

Body Size and Body Composition Change Trends in Preschool Children over a Period of Five Years

Vatroslav Horvat¹, Marjeta Mišigoj-Duraković² and Ivan Prskalo¹

¹ Faculty of Teacher Education, University of Zagreb, Zagreb, Croatia

² Department of Kinesiological Anthropology and Methodology, Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

ABSTRACT

The study investigated the changes of body size and composition in the sample of 296 preschool urban dwelling children aged 6.5 ± 0.8 years over a period of five years. Fourteen anthropometric measures were taken. Body mass index (BMI), the sum of skinfolds, the fat percentage and fat-free mass (FFM) were computed. The significant changes in body size and composition over the observed period were found. A significant increase in height and weight was registered in the boys. The average BMI did not change significantly while body fatness was significantly enlarged (from 10.79% to 16.96%, $P=0.0001$) with no changes in FFM. In the girls there were no significant changes in height, weight and BMI, while again fatness was significantly enlarged (from 15.5% to even 19.44%, $P=0.003$), with a significantly decreased share of FFM ($P<0.05$), primarily due to the decrease of the upper limbs' muscular mass. The greatest contribution to the discriminant function was obtained by the skinfolds in the boys and by the arm length and forearm circumference in the girls.

Key words: *body size, body composition, body fatness, preschool children*

Introduction

Sedentary behavior, frequently combined with inadequate dieting, as regards quality and quantity of food intake, is connected with body composition changes as well as with the development of a series of chronic metabolic and cardiovascular diseases. Having in mind the well evidenced correlation between obesity and cardiovascular (for example, coronary heart disease, or arterial hypertension) and metabolic diseases (like atherosclerosis, diabetes, elevated serum lipoproteins, metabolic syndrome), there is concern about trend of growing overweight and obesity prevalence in populations of the developed countries, as well as with their occurrence in ever younger age categories.

Many researchers reported an increase in adiposity in preschool and school children^{1–4}. Based on a longitudinal study, Valerio and associates⁵ observed that the children who were overweight or obese at the age of 7 tended to maintain this condition in prepubertal age also. Must and co-workers⁶ demonstrated, based on a 55-year long study, the correlation of overweight in adolescents with long-term morbidity and mortality. Vanhala and associates⁷ established that adult obesity was potentially more dangerous for health status if it was present since

childhood. Hensen and co-workers⁸ found in 6–7-year-old Danish children associations between body fatness and cardiovascular disease risk factors as blood pressure, fasting glucose and insulin. Findings of Ribeiro and co-workers⁹ suggested that 8–15-year-old children in the highest quartile of body fatness were at increased risk of having other risk factors as high blood pressure, high total cholesterol and low physical activity index.

In the Croatian population of school children and youth secular trend of enlarged body height and body weight is obvious also¹⁰. According to the poll, conducted by Kuzman and associates¹¹, in the population of 13 years of age 11% of boys and 5% of girls are overweight, whereas 2% of boys and 1% of girls are obese. At the age of 15 years, 15% of boys and 6% of girls are overweight, whereas 2% of boys and 1% of girls are obese. Information about the trend of anthropometric characteristics changes and about the status of how well Croatian preschool children are nourished is far harder to find.

In most studies the state of being nourished has been determined mostly based on body mass and body height only, using the body mass index (BMI). Nowadays, how-

ever, assessments are more often based on the analyses of body composition and fat distribution^{3,8,9,12–15}.

The aim of the present study was to analyze changes of morphological anthropometric characteristics, especially from the body size and body composition points of view, as well as from the aspect of the level of being nourished and musculo-skeletal development level in the population of Croatian preschool urban dwelling children aged 6.5 years over a period of five years.

Subjects and Methods

The research was conducted with a total subject sample of 296 urban dwelling children attending preschools of the average age of 6.5 ± 0.8 years. The data were collected in two time points: in 1998, on the sample of 99 children (59 boys and 40 girls), and in 2003, on the sample of 197 children (99 boys and 98 girls). Fourteen anthropometric measures were taken (body mass and body height, sitting height, three skinfolds, five circular measures of body extremities, arm length, shoulder and hip width) using standard procedures and instruments according to IBP¹⁶. The measurements took place in three Zagreb preschools in the morning, immediately after the children's arrival.

Body mass index (BMI) was calculated as body mass / body height² (in kg/m²).

The sum of three skinfolds was computed as well as body composition based on the body fatness percentage, using the method of Slaughter and colleagues¹⁷. The amounts of body fatness and of fat-free mass were also calculated (in kg).

The differences between the samples measured in 1998 and 2003 in the investigated variables were examined by the Student's *t*-test, that is, by Mann-Whitney U-test for the irregularly distributed variables (Kolmogorov-Smirnov test: $P < 0.05$). Multivariate discriminant analysis was conducted in the set of anthropometric variables to determine the contribution of individual variables to the discriminant function. The data were processed using the software package Statistica (release 7.1).

Results

In Tables 1 and 2 the indices of anthropometric measures are displayed in order to enable an insight into body size and body composition and their changes in 6.5 years aged boys and girls over five years.

The results revealed a significant increase in the measures of body height and body mass of the boys in the five-year period. An average increase in body mass amounts almost 10%. And since the average BMI has not changed significantly in five years, considerable changes were registered in body composition. A significant in-

TABLE 1
DESCRIPTIVE INDICATORS OF ANTHROPOMETRIC MEASURES IN THE SAMPLES OF BOYS MEASURED IN 1998 AND 2003 AND THE SIGNIFICANCE OF THEIR DIFFERENCES, VERIFIED BY STUDENT'S *T*-TEST

Variables	1998 (N=57) M ± SD	2003 (N=99) M ± SD	T test / U test*	
			P	P
Body mass	21.77 ± 3.00	23.92 ± 3.97		0.001
Body height	117.86 ± 5.34	121.94 ± 5.53	0.000	
Sitting height	64.81 ± 6.07	67.01 ± 3.39		0.101
Arm length	49.19 ± 3.44	46.78 ± 2.76	0.000	
Shoulder width	26.14 ± 1.38	26.45 ± 1.25	0.156	
Hip width	19.15 ± 1.13	19.31 ± 1.16	0.426	
Extended upper arm circumference	17.93 ± 1.61	17.70 ± 1.71		0.243
Bent upper arm circumference	19.03 ± 1.79	18.70 ± 1.76	0.2707	
Forearm circumference	17.78 ± 1.22	17.12 ± 1.31	0.002	
Thigh circumference	33.63 ± 3.46	34.79 ± 3.57		0.066
Calf circumference	24.54 ± 1.92	24.52 ± 2.20		0.459
Triceps skinfold	7.39 ± 3.38	11.88 ± 4.35	0.000	
Subscapular skinfold	4.15 ± 2.14	6.73 ± 3.88		0.000
Abdominal skinfold	3.59 ± 2.37	8.79 ± 5.75		0.000
BMI	15.61 ± 1.32	16.03 ± 1.95		0.714
Sum of skinfolds	15.30 ± 7.23	27.40 ± 13.19		0.000
% of body fatness	10.79 ± 4.71	16.96 ± 5.33	0.000	
Body fatness (kg)	2.42 ± 1.26	4.21 ± 2.02		0.000
Fat free mass(kg)	19.35 ± 2.35	19.71 ± 2.38	0.3609	

* When the distribution was not normal, M arithmetic mean, SD standard deviation

TABLE 2
 DESCRIPTIVE INDICATORS OF ANTHROPOMETRIC MEASURES IN THE SAMPLES OF GIRLS MEASURED IN 1998 AND 2003
 AND THE SIGNIFICANCE OF THEIR DIFFERENCES, VERIFIED BY STUDENT'S *T*-TEST

Variables	1998 (N=40) M ± SD	2003 (N=98) M ± SD	T test / U test*	
			P	P
Body mass	23.20 ± 4.55	23.29 ± 3.96	0.907	
Body height	119.81 ± 6.79	120.55 ± 5.07	0.242	
Sitting height	64.06 ± 7.05	65.68 ± 2.75		0.711
Arm length	48.60 ± 3.36	45.39 ± 2.53	0.000	
Shoulder width	25.90 ± 1.90	26.19 ± 1.30	0.307	
Hip width	18.79 ± 1.70	18.89 ± 1.09	0.699	
Extended upper arm circumference	18.89 ± 1.96	17.65 ± 1.80	0.000	
Bent upper arm circumference	19.89 ± 2.20	18.65 ± 1.91	0.0012	
Forearm circumference	17.98 ± 1.31	16.87 ± 1.38	0.000	
Thigh circumference	36.42 ± 3.99	35.24 ± 4.17	0.128	
Calf circumference	25.30 ± 2.17	24.60 ± 2.14	0.085	
Triceps skinfold	10.86 ± 5.57	13.53 ± 5.21		0.000
Subscapular skinfold	6.24 ± 4.17	8.27 ± 5.03		0.000
Abdominal skinfold	5.88 ± 5.23	10.51 ± 7.36		0.000
BMI	16.28 ± 2.21	15.98 ± 2.16	0.46	
Sum of skinfolds	22.98 ± 14.38	32.30 ± 16.90		0.000
Body fatness (%)	15.53 ± 6.95	19.44 ± 6.87	0.003	0.003
Body fatness (kg)	3.77 ± 2.40	4.75 ± 2.54		
Lean body mass (kg)	19.43 ± 3.10	18.55 ± 1.98	0.048	

* When the distribution was not normal, M arithmetic mean, SD standard deviation

crease was obtained in all skinfolds measures, especially in the abdomen skinfold – the average thickness of this skinfold was more than doubled over the observed period. The trend of significant enlargement of subcutaneous fatty tissue is also obvious in the sum of the three skinfolds and in body fatness percentage, which was dramatically enhanced (from 10.79% to 16.96%, $P=0.0001$). Simultaneously, no significant changes in fat-free mass were obtained. Circumference measures remained mainly the same or certain ones even decreased, like the ones of the upper extremities.

The results obtained in the sample of girls show no significant changes over five years in body size dimensions. And since body mass and BMI had not changed significantly in the observed period, significant changes were registered in body composition. An increase was obtained in the measures of subcutaneous fat, especially in the sum of the three skinfolds. The largest changes were again obtained in the abdominal skinfold with almost a double increase. The body fat percentage also increased significantly (from 15.5% to even 19.44%, $P=0.003$). Additionally, fat-free mass decreased ($P<0.05$), and the circumference measures of the upper limbs significantly decreased as well.

The comparison of boys and girls revealed no significant differences in body height, body mass and BMI in

both measurement points ($P_{1998}=0.1003$; $P_{2003}=0.8530$). The significant differences in body composition, that is, higher values of skinfolds and of their sum ($P_{1998}=0.0003$; $P_{2003}=0.0303$) as well as of the fat percentage ($P_{1998}=0.0003$; $P_{2003}=0.0478$) were obtained in girls. While at the first measurement point (1998) of the observed five-year period no significant gender differences occurred in the amount of fat-free mass, at the second measurement point (2003) the significant difference between the boys and the girls was obtained for the amount of fat-free mass ($p=0.00139$), primarily due to its significant decrease in the girls. The multivariate method of discriminant analysis confirmed the differences between the first and the second measurement in the space of anthropometry of both genders (Table 3).

Skinfold measures had the greatest contribution to the discriminant function in the subsample of boys. In the girls, the predominant contribution was obtained for the arm length and forearm circumference, only then followed by the measures of skinfolds.

Discussion

The study indicated significant changes in body size and composition of preschool children over the observed period. The significant increase in body height and body

TABLE 3
DISCRIMINANT ANALYSIS OF THE TWO SAMPLES OF BOYS
AND GIRLS (1998 AND 2003) IN THE SPACE OF
ANTHROPOMETRIC VARIABLES: THE STRUCTURE OF THE
DISCRIMINANT FUNCTION AND CENTROIDS OF GROUPS

	Eigen- value	Canonical R	Wilks' Lambda	Chi-Sqr.	df	p-level
Boys	2.96	0.86	0.25	202.47	14	0.0000
Girls	2.03	0.82	0.33	143.05	14	0.0000

Variable	Boys		Girls	
	Discriminant function structure	Discriminant function structure	Discriminant function structure	Discriminant function structure
Mass		-0.17		-0.01
Height		-0.21		-0.12
Sitting height		-0.14		-0.12
Arm length		0.22		0.37
Triceps skinfold		-0.31		-0.16
Abdominal skinfold		-0.30		-0.22
Subscapular skinfold		-0.22		-0.14
Extend upper arm circum		0.04		0.21
Bent upper arm circum		0.05		0.20
Forearm circum		0.14		0.26
Thigh circum		-0.09		0.09
Calf circum		0.00		0.10
Hip width		-0.04		-0.02
Shoulder width		-0.07		-0.06
		Centroids		Centroids
G_1:0		2.25		2.21
G_2:1		-1.30		-0.90

mass was registered in the boys. The average BMI did not change significantly as opposed to body composition in which the share of body fatness was significantly enlarged with any changes in the amount of fat-free mass. In the girls there were no significant changes in body height, body mass and BMI, but the fatness component was significantly enlarged in them as well, together with the significantly decreased share of fat-free mass, primarily due to loss of upper limb muscular mass. Similar mean BMI values were reported by Graf and associates¹⁸ for German children of similar age.

REFERENCE

1. KALIES H, LENZ J, VON KRIES R, *Int J Obes Relat Metab Disord*, 26 (2002) 1211. — 2. MORENO LA, FLETA J, SARRIA A, RODRIGUEZ G, BUENO M, *Prev Med*, 33 (2001) 357. — 3. WEDDERKOPP N, FROBERG K, HANSEN HS, ANDERSEN LB, *Scand J Med Sci Sports*, 14 (2004) 150. — 4. AL-SENDI AM, SHETTY P, MUSAIGER AO, *Ann Hum Biol*, 30 (2003) 367. — 5. VALERIO G, D'AMICO O, ADINOLFI M, MUNCIGUERRA A, D'AMICO R, FRANCEZE A, *Nutr Metab Cardiovasc Dis*,

Enhanced total body fatness was reported in many studies over the last two decades^{1–4,13}. In the sample of 6–7-year-old Danish children Hensen and colleagues⁸ described the similar BMI values and body fatness percentages, also with gender dimorphism in the body fatness indicators. Gender dimorphism of fat patterning in children present even at the preschool and early school age was also confirmed by other European authors^{8,12,14}.

A significant increase of fat mass, especially on the stomach, is particularly unfavorable as it may increase the occurrence risk of chronic cardio-vascular and metabolic diseases later on in the life. Moreover, such a distribution of subcutaneous fatty tissue is combined with the simultaneous decrease in muscular mass, particularly pronounced in girls. Similar trend to the central patterning of fat distribution already at the age of 6.5 years was reported by Moreno et al.¹⁹.

The observed reduction of fat-free mass, especially in the preschool girls, indicates decreased physical activity. Further investigations are necessary; special attention should be directed to the life styles of preschool children and to the amounts of time spent in physical activities of various forms and intensities, to the analysis of energy expenditure and to nutritional habits.

Conclusion

The finding of the increase in the share of fatness component in boys and girls, and of the decrease in fat-free mass in girls over the five-year period impose the necessity of continuous monitoring of the trend of changes in the population of preschool children to preschool teachers and health care experts in order to be able to plan and timely launch curricula and syllabus intervention measures in the area of physical activity and exercise, as well in the areas of nutrition and prevention of early occurrence of obesity.

Acknowledgements

This work was supported by the following Croatian Ministry of Science, Education and Sports grants: »The Role of Physical Activity Level in Chronic Cardiovascular Disease Prevention« (No. 034-0342282-2325) and »Kinesiological education in preschool and primary education« (No. 227-2271694-1696).

16 (2006) 272. — 6. MUST A, JACQUES PF, DALLAL GE, BAJEMA CJ, DIETZ WH, *N Engl J Med*, 327 (1992) 1379. — 7. VANHALA M, VANHALA P, KUMPUSALO E, ET AL, *BMJ*, 317 (1998) 319. — 8. HANSEN SE, HASSELSTROM H, GRONFELDT V, FROBERG K, ANDBERSEN LB, *Prev Med*, 40 (2005) 740. — 9. RIBEIRO JC, GUERRA S, OLIVEIRA J, ANDERSEN LB, DUARTE JA, MOTA J, *Am J Hum Biol*, 16 (2004) 556. — 10. PREBEG Z, *Lijec Vjesn*, 124 (2002) 3. — 11. KUZMAN M,

- PEJNOVIĆ-FRANELIĆ I, PAVIĆ-ŠIMETIN I, Medix, 10(2004) 73. — 12. WEBSTER-GANDY J, WARREN J, HENRY CJ, Int J Food Sci Nutr, 54 (2003) 467. — 13. POPLAWSKA H, DMITRUK A, WILCZEWSKI A, Ann Hum Biol, 2006; 33(1): 78–88. — 14. GULTEKIN T, AKIN G, OZER BK, Antropol Anz, 63 (2005) 427. — 15. ORDEN AB, OYHENAT EE, Am J Hum Biol, 18 (2006) 590. — 16. WEINER, JS, LOURIE AS, Practical Human Biology (Academic Press, New York, 1981). — 17. SLAUGHTER MH, LOHMAN TG, BOILEAU RA, HORSWILL CA, STILLMAN RJ, VAN LOAN MD, BEMBEN DA, Hum Biol, 60 (1988) 709. — 18. GRAF C, KOCH B, DORDEL S, SCHINDLER-MARLOW S, ICKS A, SCHULLER A, BJARNASON-WEHRENS B, TOKARSKI W, PREDEL HG, Eur J Cardiovascular Prev Rehabil, 11 (2004) 284. — 19. MORENO LA, FLETA J, SARRIA A, RODRIGUEZ G, GIL C, BUENO M, Int J Obes Relat Metab Disord, 25 (2001) 1656.

M. Mišigoj-Duraković

*Department of Kinesiological Anthropology and Methodology. Faculty of Kinesiology Uniuersity of Zagreb, Horvaćanski zavoj 15, 10 000 Zagreb, Croatia
e-mail: mmisigoj@kif.hr*

PROMJENA GRAĐE I SASTAVA TIJELA PREDŠKOLSKE DJECE U PETOGODIŠNJEM PERIODU

SAŽETAK

U radu su ispitane promjene u građi i sastavu tijela predškolske djece u petogodišnjem razdoblju. Uzorak je činilo ukupno 296 gradske djece u dobi od 6.5 ± 0.8 godina. Izmjereno je četrnaest antropometrijskih mjera, iz kojih je izračunat indeks tjelesne mase (BMI), suma kožnih nabora, postotak tjelesne masti i nemasna tjelesna masa. Utvrđene su značajne promjene u građi i sastavu tijela djece iste dobi u petogodišnjem razdoblju. U dječaka značajno su se povećale visina i masa tijela. I dok se prosječne vrijednosti BMI nisu značajno promijenile, udio tjelesne masti u sastavu tijela značajno se povećao (s 10,79% na 16,96%, $p=0,0001$) bez promjena u nemasnoj masi tijela. U djevojčica nije bilo značajnijih promjena u visini, masi i BMI, dok se i u njih udio tjelesne masti značajno povećao (s 15,5% na čak 19,44%, $p=0,003$). Pri tom se opaža značajno smanjenje nemasne mase tijela ($p<0,05$), primarno zbog smanjenja mišićne mase gornjih udova. Najveći doprinos diskriminacijskoj funkciji dale su mjere kožnih nabora i duljina ruke u dječaka te opseg podlaktice u djevojčica.