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Fat Patterning in Children from 3 to 17 Years of Age

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The **aim** of the present work is to characterize the age and sexual differences of Body Fat and Fat Free Mass during the growing up period from 3 till 17 years, anthropological features which are basic for the body composition assessment. The study was made after the classical methods of Martin-Saller and 1464 boys and 1468 girls were investigated. The data about stature, body weight, BMI, %BF, BF(kg), %FFM, FFM(kg) are analyzed. The results show that between 3 and 17 years girls accumulate and have constantly more quantity of Body Fats, while boys accumulate and have constantly more quantity of Fat Free Mass. The body nutritional status in boys changes considerably between 9 and 10, and 12 and 13 years of age, while in girls these changes happen one year earlier – between 8 and 9, and 11 and 12 years of age, occurring again between 13 and 15 years.

Key words: children and adolescents, anthropological assessment, fat patterning.

Introduction

The anthropological assessment of body composition is an easily applied approach for the body nutritional status's evaluation and along with it about the obesity on individual and population level. Like basic patterns concerning this valuation are used mainly the following features: Body Mass Index (BMI); Body Fat (BF) and Fat Free Mass (FFM) as a relative share and absolute quantity; interrelation between waist and hip circumferences; waist circumference; interrelation between Subcutaneous Fat Tissue (SFT) quantity on body and extremities and so on. In the Bulgarian and foreign scientific literature, however, the reports concerning methodic approaches and norm's data are mainly for adults. Rarely could be found papers that assessed the body composition during growth ages, i.e. concerning the children and adolescents. The basic contemporary indicator according whose data the body nutritional status is discussed in these reports is the BMI, and only for the differentiation of overweight and obesity in children and adolescents [3]. The cut off points, recommended by the WHO, concerning the undernourishment and emaciation diagnosis were published first at 2007 [2], and we still have not come in the literature to any national or regional data about the frequency of those two types body nutritional status during the growing up period. Scantier is also the information concerning the assessment of body composition type throughout this period by means of the other indicators mentioned above, since it is missing in Bulgaria.

The **aim** of the present work is to characterize the age and sexual differences of Body Fat and Fat Free Mass during the growing up period from 3 till 17 years, anthropological features which are basic for the body composition assessment.

Material and Methods

Two transversal investigations of children and adolescents at the age between 3 and 6 years, as well as between 7 and 14 years respectively were carried out during 1993-2001 and 2004-2007 in Sofia city covering 5 schools and 7 kindergartens. The study was made by a qualified stuff of anthropologists after the classical methods of M a r t i n - S a l l e r [4]. Object of the investigations were 1464 boys and 1468 girls at the age from 3 to 17 years, uniformly distributed into 15 age groups for both genders separately. From the detailed data collected according to the complex anthropological program, in the present work were analyzed the sexual and age differences for the following features: stature, body weight, BMI, %BF, BF(kg), %FFM, FFM(kg). The assessment of body composition was made by the two-component model of Behnke [1] that separates 2 basic components of the body weight - BF and FFM, the last one representing all fat free tissues. The relative share of BF (%BF), on which base was computed as the relative share of FFM (%FFM), so the absolute quantity of BF(kg) and FFM(kg), was determined by the regression equations of S l a u g h t e r et al. [5]. The equations are made out using the sum - subscapular skinfold plus triceps skinfold.

According to the application of these equations the investigated boys are divided into two age groups: pre puberty up to 9 years inclusive, and puberty from 10 to 17 years inclusive. The differentiation of pre puberty and puberty developmental stages in boys are made according to the studies about Bulgarian children elaborated by S t a n c h e v et al. [7] and T o m o v a et al. [8].

For every age group are computed the variation-statistical parameters of the features, as well as the sexual differences like absolute differences and relative units by the Index of Sexual Differences (ISD). The differences throughout ages are made also by the Absolute Year Alteration (AYA) and Relative Year Alteration (RYA). The statistical significance was calculated by the t-test of Student at P = 0.05.

The ISD and RYA are computed as Index Units (IU) by the submitted formula of W o l a n s k i [6] concerning the objectivity of different inter-group comparisons:

$$IU = \frac{2 \times (x_2 - x_1) \times 100}{(x_2 + x_1)}.$$

Concerning the age differences $\bar{x}_1$ is mean value of a given feature for some age and $\bar{x}_2$ – mean value of the same feature for next coming age. Concerning the sexual differences $\bar{x}_1$ is mean value of respective feature in girls and $\bar{x}_2$ – mean value of the same feature in boys.

Results

For the objective assessment of the anthropological indicators about body composition, in the present paper we are giving also data about stature and body weight being basic parameters that characterize the human physical development.

The stature and body weight in boys increase significantly during every one year period between 3 and 17 years. In girls the stature increases significantly till 14 years and the body weight till 13 years of age. After those years the growth in girls calms down and at 17 years the growth of stature and body weight practically stops.

Even from 3 years of age on, the sexual differences are available concerning stature and body weight. Regardless of the fact that during growing up period up to 8 years these differences didn't reach statistical significance, boys are constantly higher than girls. Concerning stature between 8 and 12 years and body weight between 9 and 13 years, girls already outstrip boys, reflecting the earlier maturation in girls. After those ages the boys again are reliably higher and heavier than girls.

The data about BMI analyzed in this work are presented as general basic characterization for body nutritional status during the growing up period.

Boys and girls have relatively equal values for BMI almost through the whole period 3-17 years of age. Only at 5 years the BMI is considerably higher in boys and at 12 years – it is considerably higher in girls. In boys the BMI increases reliable from 9 till 10 years, as well as from 12 till 13 years. In girls the authentic change of body nutritional status occurred one year earlier, i.e. from 8 till 9 years and from 11 till 12 years, the change lasting from 13 till 15 years, as well.

More detailed information of body nutrition status during growth could be gotten assessing the two body weight components - Body Fat (BF) and Fat Free Mass (FFM). The relative share of BF is constantly higher in girls between 3 and 17 years, the sexual differences are statistically significant at 4 years and from 7 years of age till the end of the studied period. Reciprocally to the result above, the relative share of FFM is higher in boys during the entire period under investigation and the sexual differences are also statistically significant during the same years. The girls gain more intensively BF after 9 years, while the boys gain considerably more FFM after 13 years, which is connected with their later period of active sexual maturation. An age determined stage is established concerning the type of proportion between both basic body weight components. Periods of an intensive rise for BF and such of a FFM reduction respectively, succeeded each other. Most frequently the intervals are one year ones and rarely the change comes every second year, as for instance is the considerable % BF increment and the relative reduction of % FFM between 7 and 9 years. Except few cases the intensity of increment and reduction for both body components are similar concerning both sexes, the changes being more slightly expressed at the beginning and the end of the studied growth period. The extent of BF changes throughout ages is better underlined in girls and those of FFM – in boys.

Conclusions

1. For the first time in Bulgaria is made anthropological characterization of body composition during the growing up period between 3 and 17 years of age on the ground of contemporary, recommended by the WHO criteria.

2. Specific sexual and age differences are established showing that:

– between 3 and 17 years girls accumulate and have constantly more quantity of Body Fats, while boys accumulate and have constantly more quantity of Fat Free Mass;

– the body nutritional status in boys changes considerably between 9 and 10, and 12 and 13 years of age, while in girls these changes happen one year earlier - between 8 and 9, and 11 and 12 years of age, occurring again between 13 and 15 years.

3. It is established that on the ground of regular, continuous increment in stature and body weight between 3 and 17 years the age changes, concerning proportion between Body Fat and Fat Free Mass, reflect the specificity in body maturation during growing up period. The intensive increment or reduction of BF goes along with reciprocally changes in FFM.

Table 1. Biostatistical data of investigated features

Age	*n* ♂	*n* ♀	Stature						Body weight						BMI					
			♂		♀		Inter-sexual differences		♂		♀		Inter-sexual differences		♂		♀		Inter-sexual differences	
			mean	SD	mean	SD	AD	ISD	mean	SD	mean	SD	AD	ISD	mean	SD	mean	SD	AD	ISD
3	80	80	101.20	4.30	98.99	3.89	2.20*	2.20	16.33	2.11	15.48	1.80	0.85*	5.37	15.91	1.43	15.76	1.26	0.15	0.94
4	80	80	107.70	4.13	106.52	5.39	1.18	1.10	18.35	3.09	17.96	2.68	0.40	2.20	15.75	1.83	15.76	1.48	-0.01	-0.07
5	80	80	114.66	4.97	113.91	4.97	0.75	0.66	21.06	3.97	20.01	2.72	1.04	5.07	15.92	1.87	15.38	1.42	0.53*	3.41
6	80	80	121.28	4.93	120.40	5.16	0.88	0.73	23.86	4.26	22.88	3.93	0.99	4.23	16.14	2.04	15.72	2.04	0.42	2.64
7	110	110	125.79	5.83	125.85	5.23	-0.07	-0.05	25.84	4.53	25.55	4.48	0.29	1.13	16.24	1.95	16.06	2.04	0.19	1.16
8	100	101	131.01	5.93	130.52	5.13	0.48	0.37	28.22	5.01	27.37	4.51	0.86	3.08	16.35	1.97	15.99	1.96	0.36	2.22
9	100	101	136.49	5.94	137.56	6.48	-1.07	-0.78	32.39	6.50	32.88	7.48	-0.50	-1.52	17.27	2.54	17.23	2.84	0.04	0.21
10	100	98	142.05	7.14	142.30	6.45	-0.25	-0.17	36.28	8.68	35.81	7.44	0.47	1.31	17.79	2.92	17.57	2.86	0.22	1.26
11	100	100	147.89	6.04	149.20	6.83	-1.31	-0.88	40.16	7.24	41.15	9.55	-0.99	-2.44	18.28	2.77	18.32	3.19	-0.04	-0.20
12	97	100	152.49	7.97	155.54	7.22	-3.05*	-1.98	43.30	9.12	47.42	10.95	-4.12*	-9.07	18.47	2.65	19.44	3.44	-0.97*	-5.11
13	101	99	160.48	8.13	160.11	5.54	0.37	0.23	50.67	10.64	51.08	11.06	-0.41	-0.81	19.57	3.33	19.87	4.01	-0.30	-1.54
14	99	101	167.43	7.84	162.11	5.53	5.32*	3.23	54.81	11.02	50.37	8.13	4.44*	8.44	19.45	3.14	19.13	2.72	0.32	1.66
15	100	100	172.64	6.92	162.77	6.01	9.87*	5.89	59.64	12.26	52.99	8.78	6.65*	11.81	19.92	3.33	19.98	3.03	-0.06	-0.30
16	119	120	175.49	6.19	163.52	5.29	11.97*	7.06	63.05	11.99	54.28	9.47	8.78*	14.96	20.40	3.23	20.26	3.13	0.15	0.72
17	118	118	177.70	5.98	163.84	5.83	13.87*	8.12	66.49	12.14	54.49	9.29	12.00*	19.84	20.99	3.21	20.25	2.97	0.73	3.56

Table 1. Continuation

Age	*n* ♂	*n* ♀	%Body fat						Body fat (kg)						%Fat Free Mass						Fat Free Mass (kg)					
			♂		♀		Inter-sexual differences		♂		♀		Inter-sexual differences		♂		♀		Inter-sexual differences		♂		♀		Inter-sexual differences	
			mean	SD	mean	SD	AD	ISD	mean	SD	mean	SD	AD	ISD	mean	SD	mean	SD	AD	ISD	mean	SD	mean	SD	AD	ISD
3	80	80	15.60	3.19	16.01	2.95	-0.42	-2.64	2.58	0.81	2.51	0.69	0.08	2.97	84.40	3.19	83.99	2.95	0.42	0.50	13.75	1.53	12.97	1.29	0.78*	5.82
4	80	80	14.80	3.56	16.28	3.55	-1.48*	-9.50	2.80	1.25	2.98	1.01	-0.18	-6.24	85.20	3.56	83.72	3.55	1.48*	1.75	15.55	2.01	14.98	1.90	0.58	3.79
5	80	80	14.84	4.37	15.85	3.46	-1.01	-6.56	3.26	2.00	3.22	1.11	0.04	1.37	85.16	4.37	84.15	3.46	1.01	1.19	17.79	2.27	16.79	1.97	1.00*	5.76
6	80	80	15.64	5.53	16.82	5.40	-1.17	-7.24	3.90	2.29	4.02	2.07	-0.12	-2.97	84.36	5.53	83.18	5.40	1.17	1.40	19.96	2.55	18.86	2.20	1.11*	5.69
7	110	110	14.58	5.12	15.98	4.81	-1.41*	-9.20	3.95	2.32	4.25	2.12	-0.31	-7.49	85.42	5.12	84.02	4.81	1.41*	1.66	21.89	2.79	21.30	2.68	0.60	2.76
8	100	101	15.01	6.05	17.08	5.35	-2.07*	-12.90	4.47	2.86	4.83	2.23	-0.36	-7.74	84.99	6.05	82.92	5.35	2.07*	2.46	23.75	2.87	22.53	2.89	1.22*	5.26
9	100	101	16.56	6.44	18.46	6.38	-1.90*	-10.86	5.69	3.51	6.46	3.86	-0.77	-12.60	83.44	6.44	81.54	6.38	1.90*	2.31	26.69	3.72	26.42	4.10	0.27	1.02
10	100	98	15.90	8.96	19.85	7.49	-3.96*	-22.14	6.40	5.71	7.55	4.43	-1.15	-16.47	84.10	8.96	80.15	7.49	3.96*	4.82	29.88	4.47	28.26	3.96	1.62*	5.58
11	100	100	17.14	8.25	19.72	6.66	-2.58*	-14.00	7.40	4.86	8.61	4.97	-1.21	-15.09	82.86	8.25	80.28	6.66	2.58*	3.16	32.76	3.71	32.54	5.42	0.21	0.66
12	97	100	16.75	8.40	21.37	6.99	-4.62*	-24.24	7.81	5.73	10.73	6.01	-2.92*	-31.49	83.25	8.40	78.63	6.99	4.62*	5.71	35.50	5.31	36.69	5.95	-1.20	-3.32
13	101	99	18.95	9.82	22.57	7.47	-3.62*	-17.44	10.32	7.25	12.20	6.74	-1.88	-16.71	81.05	9.82	77.43	7.47	3.62*	4.57	40.35	6.36	38.88	5.35	1.47	3.71
14	99	101	16.58	8.06	23.08	5.72	-6.50*	-32.78	9.70	6.62	11.95	4.72	-2.25*	-20.81	83.42	8.06	76.92	5.72	6.50*	8.11	45.11	6.77	38.42	4.55	6.69*	16.02
15	100	100	16.42	8.04	24.06	6.09	-7.64*	-37.73	10.60	8.58	13.14	5.93	-2.55*	-21.44	83.58	8.04	75.94	6.09	7.64*	9.58	49.04	5.97	39.85	4.32	9.20*	20.69
16	119	120	16.14	7.88	24.56	5.95	-8.42*	-41.35	10.97	8.03	13.71	5.59	-2.74*	-22.20	83.86	7.88	75.44	5.95	8.42*	10.57	52.08	5.74	40.56	5.21	11.52*	24.86
17	118	118	16.66	7.13	24.68	5.87	-8.02*	-38.80	11.74	7.38	13.86	5.64	-2.13*	-16.60	83.34	7.13	75.32	5.87	8.02*	10.11	54.75	6.59	40.72	4.85	14.03*	29.39

$p \leq 0.05$ (statistical significance of inter-sexual differences)

Table 2. Growth velocity

Age period	Stature				Body weight				BMI			
	♂		♀		♂		♀		♂		♀	
	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA
3-4	6.50*	6.22	7.5*	7.3	2.02*	11.65	2.5*	14.8	-0.17	-1.05	0.0	0.0
4-5	6.96*	6.26	7.4*	6.7	2.70*	13.71	2.1*	10.8	0.17	1.07	-0.4	-2.4
5-6	6.62*	5.61	6.5*	5.5	2.81*	12.50	2.9*	13.3	0.22	1.38	0.3	2.2
6-7	4.51*	3.65	5.5*	4.4	1.98*	7.96	2.7*	11.0	0.11	0.65	0.3	2.1
7-8	5.22*	4.07	4.7*	3.6	2.38*	8.81	1.8*	6.9	0.11	0.64	-0.1	-0.4
8-9	5.48*	4.09	7.0*	5.2	4.16*	13.74	5.5*	18.3	0.92	5.46	1.2*	7.5
9-10	5.57*	4.00	4.7*	3.4	3.90*	11.34	2.9*	8.5	0.53*	3.00	0.3	2.0
10-11	5.84*	4.02	6.9*	4.7	3.88*	10.14	5.3*	13.9	0.49	2.70	0.7	4.2
11-12	4.60*	3.06	6.3*	4.2	3.15*	7.54	6.3*	14.2	0.19	1.05	1.1*	6.0
12-13	7.99*	5.11	4.6*	2.9	7.36*	15.67	3.7*	7.4	1.09*	5.75	0.4	2.2
13-14	6.95*	4.24	2.0*	1.2	4.14*	7.85	-0.7	-1.4	-0.12	-0.61	-0.7*	-3.8
14-15	5.21*	3.06	0.7	0.4	4.83*	8.44	2.6*	5.1	0.47	2.39	0.9*	4.4
15-16	2.85*	1.64	0.7	0.5	3.41*	5.56	1.3	2.4	0.48	2.40	0.3	1.4
16-17	2.21*	1.25	0.3	0.2	3.44*	5.31	0.2	0.4	0.58	2.82	0.0	0.0

* $P \leq 0.05$ (statistical significance of inter-age differences); AYA – Absolute Year Alteration; RYA – Relative Year Alteration

Table 2. Continuation

Age period	%Body Fat				Body Fat (kg)				%Fat Free Mass				Fat Free Mass (kg)			
	♂		♀		♂		♀		♂		♀		♂		♀	
	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA	AYA	RYA
3- 4	-0.80	-5.25	0.26	1.62	0.22	7.99	0.47*	17.16	0.80	0.94	-0.26	-0.31	1.80*	12.32	2.00*	14.34
4-5	0.04	0.30	-0.43	-2.65	0.46	15.32	0.24	7.73	-0.04	-0.05	0.43	0.51	2.24*	13.42	1.82*	11.45
5-6	0.80	5.23	0.97	5.91	0.64	17.79	0.80*	22.09	-0.80	-0.94	-0.97	-1.15	2.17*	11.50	2.06*	11.57
6-7	-1.06	-7.05	-0.83	-5.08	0.04	1.13	0.23	5.66	1.06	1.25	0.83	1.00	1.93*	9.23	2.44*	12.16
7-8	0.43	2.92	1.10	6.62	0.53	12.57	0.58	12.82	-0.43	-0.51	-1.10	-1.31	1.85*	8.12	1.23*	5.63
8-9	1.55	9.82	1.38	7.78	1.22*	24.00	1.63*	28.79	-1.55	-1.84	-1.38	-1.68	2.94*	11.67	3.89*	15.89
9-10	-0.66	-4.07	1.39	7.27	0.71	11.68	1.09	15.55	0.66	0.79	-1.39	-1.72	3.19*	11.27	1.84*	6.72
10-11	1.24	7.49	-0.14	-0.70	1.00	14.50	1.06	13.11	-1.24	-1.48	0.14	0.17	2.88*	9.18	4.28*	14.09
11-12	-0.38	-2.26	1.66	8.07	0.41	5.36	2.12*	21.91	0.38	0.46	-1.66	-2.09	2.74*	8.03	4.15*	11.99
12-13	2.20	12.31	1.20	5.45	2.51*	27.72	1.48	12.87	-2.20	-2.67	-1.20	-1.54	4.85*	12.79	2.18*	5.78
13-14	-2.37	-13.32	0.51	2.25	-0.62	-6.21	-0.25	-2.07	2.37	2.88	-0.51	-0.67	4.76*	11.14	-0.46	-1.19
14-15	-0.16	-0.97	0.98	4.14	0.90	8.83	1.19	9.47	0.16	0.19	-0.98	-1.28	3.94*	8.36	1.43*	3.65
15-16	-0.28	-1.71	0.50	2.05	0.38	3.51	0.57	4.27	0.28	0.33	-0.50	-0.66	3.03*	6.00	0.71	1.77
16-17	0.52	3.16	0.13	0.51	0.76	6.73	0.15	1.08	-0.52	-0.62	-0.13	-0.17	2.67*	5.00	0.16	0.39

* $P \leq 0.05$ (statistical significance of inter-age differences); AYA – Absolute Year Alteration; RYA – Relative Year Alteration

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