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Sex Differences in Morphological Characteristics of Pre-school Children

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ABSTRACT The study was conducted on a sample of 110 preschool children. The InBody 230 apparatus was used to measure morphological characteristics and provide estimates of body composition. Results of MANOVA revealed statistically significant differences ($F=21.364$; $p<0.000$) between the subgroups. Univariate analysis of variance (ANOVA) demonstrated individual differences. Regression analysis did not show any statistically significant correlation between the predictor systems with the criterion (BMI) in boys. System predictors in girls pointed to a statistically significant correlation ($R=0.615$; $p<0.045$) with the criterion. Conclusion is that there are no major changes in the morphology and structure of body composition in either sex. Children are at a similar nutritional status and there are no significant changes in the assessment of body adipose tissue. BMI provides limited information about the relation with body composition in children, but can serve as a good parameter when monitoring obesity in children.

INTRODUCTION

Body composition or constitution, is the most prominent characteristic of a person. In adults, it represents man's lifestyle, sports activity, success, but also illness. Preschool age, in terms of growth and development, can be defined as very heterogeneous with uneven level of development that varies with race and gender (Taylor et al. 2002). When trying to define the physical constitution of children, special attention should be paid to gender differences in the distribution of body constitution, changes in somatotype (Singh 2011), as well as the stability of individual physical constitution during the growth and development (Longkumer 2014).

There are different approaches to defining and comparison of body composition in children, as well as defining the morphological structure of space and the ways in which physical parameters are obtained and compared. If we compare the methods of assessment of body composition over a period of three decades, the differences between the authors can be noted. Heinonen et al. (1998) argue that the bioelectrical impedance (BIA) method gives better results than DXA method because the results are obtained at the level of the whole body, a fact that is designed for the older sample. Further research conducted by Bray et al. (2002) comparing the six different methods for estimating body fat shows that the worst results evaluating body fat were provided by the BIA method. The most efficient method of estimating the percentage proved to be the Pennington 4-compartment model by which the body fat expressed in kilograms is divided by the current body weight and multiplied by 100. This is supported by the findings of Eisenmann et al. (2004) indicating that the BIA method in 3-8 years old children has limited use in the assessment of body composition, while the free anthropometric method of body mass index (BMI) and skin folds (SFs) proved more useful in the assessment of body

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composition and monitoring of obesity. Also, recent research show that the standard anthropometric methods to define the morphological types are still used with some thirty-three percent and the BIA method with twenty-five percent of all methods used (Silva et al. 2013). The best indicators, and indicators of child growth and development to some extent, are height/weight ratios used to calculate the BMI (body weight (kg)/body height (m2)). They act as an important indicator of nutritional status and health risks they pose (Janssen et al. 2004). A Japanese study by Satake et al. (2010) using the computed tomography (CT) examined children who were not obese aged 6-20 years in reference to subcutaneous adipose tissue and visceral fat. The study indicated that children aged 6-10 years were similar, while adolescents differ in subcutaneous adipose tissue in favour of the girls and visceral fat in favour of the boys. The opposite findings regarding the preschool children aged 6-7 years also from Japan were stated by Sakai et al. (2011). The authors have stated that a lower percentage of adipose tissue was found in girls of preschool age, which is explained by entering the phase of early maturation.

The researchers' aim was to identify the differences in the composition of body structure and morphological characteristics of preschool children as well as to determine the correlation between composition of body structure, morphological characteristics and the state of nutrition by using the BIA and anthropometric methods.

MATERIAL AND METHODS

Research Sample

The sample consisted of 110 children with mean age 6.25±0.31 years, divided into two homogeneous sub-sample groups of 60 boys and 50 girls who at the time of measurement attended preschools on 11th April in Novi Beograd. The sample was drawn from the population of preschool children by random sampling method (quota sampling). This type of pattern has professional and scientific justification when investigating a mass phenomenon and homogenization group (sample) had previously been carried out and therefore, the planned research quota sample method can provide very good results and external validity of the study (generalization).

Research Design

The study used non-experimental research design (ex post facto draft). Parents or guardians of children had been informed in writing about the plan, its realisation and duration and asked to sign a consent form in accordance to ethical principles for biomedical research on humans (World Medical Association Declaration of Helsinki 2013). The measuring had begun at the end of November 2015 after the written consents had been obtained from parents or guardians of children.

Research Instrument and Procedure

Anthropometric measures, which are measured in accordance with the guidelines of the International Biological Program (IBP) (Lohman et al. 1988) for the evaluation of longitudinal dimensionality of the skeleton are: 1) Body height (0.1 cm): to estimate the volume and mass of the body; 2) Body weight (0.1 kg): for the evaluation of subcutaneous adipose tissue; 3) Abdominal skin fold (0.1 cm); 4) Back skin fold (0.1 cm) and 5) Upper arm skin fold (0.1 cm).

Based on the values of the Body height and Body weight variable, BMI (Body Mass Index) was calculated in a manner that the value of body weight in kilograms was divided by the square of body height in meters, according to the following formula: BMI=(BW (kg) / BH (m^2)).

A sample of measuring instruments for the assessment of body composition was taken by InBody 230 (Biospace Co. Ltd., Seoul, Korea) a device, which operates on the basis of bioelectrical impedance and consisted of the following variables: 1) Total amount of muscle (0.1 kg); 2) Total amount of adipose tissue (0.1 kg); 3) Total amount of water (0.1 kg); 4) Intracellular fluid (0.1 kg); 5) Extracellular fluid (0.1 kg); 6) Total amount of protein (0.1 kg); 7) Total amount of mineral particles (0.1 kg), and 8) Fat-free mass (0.1 kg).

When measuring the longitudinal dimensionality of the skeleton the researchers' complied with certain standards (IBP). Posture of the respondents was standing (respondent standing barefoot in his underwear, head in the Frankfurt horizontal position). After that, the parameter was defined. The Anthropometry by Martin was the measuring instrument used. The distance from the ground to the top of his head has been measured. The results are expressed as 0.1 cm value. The body weight was measured by digital medical scale with participant standing barefoot in upright position on it. The results are expressed as 0.1 kg value. All skin folds were measured with John Bull type calliper while the respondent was in an upright position. In measuring abdominal skin fold (umbilicus), the measuring assistant lifted the left hand transverse abdominal skin fold in place which is 5 cm above the navel. The assistant measured the thickness of the skin fold with the top of the calliper; the measured value is expressed as 1 mm. The result was recorded after the first measuring. The back skin fold (subscapularis) was measured in a manner that the measuring assistant lifted the skin fold by his left arm in place at the blades level. The assistant measured the thickness of the skin fold with the top of the calliper; the measured value was expressed as 1 mm. The result was also recorded after the first measuring. The upper arm skin fold had been measured while the respondent was also standing with hands stretched down the body. The assistant measured the thickness of the skin fold by lifting the longitudinal skin fold above the triceps (triceps brachii) at its broadest and, with the top of the calliper, measured the thickness of skin fold. The result was also expressed as 1 mm value and recorded after the first measuring.

The BIA analysis was used to estimate body composition. The advantage of this method is that it can be used in clinical conditions and in the field. This method assessed the structure of body composition by broadcasting low, safe doses of electricity (800 micro amps) through the children's body. The current is passed through the body, without resistance of the muscles, while resistance occurred when the current passed through the adipose tissue. This resistance is called bioelectrical impedance, and was measured by a device that estimates body composition. The BIA method has become the reference method in body composition analysis research studies.

Data Analysis

Statistical analysis included the computation of basic descriptive statistics: starting with measures of central tendency (M) the arithmetic mean of the measures of variability and (SD) standard deviation. To determine statistically significant differences in the overall status of body composition and morphological characteristics between groups of subjects, a multivariate (MANOVA) analysis of variance was used. Individual statistically significant differences were tested by univariate (ANOVA) analysis of variance. Relations between sets of variables for assessing body composition and morphological characteristics of the system as a predictor variable and variables for assessing nutritional status as criteria were calculated by linear regression analysis for both sexes. Correlation analysis revealed a partial correlation with BMI variables tested whereby the influence of other variables on the correlation was considered as a constant.

RESULTS

Based on Wilks F test in Table 1 it can be concluded that there exists statistically significant differences between boys and girls in the entire tested area of body composition and morphological characteristics all at the conclusion of $p<0.001$. Individual differences were found in the variables: *Body height*, *Intracellular fluid*, *Extracellular fluid* and in the variable *Total amount of protein* in favour of the boys, while girls achieve better and statistically significant values in variable *Total amount of minerals*.

Following text show the values of partial correlation and linear regression analysis of body composition and morphological characteristics of the BMI for both sexes at the conclusion of $p<0.005$.

Based on the results in Table 2, linear regression analysis of the body composition and morphological characteristics of the criterion (*BMI*), it can be concluded that the system of predictors in boys did not achieve a statistically significant correlation. Partial correlation coefficients when each variable in the predictor system is observed individually, and the impact of other predictor system variables is disregarded, also leads to a conclusion that statistically significant correlation with BMI variable has not been achieved. The adjusted coefficient of determination in boys explains for only 21.8 percent of the common variance with the criterion.

In Table 3, the coefficient of multiple correlation and its significance show a statistically significant correlation between predictor system and criterion in girls. The adjusted coeffi-

Table 1: Descriptive statistics and differences in the morphological characteristics and body composition

Variable	*BoysN(60)*		*GirlsN(50)*			
	M	*SD*	*M*	*SD*	*f*	*p*
Body Height (0.1cm.)	1233.6	41.98	1196.5	50.83	17.59	**0.000**
Body Weight (0.1kg.)	245.20	26.66	254.46	39.47	2.13	0.147
Body Mass Index (kg/m^2)	19.87	2.01	20.86	2.59	5.05	0.027
Abdominal Skin Fold (0.1cm.)	78.65	36.95	83.08	36.57	0.39	0.531
Back Skin Fold (0.1cm.)	61.88	19.47	64.98	18.50	0.72	0.397
Upper Arm Skin Fold (0.1cm.)	89.92	30.20	85.22	26.31	0.74	0.391
Total Amount of Muscle (0.1kg.)	11.85	2.04	11.17	2.30	2.65	0.106
Total Amount of Adipose Tissue (0.1kg.)	5.81	2.43	4.90	2.35	1.41	0.236
Total Amount of Water (0.1kg.)	17.28	2.50	16.27	2.77	4.04	0.047
Intracellular Fluid (0.1kg.)	10.11	1.36	9.31	1.16	10.64	**0.001**
Extracellular Fluid (0.1kg.)	6.30	0.85	5.74	0.76	12.96	**0.000**
Total Amount of Protein (0.1kg.)	4.39	0.58	3.99	0.55	13.79	**0.000**
Total Amount of Mineral Particles (0.1kg.)	1.53	0.23	1.71	0.21	17.68	**0.000**
Fat-free Mass (0.1kg.)	22.32	2.98	22.64	2.33	0.36	0.545
F=21.364; P=**0.000**						

Legend: M - arithmetic mean; S - standard deviation; f - f univariate test; p - level of statistical significance test f; F - Wilks multivariate F test; P -multivariate F test statistical significance

Table 2: BMI regression analyses and correlation - Boys

Variable	*rpart.*	*prpart.*	*t*	*Beta*	*pbeta*
Abdominal Skin Fold	-0.095	0.472	-0.311	-0.103	0.757
Back Skin Fold	-0.191	0.144	-0.348	-0.093	0.729
Upper Arm Skin Fold	-0.010	0.937	0.215	0.045	0.830
Total Amount of Muscle	-0.055	0.674	-0.712	-0.857	0.480
Total Amount of Adipose Tissue	-0.302	0.057	-1.927	-0.411	0.019
Total Amount of Water	-0.066	0.617	0.801	0.985	0.427
Intracellular Fluid	0.240	0.064	0.527	3.054	0.600
Extracellular Fluid	0.236	0.070	0.989	3.859	0.328
Total Amount of Protein	0.183	0.161	-0.525	-0.202	0.602
Total Amount of Mineral Particles	0.169	0.198	0.171	0.149	0.865
Fat-free Mass	0.234	0.071	-0.639	-5.595	0.526
R=0.467; R^2=0.218					
F=1.219; P=0.301					

Legend: rpart. - Partial correlation coefficient; prpart.- partial correlation statistical significance; t - value of t-test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression beta coefficient; R - coefficient of multiple correlation; R2 - determination coefficient; F - value of F ratio; P - multiple correlation coefficient statistical significance.

cient of determination explains for almost thirty-eight percent of the common variance with the criterion. Based on the standardized regression coefficients Beta and their statistical significance the positive correlation of the *Total amount of adipose tissue* variable on the results achieved in the BMI variable in girls can be noted. Review of the partial correlation coefficient revealed the largest positive significant correlations between the variables *Back skin fold* and the *BMI*.

DISCUSSION

Results of the analyses of the morphological characteristics and body composition in boys and girls have indicated certain, but not essential differences, realized in the longitudinal dimensionality of the skeleton and variables that estimate the total amount of intracellular and extracellular water amounts in favour of the boys. The boys compared with their female peers also displayed higher values of total amount of protein mass in the body. Certainly, it should not be claimed that the values of these parameters in girls are substantially reduced since it should be confirmed by clinical-laboratory methods. However, it is necessary to emphasise the importance of these fluids in children. That is, when the values of the extracellular fluid are extremely reduced, intracellular fluid experienc-

Table 3: BMI regression analyses and correlation - Girls

Variable	*rpart.*	*prpart.*	*t*	*Beta*	*pbeta*
Abdominal Skin Fold	0.208	0.147	1.470	0.472	0.150
Back Skin Fold	0.344	**0.015**	0.354	0.081	0.725
Upper Arm Skin Fold	-0.101	0.486	-1.743	-0.436	0.089
Total Amount of Muscle	0.046	0.754	-0.218	-0.047	0.829
Total Amount of Adipose Tissue	0.252	0.078	2.729	0.538	**0.010**
Total Amount of Water	0.035	0.811	1.931	0.490	0.061
Intracellular Fluid	-0.011	0.941	1.161	0.383	0.253
Extracellular Fluid	-0.124	0.390	-0.048	-0.014	0.962
Total Amount of Protein	0.139	0.336	-0.050	-0.008	0.960
Total Amount of Mineral Particles	-0.114	0.432	-0.668	-0.226	0.508
Fat-free Mass	-0.149	0.300	-1.395	-0.209	0.171
R=0.615; R^2=0.378					
F=2.101; P=**0.045**					

Legend: rpart. - Partial correlation coefficient; prpart.- partial correlation statistical significance; t - value of t-test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression beta coefficient; R - coefficient of multiple correlation; R2 - determination coefficient; F - value of F ratio; P - multiple correlation coefficient statistical significance.

es more intensive osmosis. This phenomenon in children can lead to different CNS states manifested by vomiting, drowsiness, confusion, and headache. In the past, the thesis that a proper diet regime must contain a large amount of protein was widely accepted. Accordingly, the quality of the diet does not depend on the amount of protein and of their origin, but on the use of a variety of healthy ingredients. Foods rich in protein and calories, consumed by children in developed countries and affects faster growth, can lead to serious consequences in adolescence and later periods of life: obesity, diabetes and atherosclerosis (Nader et al. 2006). Experience from the US shows that, along with the increase in the prevalence, the overweight children suffer more difficult obesity conditions. The findings clearly point to that (Sturm 2007). The author has stated that from year 2000 to year 2005, the prevalence of obesity in BMI>30 increased by twenty-four percent, BMI>40 by fifty percent, and the prevalence of BMI>50 increased by seventy-five percent. Even earlier survey conducted by Abraham et al. (1971) indicates that excessive weight at young age represents a significant predictive factor in the old age. The data suggests that excessive weight among children in Europe has continued to increase during the last three decades, and this is particularly manifested in the countries of south Europe (Lobstein and Frelut 2003; Rysha et al. 2017).

No major deviations were found regarding the body weight in the tested sample in question, as well as body mass index, although the average values indicate that girls are slightly heavier and with greater BMI values. These values were found to be statistically significantly different. Average values of BMI in boys amounted to BMI=19.87±2.01 and in girls BMI=20.86 ±2.59. From this fact we can conclude that children of both sexes have the normal nutritional status as prescribed by the National Institutes of Health (1988), which indicates that the normal weight of children at this age are those children whose BMI values are in the range between BMI=18.5-24.9 kg/m2. The research results indicate that both boys and girls are at a satisfactory level of nutrition, and that the essential difference between them in body composition observed are consistent with the findings of Wachira et al. (2014) and Araujo et al. (2017), but it is also obvious that in the test age for this sample, the growth of long tubular bones in boys is more pronounced and faster than in girls. Uneven bodily growth and development, as well as the intensity of certain processes in the body are responsible for the bone growth in length in male subjects. A recent study presented by Stamm et al. (2014) suggest that there are gender differences in the height/weight ratio and a growing tendency in their increase, still, the differences are most notable in high school children and somewhat less in younger children. Therefore, defining the physical constitution of children poses quite a big problem, since children do not yet have stable reference characteristics because they vary depending on gender, age, race, body height and body fat as confirmed by the research (Daniels et al. 1997; Pelemiš et al. 2016).

The variables for evaluation of subcutaneous blubber and total body fat indicate that the differences between sexes do not exist, which is confirmed by Mast et al. (1998) research conducted in Germany in 5-7 years old children where differences in adipose tissue were not observed, as opposed to differences in body weight and BMI in favour of the boys. Contrary to the findings in 3-8 years old children in favour of smaller average values of body fat assessed by DXA method by Taylor et al. (1997).

Girls had higher average total quantity of minerals in the body. It is obvious that at that period the girls have not yet entered a phase of rapid growth, but higher values of the total amount of minerals in the body found in girls, and reduced values of extra and intracellular fluid may indicate differences in hormonal status between the genders. Due to greater amounts of minerals that are integral parts of many enzymes, girls probably have better body regulation mechanisms.

The results obtained in the analyses of the relation of body composition and morphological characteristics with the nutritional status (BMI) showed no statistically significant correlation in boys. In order to attain more precise data on their relation, the variables used to obtain the BMI were not considered in the analyses. The partial correlations between individually tested variables when the influence of others was considered as a constant, also was not found to be not statistically significantly correlated. Even the total amount of body fat was not significantly associated with nutritional status in boys. Certainly, the bone growth in length decreased values of body fat in boys compared to girls, which is consistent with research by Bala et al. (2009) conducted on a sample of preschool age children in Serbia. The authors note that the volume and subcutaneous adipose tissue were more pronounced in girls, and bone growth in length in boys. It is undisputed that in future research as indicated in the research by Sevic et al. (2005) conducted in an older sample; in addition to BMI as a measure of nutritional status other methods to obtain more accurate results for assessing body composition should be included.

The system of predictor variables in girls showed a statistically significant correlation with the BMI. The largest positive contribution to cohesion is achieved through the total amount of body fat (Pongcharoen et al. 2017). The higher the values of adipose tissue in girls, the higher their BMI values. It was to be expected given that research by Kromeyer-Hauschild et al. (2012) has showed that the characteristic of the girls at this age is a greater amount of subcutaneous adipose tissue and adipose tissue defines nutritional status, although in a test, sample of respondents did not differ in regard to adipose tissue, it prevailed due to the fact that on average the girls are slightly shorter and heavier than the boys. The partial correlations between variables established that the largest and statistically most significant positive correlation exists between the back skin fold and the BMI. The girls compared to the boys exercised the higher average value of the back skin folds; however, the positive correlation between these two variables was not expected. It was expected that the BMI will correlate with abdominal subcutaneous adipose tissue, which was also found to be substantially higher in girls than in boys. In the anthropometric measure *Back skin fold* mark a genetic predisposition to obesity. This may mean that findings in this sample suggest that girls, in terms of nutritional status, are more predisposed to be overweight than boys although the boys at this age are heavier. On the other hand, considering the correlation regression model authors Zenic et al. (2013) recommend a non-linear regression model for determining the relation to the criterion and consider it to be more efficient because it identifies possible breakpoints in the regression line.

CONCLUSION

Although the investigated sample was of normal nutritional status, the researchers' believe that monitoring nutritional status of children has an exceptional public importance since it is associated with many cardiovascular diseases, hypertension and diabetes, that are the leading causes of mortality in adulthood in developed countries. Within the growth and development and mutual relations of morphological dimensions and body composition with nutritional status, certain rules can be defined. Those depend on the endogenous and exogenous factors, particularly on gender, as the results of a number of researches have shown. The BMI cannot be considered as a good indicator of relation with body composition in children. It offers limited possibilities. Attempts to define the particular rules, or at least a tendency, are based on the fact that individual differences among children are the generators of different bodily constitution, as well as types. These results may be further verified in other and larger samples of children. The researchers' recommend that the age categories be further defined and age intervals shortened up to three months since physical development in preschool children is slightly slower compared to the cognitive, affective and motor development.

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