

Body Weight and Body Composition in Children at the Age of 3-6 Years

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The aim of this study was to be traced out the changes in body weight and body composition during the ages 3-6 years and to be assessed the sexual differences in these basic for the children's physical development anthropometrical features. The data presented were a part of detailed cross-sectional study carried out from June 2004 till May 2005. Anthropometrically were investigated 640 children (320 boys and 320 girls) from Sofia. The results showed slightly expressed differences of body weight throughout the investigated period. In body composition features, however, were available the underlined sex connected differences — boys had considerably more LBM and girls had considerably more FM. The absolute quantity of FM and LBM increased with ages in parallel with the body weight increment. The interrelation between body components remained relatively constant during the investigated period reflecting the specificity in body composition type for each sex even in this early childhood.

Key words: anthropometry, body composition, fat mass, lean body mass, early childhood.

Introduction

Body weight is one of the basic characteristics of physical development in man. Except of its genetically determination, the body weight is strongly influenced by the environmental factors, which defines its great importance for the assessment of health status in the growing up organism. Following the accepted in anthropology 2-component model of B e h n k e [1], the two basic components of body weight that determine the individual's body composition are the Body Fat (BF) and the fat-free tissues — the so called Lean Body Mass (LBM). The measurements of body composition give possibility for more precise assessment of body nutritional status and aid in the treatment of childhood growth disorders [3]. Investigation about these problems in children and adolescents could be found very rarely in Bulgaria, and for the preschool children they are practically missing.

The aim of this study is to be traced out the changes in body weight and body composition during the ages 3-6 years and to be assessed the sexual differences in these basic for the children's physical development anthropometrical features.

Material and Methods

Subjects of the current research are 640 children (320 boys and 320 girls) at the age of 3-6 years. The children are divided into four age groups, respectively 3, 4, 5 and 6 years old

ones. The data presented are part of a detailed cross-sectional study carried out from June 2004 till May 2005 in 7 kindergartens from several districts of the Sofia City.

The data about body weight and its two basic components BF and LBM computed as a total quantity and a relative share of the body weight were analyzed.

The body weight was measured with electronic scales (Body fat monitor BF-666) and the triceps and subscapular skinfolds' thickness were measured on the right side of the body with a Holtain caliper by using the approved standard methods of WHO [5].

The relative body fat (%BF) was calculated according to the formulae of S l a u g h - t e r et al. [2] for children from both sexes.

Σ triceps skinfold + subscapular skinfold > 35 mm:

$$\% \text{ BF } (\text{♂}) = 0,783 \times [\text{triceps skinfold} + \text{subscapular skinfold}] + 1,6$$

$$\% \text{ BF } (\text{♀}) = 0,546 \times [\text{triceps skinfold} + \text{subscapular skinfold}] + 9,7$$

Σ triceps skinfold + subscapular skinfold < 35 mm:

$$\% \text{ BF } (\text{♂}) = 1,21 \times [\text{triceps skinfold} + \text{subscapular skinfold}] - 0,008 \times (\text{triceps skinfold} + \text{subscapular skinfold})^2 - 1,7$$

$$\% \text{ BF } (\text{♀}) = 1,33 \times [\text{triceps skinfold} + \text{subscapular skinfold}] - 0,013 \times (\text{triceps skinfold} + \text{subscapular skinfold})^2 - 2,5$$

On the base of %BF was calculated the total quantity of BF (in kg) as a share of the body weight following the formula:

$$\text{BF} = \frac{\text{Body weight} \times \% \text{BF}}{100}$$

The relative Lean body mass (%LBM) was computed as a difference between 100 and the %BF (%LBM = 100 - %BF) and the total quantity LBM (in kg) was calculated as a share of body weight by the formula: LBM = Body weight - BF.

The sexual differences were evaluated and standardized by the Index of Sexual Differences (ISD), which was computed by the generally accepted in the anthropology formula for inter-group comparisons [4]. This index shows the established sexual differences in relative index units (IU):

$$\text{ISD} = 2 \times (\bar{x} \text{ boys} - \text{girls}) \times 100 / (\text{boys} + \text{girls}).$$

The age differences were estimated by the Total Year Increment (TYI) calculated as a difference between the mean value of a feature for the given age (\bar{x}_2) and the mean value of the same feature for the previous age (\bar{x}_1): TYI = $\bar{x}_2 - \bar{x}_1$.

The statistical significance of the established sexual and age differences was assessed by the t-test of Student, computed by the independent extracts formula and evaluated in value of importance for $P \leq 0,05$ and $P \leq 0,001$.

Results

From the beginning till the end of the investigated age period, the children of both sexes had close means for body weight. Boys were slightly heavier than girls, but the differences were statistically significant concerning only the 3 years old children ($p \leq 0,05$). At the age of 3 boys weighed 16,3 kg and girls — 15,5 kg (Table 1, Fig. 1). Through the period 3-6 years of age the body weight increased nearly in 50,0% for both sexes and its values for the 6 years old children were 23,9 kg in boys and 22,9 kg in girls. The increment of body weight was statistically significant ($p \leq 0,001$), as in boys so in girls, for all the three one-year periods (Table 2).

Table 1. Biostatistical data about body weight and body composition features

Age in years	♂							♀							Sexual differences		
	<i>n</i>	\bar{x}	SD	SEM	<i>V</i>	min	max	<i>n</i>	\bar{x}	SD	SEM	<i>V</i>	min	max	Absolute	t-test	ISD
Body weight																	
3	80	16,3	2,1	0,2	12,9	13,0	23,4	80	15,5	1,8	0,2	11,6	10,1	21,0	0,8	2,8*	5,0
4	80	18,4	3,1	0,3	16,8	12,7	34,7	80	18,0	2,7	0,3	14,9	12,4	24,0	0,4	0,9	2,2
5	80	21,0	4,0	0,4	18,9	16,3	44,8	80	20,0	2,7	0,3	14,4	15,0	29,9	1,0	1,9	4,9
6	80	23,9	4,2	0,5	17,8	17,2	43,0	80	22,9	3,9	0,4	17,2	15,8	34,3	1,0	1,5	4,3
Relative body fat (%)																	
3	80	19,5	4,2	0,5	21,5	12,1	36,3	80	22,3	4,5	0,5	20,2	14,6	36,7	2,8	4,2**	-13,4
4	80	18,4	4,3	0,5	23,4	11,6	35,3	80	22,8	5,6	0,6	24,6	14,4	40,7	4,4	5,7**	-21,4
5	80	18,4	5,1	0,6	27,7	9,9	38,6	80	22,0	5,4	0,6	24,5	12,8	46,0	3,6	4,3**	-17,8
6	80	19,5	6,9	0,8	35,4	10,8	42,1	80	23,1	7,2	0,8	31,2	12,2	46,0	3,6	3,2*	-16,9
Body fat (kg)																	
3	80	3,2	1,0	0,1	31,3	1,6	7,8	80	3,5	1,0	0,1	28,6	2,0	7,7	0,3	1,7	-9,0
4	80	3,4	1,4	0,2	41,2	1,5	10,2	80	4,2	1,5	0,2	35,7	1,9	9,3	0,8	3,1*	-21,0
5	80	4,0	2,2	0,2	55,0	2,1	17,3	80	4,5	1,6	0,2	35,6	2,1	13,8	0,5	1,4	-11,8
6	80	4,9	2,7	0,3	55,1	2,1	17,4	80	5,5	2,6	0,3	47,3	2,4	13,7	0,6	1,5	-11,5
Relative lean body mass (%)																	
3	80	80,5	4,2	0,5	5,2	63,7	87,9	80	77,7	4,5	0,5	5,8	63,3	85,4	2,8	4,2**	3,5
4	80	81,6	4,3	0,5	5,3	64,7	88,4	80	77,2	5,6	0,6	7,3	59,3	85,6	4,4	5,7**	5,5
5	80	81,6	5,1	0,6	6,3	61,4	90,1	80	78,0	5,4	0,6	6,9	54,0	87,2	3,6	4,3**	4,5
6	80	80,5	6,9	0,8	8,6	57,9	89,2	80	76,9	7,2	0,8	9,4	54,0	87,8	3,6	3,2*	4,6
Lean body mass (kg)																	
3	80	13,1	1,4	0,2	10,7	10,6	17,7	80	12,0	1,1	0,1	9,2	7,9	14,7	1,1	5,6**	8,8
4	80	14,9	1,9	0,2	12,8	11,2	24,5	80	13,8	1,6	0,2	11,6	9,9	18,0	1,1	4,0**	7,7
5	80	17,0	2,1	0,2	12,4	13,7	27,5	80	15,5	1,9	0,2	12,3	11,5	21,4	1,5	4,7**	9,2
6	80	19,0	2,4	0,3	12,6	14,1	27,1	80	17,4	2,1	0,2	12,1	13,1	23,0	1,6	4,5**	8,8

* $P < 0,05$; ** $P < 0,001$

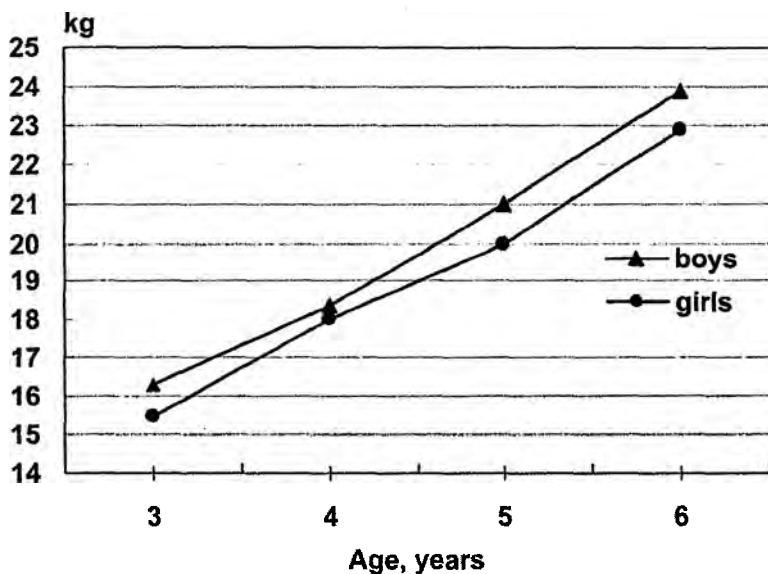


Fig. 1. Body weight

Table 2. Total year increment

Age period	♂			♀		
	n	TYI	t-test	n	TYI	t-test
Body weight						
3-4	80	2,1	4,8**	80	2,5	6,8**
4-5	80	2,6	4,8**	80	2,0	4,8**
5-6	80	2,9	4,3**	80	2,9	5,4**
Relative body fat (%)						
3-4	80	-1,1	1,6	80	0,5	0,6
4-5	80	0,0	0,0	80	-0,8	0,9
5-6	80	1,1	1,2	80	1,1	1,1
Body fat (kg)						
3-4	80	0,2	1,2	80	0,7	3,3**
4-5	80	0,6	1,9	80	0,3	1,1
5-6	80	0,9	2,2*	80	1,0	3,0*
Relative lean body mass (%)						
3-4	80	1,1	1,6	80	-0,5	0,6
4-5	80	0,0	0,0	80	0,8	0,9
5-6	80	-1,1	1,2	80	-1,1	1,1
Lean body mass (kg)						
3-4	80	1,8	6,7**	80	1,8	8,0**
4-5	80	2,1	6,7**	80	1,7	6,4**
5-6	80	2,0	5,5**	80	1,9	5,9**

* $P < 0.05$; ** $P < 0.001$

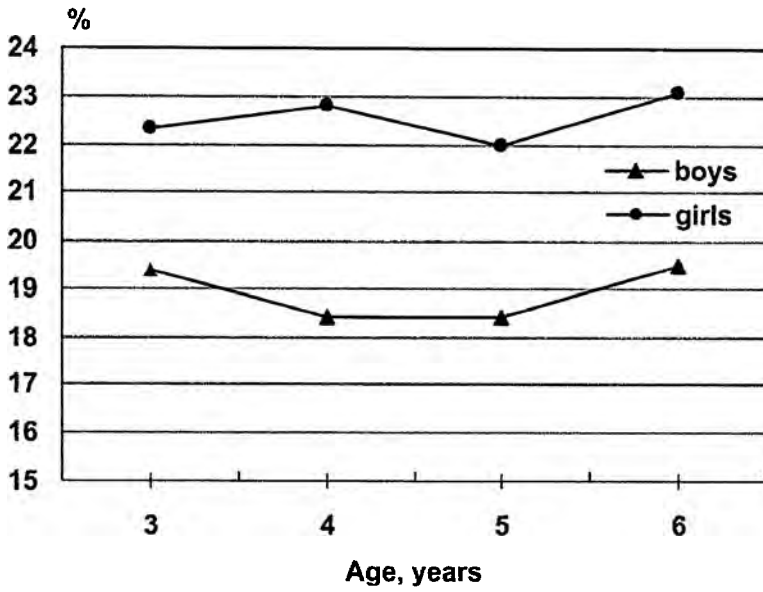


Fig. 2. Relative body fat, %

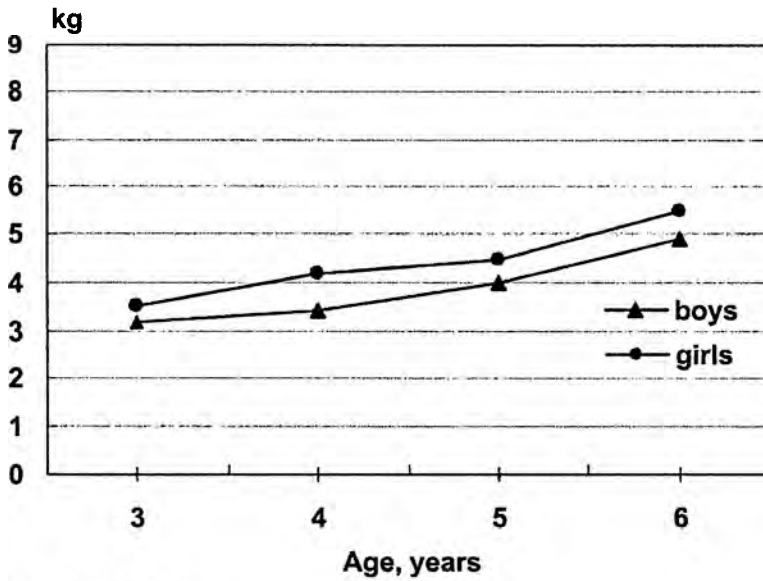


Fig. 3. Body fat, kg

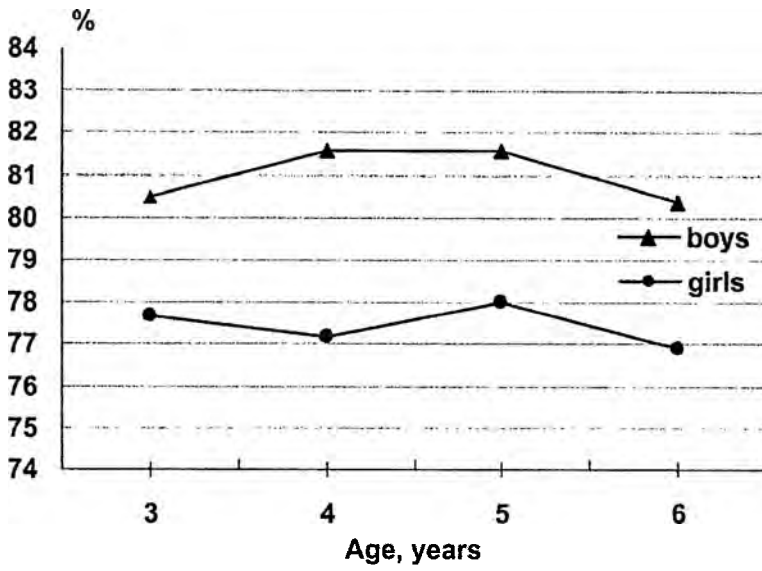


Fig. 4. Relative lean body mass, %

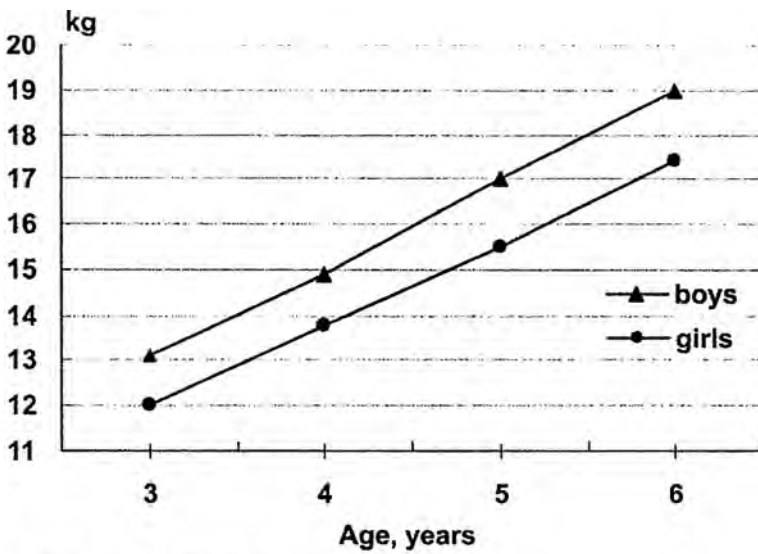


Fig. 5. Lean body mass, kg

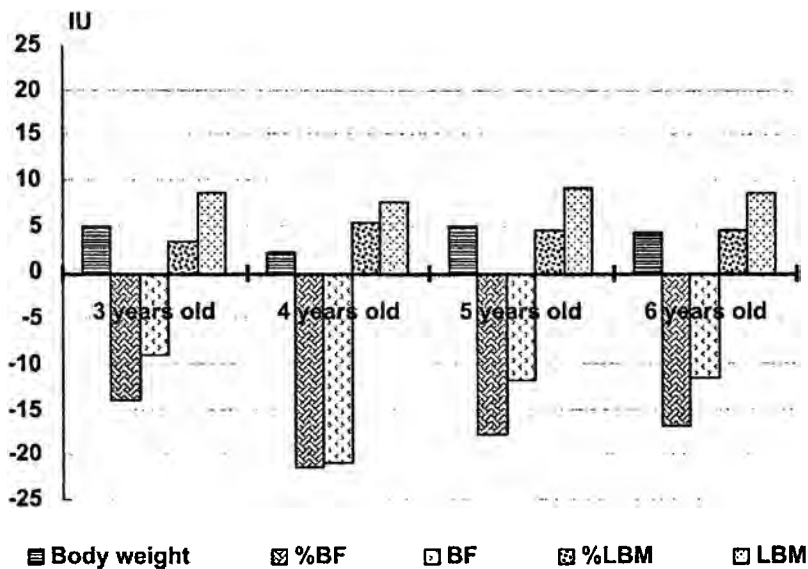


Fig. 6. Sexual differences according to the ISD data

The results about both components of body weight showed marked sexual differences in body composition type. The girls have had more quantity of body fat (%BF and BF) than boys and the quantity of lean body mass (%LBM and LBM) was bigger in boys (Table 1, Figs. 2, 3, 4, 5). The differences between boys and girls for BF were statistically significant only about the age of 4 ($p \leq 0,05$), while concerning the other three features, the differences were significant for all investigated age periods ($p \leq 0,001$; $p \leq 0,05$).

In regard to the inter-age aspect, the total quantity of BF increased in the ages parallel to the body weight increment for both sexes. Between 3 and 6 years of age, the BF increased in 1,7 kg for boys and slightly more for girls — in 2 kg. The increment was statistically significant for boys during the last one-year period and for girls — in the periods 3-4 and 5-6 years of age ($p \leq 0,001$; $p \leq 0,05$). The relative BF (%BF), however, in both sexes remained comparatively equal as a whole for the investigated period (Table 2).

The total quantity of LBM increased also parallel to the body weight, likewise the BF, but the increment was statistically significant ($p \leq 0,001$) in all the three one-year periods concerning boys and girls. The increment of LBM, during the whole studied period (from 3 to 6 years of age), was approximately three times bigger than those of BF, the gain to LBM being 5,9 kg for boys and 5,4 kg for girls. The changes of relative LBM with the ages were small and not statistically significant in both sexes (Table 2).

Notwithstanding the increment of the total quantity BF and LBM with ages, the inter-relation of both relative body components remained comparatively equal between 3 and 6 years of age. This finding showed that through the investigated childhood period, the body composition type remained relatively unchangeable.

The data of ISD displayed slightly expressed sexual differences of body weight (2,2 IU + 5,0 IU) throughout the investigated period. Concerning the body composition features, however, underlined sex-connected differences were available. The ISD data about relative BF varied within 13,4 IU and 21,4 IU, and about BF — within 9,0 IU and 21,0 IU, with priority of girls during the entire period under study. The sexual differ-

ences of LBM, assessed by the ISD data, were more slightly expressed with priority for boys — 3,5 IU ÷ 5,5 IU concerning the relative LBM and 7,7 IU ÷ 9,2 IU concerning the LBM (Table 1, Fig. 6).

According to the comparative assessment of the sexual differences concerning body weight and body composition features, boys and girls differed mostly on the quantity body fat (both as relative share and total quantity), which means are bigger in girls for all the investigated age groups.

Conclusions

1. Throughout the investigated period boys and girls showed close means about body weight but the results concerning its two components displayed significant sex-related differences in body composition type.

2. Notwithstanding the increment of the total quantity BF and LBM with ages in parallel to the increment of body weight, the body composition type remained relatively unchangeable in both sexes.

3. During the entire period under study the body fat quantity (%BF and BF) was bigger in girls compared to boys, but the quantity lean body mass (%LBM and LBM) was bigger in boys than in girls.

4. Quantitatively assessed by the ISD, the inter-sexual differences were best expressed in the body fat quantity with priority for girls, concerning all investigated age groups.

5. The detailed description of the specific peculiarities in age and sexual differences concerning the investigated features in children aged from 3 to 6 years outlines the tendencies in the sex-related differentiation in body composition during this early age.

References

1. B e h n k e , A.R. Anthropometric evaluation of body composition through life. —Ann. N. Y. Acad. Sci., **110**, 1963, 450-464.
2. S l a u g h t e r , M. H., T. G. L o h m a n , R. A. B o i l e a u , C. A. H o r s v i l l , R. J. S t i l l m a n , M. D. v a n L o a n , D. A. B e m b e n. Skinfold equations for estimation of body fatness in children and youth. —Hum. Biol., **60**, 1988, 709-723.
3. W e l l s , J. C. K., N. J. F u l l e r , O. D e w i t , M. S. F e w t r e l l , M. E l i a , T. J. C o l e. Four-component model of body composition in children: density and hydration of fat free mass and comparison with simpler models. —Am. J. Clin. Nutr., **69**, 1999, 904-912.
4. W o l a n s k i , N. Asymmetria ciała człowieka i jej zmienność w świetle funkcji kończyn. —Przeł. Anthropol., **23**, 1957, 461-464.
5. World Health Organization. Measuring obesity — classification and description of anthropometric data. Report of a WHO Consultation on the Epidemiology of Obesity. —WHO, 1989.