 6.92      | .26             |        |     |     |                 |
| **BMI** |            |      |           |                 |       |     |     |                 |
| seven-year | 814        | 16.85  | 2.77      | .09             | -5.02  | 1518 | .00 | .01             |
| eight-year | 706        | 17.58  | 2.88      | .10             |        |     |     |                 |
| **FatP** |            |      |           |                 |       |     |     |                 |
| seven-year | 814        | 22.74  | 8.06      | .28             | -0.65  | 1518 | .51 | .00             |
| eight-year | 706        | 22.97  | 5.44      | .20             |        |     |     |                 |
| **FatM** |            |      |           |                 |       |     |     |                 |
| seven-year | 814        | 6.45   | 3.02      | .10             | -6.73  | 1518 | .00 | .02             |
| eight-year | 706        | 7.57   | 3.45      | .12             |        |     |     |                 |
| **FFM** |            |      |           |                 |       |     |     |                 |
| seven-year | 813        | 21.33  | 7.93      | .27             | -8.21  | 1518 | .00 | .04             |
| eight-year | 706        | 24.04  | 3.93      | .148            |        |     |     |                 |

Legend: FatP-fat mass percentage, FatM-fat mass (kg), BMI-body mass index, FFM-fat free mass (kg), Mean – the value of arithmetic means; StdDev. (Standard Deviation) – Average deviation of the obtained results from their arithmetic mean; p – coefficient of significance p<.05. Partial Eta squared-effect size statistics.

Table 1 shows statistically significant differences in both anthropometric (height p= .00; weight p=.00) and body composition characteristics (BMI p=.04; FatP p=.00; FFM p=.00) between boys and girls. According to Means values, the girls are having a more fat percentage (23.78 vs.21.95), more fat mass (7.09 vs. 6.85) and less body mass index (17.04 vs. 17.33) than boys. The boys are taller approximately 2.93cm (132.20 vs. 129.27) and heavier1.35kg (30.09 vs. 28.74) than girls. Table 2 shows statistically significant differences in anthropometric (height p=.00; weight p=.00) and body composition characteristics (FatM p=.00; BMI p=.00; FFM p=.00) between a seven-year-olds and an eight-year-olds. By observing Mean values it can be noticed that eight year-olds have higher values in fat mass (7.57 vs. 6.45), body mass index (17.58 vs. 16.85) and free fat mass (24.04 vs. 21.33) than seven-year-olds. The eight-year-olds are approximately 6.20cm higher (133.57 vs. 127.37) and 3.75 kg heavier (31.62 vs. 27.52) than seven-year-olds.

**DISCUSSION**

In this study, we aimed to make comparisons between anthropometric and body composition parameters in primary school-age children depending on sex and age. We also assumed that there were no significant differences in anthropometric parameters and body composition between the measured boys and girls and that there were no significant differences in

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anthropometric parameters and body composition between the two generations of children. The results showed that, except in Fat mass (p = .14), there are significant differences between boys and girls in Height, Weight, Fat Percentage, Body Mass Index, and Fat-Free Mass (p < .05). For all variables Partial Eta Squared was $\eta^2 \sim .01$ (small, according to Pierce, Block, & Aguinis, 2004). Furthermore, except in Fat percentage (p = .51), there are significant differences between seven-year and eight-year girls and boys (p < .01). Partial Eta Squared for the Height variable was $\eta^2 = .21$ (large), and for the variable Weight was $\eta^2 = .09$ (medium). All remaining values Partial Eta Squared was $\eta^2 \sim .01$ (small).

If we compare the values obtained with Fomon’s “reference child” (Fomon et al., 1982) and the values obtained by Ruxton et al. (1999) a clear trend of increasing all measured characteristics in children is evident. Mean values are presented in the table 3.

Table 3. The trend of changing anthropological characteristics and body composition of children aged 7 and 8

| Variables | Age 7 | Age 8 |
|-----------|-------|-------|
| Height (cm) | 121.7 | 127.0 |
| Weight (kg) | 22.9 | 25.3 |
| FatP (%) | 12.8 | 13.0 |
| FatM (kg) | 2.9 | 3.3 |
| BMI | 15.5 | 16.9 |
| FFM (kg) | 19.9 | 22.0 |
| Height (cm) | 120.6 | 126.6 |
| Weight (kg) | 21.8 | 26.9 |
| FatP (%) | 16.8 | 23.6 |
| FatM (kg) | 3.7 | 6.5 |
| BMI | 15.0 | 16.4 |
| FFM (kg) | 18.1 | 20.5 |

Hence, due to the large increase in measured characteristics of children over the last 37 years, comparing our results with others only makes sense if we consider recent research. In our study, children from 7 to 8 years grow ~ 6.2 cm and gain ~ 4.1kg. As expected, boys are taller and heavier than girls, which is in concordance with the results of significant studies on a large population of children (Lobstein & Frelut, 2003; Binkin et al., 2010; Özkan et al., 2014; Wijnhoven et al., 2014; Datar & Chung, 2015; Dordić et al., 2016). According to WHO standard norms (WHO, 2019), the average BMI values of 17.33 kg/m² in boys and 17.04 kg/m² in girls in our study indicated average-normal nutritional status. The boys in our study have a higher BMI than the girls and this is not the rule. In some studies, boys have a higher BMI (Dordić et al., 2016; Chwalczyńska et al., 2018), yet in other studies girls do (Halasi et al., 2018; Taylor et al., 1997, Basterfield et al., 2011) and in some cases they are

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similar (Maynard et al., 2001; Planinšec & Fošnarič, 2009). For children measured in our study, BMI increases by ~ 0.7 in one year. In Hungarian 6-year longitudinal study (Kovacs et al., 2018) followed the height, weight, and BMI of seven-year-old boys and girls. After 6 years, a new generation of seven-year-olds was measured. New generation of boys and girls are taller, heavier and have a higher BMI. This increase is not statistically significant but is an indication. In this study, boys have a lower percentage of adipose tissue than girls. This is consistent with the results of available research (McCarthy et al., 2006, Halasi et al., 2018; Taylor et al., 1997; Chwałczyńska et al., 2018). Zhang et al. (2015) analysed fatness in Tibetan children. They found that there were no differences between age groups until 11 years, but all fat indices were higher in girls than in boys (p < 0.05). Finnish girls of the same age as in our study, have a higher body fat percentage than boys (23.2% vs.18.2, p < 0.001, Soininen et al., 2018). When processing the data, we also calculated the relationship between BMI and FatP. Spearman’s rank correlations suggesting a significant positive correlation (r = 0.667, p < 0.01), which is consistent with the studies of Taylor et al. (1997) and Eisenmann et al. (2004). The girls in our study had significantly higher adipose tissue mass than boys. In similar studies (Taylor et al., 1997; Dencker et al., 2007; Chwałczyńska et al., 2018) girls also have higher adipose tissue mass than boys. The study by Dencker et al. (2006) on the 8 to 11-year-olds suggests that girls have a significantly higher fat mass (FatM) (.007 and .0008) and a significantly higher percentage of fat (FatP p<.001). Consequently, girls in the prepubertal phase of life seem to have a higher fat mass and a higher percentage of fat than boys. Regarding Fat Free Mass (FFM) in our study, there is more in boys. This is also the case in the studies of Chwałczyńska et al. (2018) and Sen & Mondal (2013). Also, Dencker et al. (2007) found more Fat Free Mass (FFM) in boys (p <0.001). However, Wells et al. (2002) found no significant differences between eight-year-old boys and girls in Fat Free Mass. From the age of 3 to 11 FFM significantly increased (~ 10 kg, p < .001) in children (Nakao & Komiya, 2003). This is logical as children grow and develop. The Japanese children in that study, aged 7 and 8, recorded an FFM value of 19.10 kg, which is less than the children in our study (22.59kg).

The composition of the human body changes with ontogenetic development. The intensity of changes is determined by genetic factors and it is well influenced by environmental factors (Chwałczyńska et al., 2018). Economic power and social inequalities strongly influence the anthropological characteristics and physical composition of children. According to Dubois et al. (2012), genetics seems to play an increasingly important role in explaining differences in height, weight, and BMI from early childhood to late adolescence, especially in boys. Furthermore, common environmental factors have the strongest impact, especially in the pre-adolescent years, more significantly in girls. These findings underscore the need to target health-related-family and social impacts on children in early childhood, especially in girls.

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CONCLUSION

Age and sex-related differences in anthropological characteristics and body composition of urban children aged 7 and 8 in the Republic of Srpska seem to be comparable to those of other European regions. But, to the best of the author's knowledge, there are very few studies that analyse in details the body composition of children aged 7 and 8. The gender differences we identified probably develop from genetic predispositions as well as current environmental conditions. The increase in the value of anthropometric characteristics and body composition of the children we identified in this study is in line with global trends. There are two limitations to this study that should be considered. The participants of the study were children from one region of Bosnia and Herzegovina. It is quite possible to get slightly different results if children from other regions were measured. Secondly, if we had followed multiple generations of children, we would probably have analysed the trend of growth and development of children, or their anthropometric characteristics and body composition we could make more reliable conclusions.

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SAŽETAK

Ova studija se bavila procjenom antropometrijskih karakteristika i tjelesne kompozicije osnovnoškolske djece. Cilj istraživanja bio je da se utvrde starosne i polne razlike kod djece starosti 7 i 8 godina, što bi poslužilo procjeni zdravstvenog statusa djece i praćenja trenda njihovog rasta i razvoja. Studija je obuhvatila 1520 učenika (814 učenika drugih razreda i 706 učenika trećih razreda; 772 dječaka i 748 djevojčica). Ispitnicima su izmjereni tjelesna visina i težina, indeks tjelesne mase, procenat tjelesne masi, masa masnoće i masa bez masnoće. Rezultati su pokazali da postoje značajne razlike između dječaka i djevojčica u tjelesnoj visini i težini, procentu masnoće, indeksu tjelesne mase i masi bez masnoće (p<.05), dok razlike nije bilo u masi masnoće. Sem u procentu masnoće, postoje značajne razlike između sedmogodišnje i osmogodišnje djece u svim ostalim mjerenim varijablama. Vrijednosti antropometrijskih karakteristika i tjelesne kompozicije djece koje su dobijene mjerenjem i razlike među djecom u skladu su sa svjetskim trendovima. Za razlike između polova i generacija djece koje su utvrđene vjerovatno su zaslužne genetske predispozicije, ali i uslovi u kojima odrastaju.

Ključne riječi: zdravstveni status djece, masnoće kod djece

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