

Anthropology

Underweight in Bulgarian Boys and Girls from 3 till 17 Years of Age Living on the Borderline between 20th and 21st Century

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The aim is to characterize and classify the underweight in children and adolescents from Sofia, and to assess the gender differences in the frequency of separate categories underweight.

Totally 2931 children and adolescents aged 3-17 years are studied. Underweight are defined according to the BMI cut-offs elaborated by Cole et al. In both genders till 13 years of age the frequency of children with underweight reaches to 15.0 % in boys aged 3 and girls aged 9. Between 14 and 17 years of age the frequency of underweight children is higher, more emphasized in girls — 27% in 17 years old girls. The established underweight among present generation of Bulgarian children and adolescents could serve as a base for analyses, evaluations and prognoses for their health status. The frequency rise of thinness with ages among adolescents represents a special interest, as well as necessity of profound investigations and wide discussion in parallel with the problem of obesity.

Key words: BMI cut-offs, underweight, growing up period.

Introduction

One of the most important indicators for predisposition to some serious, socially important diseases in adulthood, or the presence of such ones during growing up period, is the Body Nutritional Status (BNS). And if the international accepted criteria for BNS for adults have been elaborated far ago, this methodological problem concerning BNS criteria during growth period of the young generations started its unification for international use hardly before several years [11]. Different indicators as weight-for-stature, weight-for-age have been used for the BNS to be categorized, as well as dif-

ferent cut-offs concerning BMI and elaborated by various percentiles, z-score or SD approaches, based mainly on national data, have been applied [15, 16, 19, 20, 21]. In many countries were taken data and published results mainly for the epidemiology of obesity [1, 2, 4, 8, 12, 18]. The underweight compared to obesity is also reliable health problem but before 2-3 years the reports in the literature about population investigations concerning undernutrition were very few and mainly for the countries in which hunger and undernourishment were officially recognized [7, 9].

As a result of constant searching and more precise definition, a team of international scientists (International Obesity Task Force – IOTF) originated criteria about fixing age and sex specific cut-offs for BMI during growth [12]. On the basis of these criteria T. Cole et al. [5, 6] elaborated and published in the British Medical Journal internationally accepted BMI cut-offs for annual determination of the underweight and overweight BNS categories in children and adolescents from 2 till 17 years concerning both genders separately. This afforded an opportunity to the scientists for assessing the epidemiology of both categories unhealthy nutritional status concerning these ages, as for the separate countries, so internationally. Furthermore according to the criteria of IOTF the cut-offs for every age group between 2 and 17 years are mathematically equalized by the LMS method to the WHO cut-offs for BMI in adults: 16, 17, 18.5, 25, and 30 kg/m². This fact gives possibility for the frequency of the different categories Body Nutritional Status in children, adolescents and adults to be compared.

The **aim** is to characterize and classify the underweight in 3-17 years old children and adolescents from Sofia living at the end of 20th and the beginning of the 21st century and to assess the gender differences in the frequency of separate categories underweight.

Material and Methods

Object of the study were: 640 pre-school children – 3-6 years (2004-2005) and 2291 children and adolescents between 7 and 17 years of age (1995-2002); or totally 2931 boys and girls uniformly distributed into 16 age groups for both genders separately.

The mean age of the investigated boys and girls in all 16 age groups is 3.5, 4.5, 5.5, 6.5, 7.5, and so on. To facilitate the presentation of the data, they are marked in whole numbers (in years) on our tables, for example in the group of the 3 years old children are enlisted those ones aged from 2 years 11 months and 30 days till 3 years 11 months and 29 days and so on for concerning all age groups.

The study was carried out in Sofia. The nests in which the investigation had to be carried out have been defined by the lottery method. Seven kindergartens and seven schools were included, situated in the center of the city; in the near areas to the city and in the outskirts.

The anthropological investigation were carried out by a team consisting of specialists in medical anthropology, who were trained in advance and tested for individual and inter-researcher's errors. All requirements for the medico-biological studies were followed, as well: the investigations were carried out in the morning, in specially equipped rooms and the boys from 3 till 17 years were in shorts and the girls in bikini. The data taken are elaborated and analyzed statistically (carried out by means of SPSS version 13.0). The statistical significance of gender differences was established by the T-criterion of Student at $P < 0.05$.

The evaluation concerning epidemiology of the different categories body nutritional status being subject of the present paper is made on the basis of the data about

Table 1. BMI cut-offs adapted according to this elaborated by Cole et al. about underweight (2007)

Age (years)	BOYS			GIRLS		
	Thinness grade III	Thinness grade II	Thinness grade I	Thinness grade III	Thinness grade II	Thinness grade I
2.5	x-13.2	13.3-13.9	14.0-14.9	x-13.1	13.2-13.7	13.8-14.6
3.5	x-13.0	13.1-13.6	13.7-14.6	x-12.9	13.0-13.5	13.6-14.3
4.5	x-12.8	12.9-13.4	13.5-14.3	x-12.6	12.7-13.2	13.3-14.1
5.5	x-12.6	12.7-13.2	13.3-14.1	x-12.4	12.5-13.0	13.1-13.9
6.5	x-12.4	12.5-13.1	13.2-14.0	x-12.3	12.4-12.9	13.0-13.8
7.5	x-12.4	12.5-13.1	13.2-14.1	x-12.3	12.4-13.0	13.1-13.9
8.5	x-12.4	12.5-13.2	13.3-14.2	x-12.4	12.5-13.1	13.2-14.1
9.5	x-12.6	12.7-13.3	13.4-14.5	x-12.5	12.6-13.3	13.4-14.4
10.5	x-12.8	12.9-13.6	13.7-14.8	x-12.8	12.9-13.6	13.7-14.8
11.5	x-13.0	13.1-13.9	14.0-15.2	x-13.2	13.3-14.0	14.1-15.3
12.5	x-13.4	13.5-14.2	14.3-15.6	x-13.6	13.7-14.6	14.7-15.9
13.5	x-13.8	13.9-14.7	14.8-16.1	x-14.2	14.3-15.1	15.2-16.6
14.5	x-14.4	14.5-15.3	15.4-16.7	x-14.6	14.7-15.7	15.8-17.2
15.5	x-14.9	15.0-15.8	15.9-17.3	x-15.2	15.3-16.2	16.3-17.7
16.5	x-15.4	15.5-16.3	16.4-17.8	x-15.6	15.7-16.6	16.7-18.1
17.5	x-15.8	15.9-16.8	16.9-18.3	x-15.9	16.0-16.9	17.0-18.4

BMI. The categorization is made according to the body mass index cut-offs elaborated by Cole et al. [5, 6] and recommended by the WHO when interage, intergroup and international comparisons in boys and girls aged 2-17 years had to be assessed (Table 1). According to these BMI cut-offs, underweight children are divided into three grades: thinness grade I, thinness grade II and thinness grade III.

Results

The means of BMI for every age-gender group are presented on Table 2 and in Figure 1.

Between 3 and 8 years, i.e. during childhood, the means of BMI didn't change tangible staying into the range 15.38-16.35 kg/m². For these ages, however, the BMI values are higher in boys, even if not much, and significant gender differences are found only in the 5 years old children.

From 9 years henceforth, when the beginning of puberty could be marked, and the annually changes of BMI means in both genders become greater with ages, the BMI increment is from 17.0 kg/m² at 9 till 21.0 kg/m² at 17. The year increasing is statistically significant between 8 and 9 years for both genders, i.e. on the borderline between childhood and puberty. Significant is also the increment between 11 and 12 in girls and one year later (between 12 and 13) in boys, which could be explained by the boys' later puberty. The last significant annual increasing of BMI values is

Table 2. Biostatistical data of BMI in children and adolescents between 3 and 17 years of age

Age (years)	Boys						Girls						Differences			
	n	mean kg/m ²	SD	SEM	min	max	n	mean kg/m ²	SD	SEM	min	max	Gender	Interage		
														Age period	Boys	Girls
3	80	15.91	1.43	0.16	13.2	21.6	80	15.76	1.26	0.14	12.9	20.3	0.15	3-4	-0.17	-0.01
4	80	15.75	1.83	0.20	12.5	25.9	80	15.76	1.48	0.17	13.2	19.1	-0.01	4-5	0.17	-0.38
5	80	15.92	1.87	0.21	13.3	26.6	80	15.38	1.42	0.16	13.2	20.7	0.53*	5-6	0.22	0.33
6	80	16.14	2.04	0.23	13.4	26.3	80	15.72	2.04	0.23	12.1	23.9	0.42	6-7	0.11	0.34
7	110	16.24	1.95	0.19	12.9	26.0	110	16.06	2.04	0.19	12.4	22.6	0.19	7-8	0.11	-0.07
8	100	16.35	1.97	0.20	13.1	24.2	101	15.99	1.96	0.20	12.3	21.3	0.36	8-9	0.99*	1.20*
9	100	17.27	2.54	0.25	12.8	26.1	101	17.23	2.84	0.28	12.0	27.8	0.04	9-10	0.20	0.41
10	100	17.79	2.92	0.29	13.8	27.7	98	17.57	2.86	0.29	12.6	25.1	0.22	10-11	0.65	0.78
11	99	18.28	2.76	0.28	13.6	25.0	100	18.32	3.19	0.32	13.4	30.1	-0.04	11-12	0.21	0.67*
12	97	18.47	2.65	0.27	14.2	26.9	100	19.44	3.44	0.34	13.2	29.1	-0.97*	12-13	1.15*	0.63
13	101	19.57	3.33	0.33	13.9	28.7	99	19.87	4.01	0.40	11.9	36.1	-0.30	13-14	-0.04	-0.35
14	99	19.45	3.14	0.32	14.1	28.9	101	19.13	2.72	0.27	12.8	31.2	0.32	14-15	0.54	0.57*
15	100	19.92	3.33	0.33	15.4	35.9	100	19.98	3.03	0.30	14.7	36.0	-0.06	15-16	0.36	0.36
16	119	20.40	3.23	0.30	14.7	31.0	120	20.26	3.13	0.29	15.4	32.4	0.15	16-17	0.58	0.00
17	118	20.99	3.21	0.30	14.9	31.4	118	20.25	2.97	0.27	15.5	31.8	0.73			

* Statistical significance at $P < 0.05$

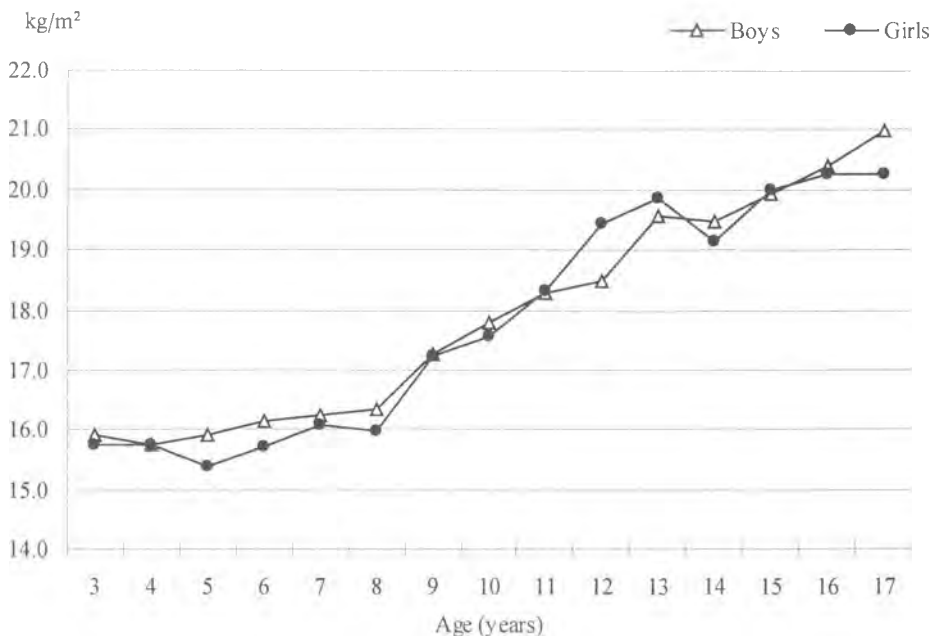


Fig. 1. Means of BMI between 3 and 17 years

established only for girls between 14 and 15, i.e. at the beginning of the postpubertal period by them.

After 9 the gender differences are already more distinctly expressed. During active puberty (11-13 years) the values of BMI become higher in girls, the gender difference being statistically significant in the 12 years old boys and girls. The BMI again is higher in boys aged 16 and 17, when postpubertal period comes.

The frequency of children and adolescents with underweight is presented on Tables 3 and 4, and in Figures 2 and 3.

Till 13 years the frequency of underweight children is not so low — from 3 till 13 concerning underweight girls it is between 5.0% and 15.84%, and for boys it is between 6.0% and 15.0%. From 14 till 17 when the puberty nearly ends, frequency of the underweight adolescents increases — in boys it comes till 22.0% and in girls it reaches even 26.67%.

The children with thinness grade I are comparatively frequent till the end of puberty. During postpuberty the underweight frequency for both genders increases considerably, more markedly in girls. The ages in which more boys with thinness grade I were found are: 3 years (11.25%), 10 years (12.0%) and between 12 and 15 years, reaching at 15-18.0%. In girls are found also variations with ages concerning frequency of thinness grade I — it is high at 4 years (11.25%), at 6 years (10.0%) and during puberty between 9 and 12, when its frequency varies among 10.0% and 12.87%. Considerable gender differences are found after 14 years when the frequency of girls with thinness grade I is constantly high (among 13.0% and 17.5%).

The frequency of children with thinness grade II more often is higher in school age girls. Most underlined are the gender differences in 17 years age boys and girls — the thinness grade II for girls comes till 9.17% and in boys it reaches hardly 2.54%.

Table 3. Frequency of the individuals with underweight

Age (years)	Underweight			
	boys		girls	
	<i>n</i>	%	<i>n</i>	%
3	12	15.00	7	8.75
4	9	11.25	9	11.25
5	7	8.75	4	5.00
6	6	7.50	11	13.75
7	7	6.36	10	9.09
8	7	7.00	13	12.87
9	8	8.00	16	15.84
10	16	12.00	14	14.28
11	6	6.00	15	15.00
12	11	11.61	12	12.00
13	13	12.87	15	15.00
14	19	19.00	22	21.78
15	22	22.00	16	16.00
16	20	16.67	29	24.16
17	18	15.25	32	26.67

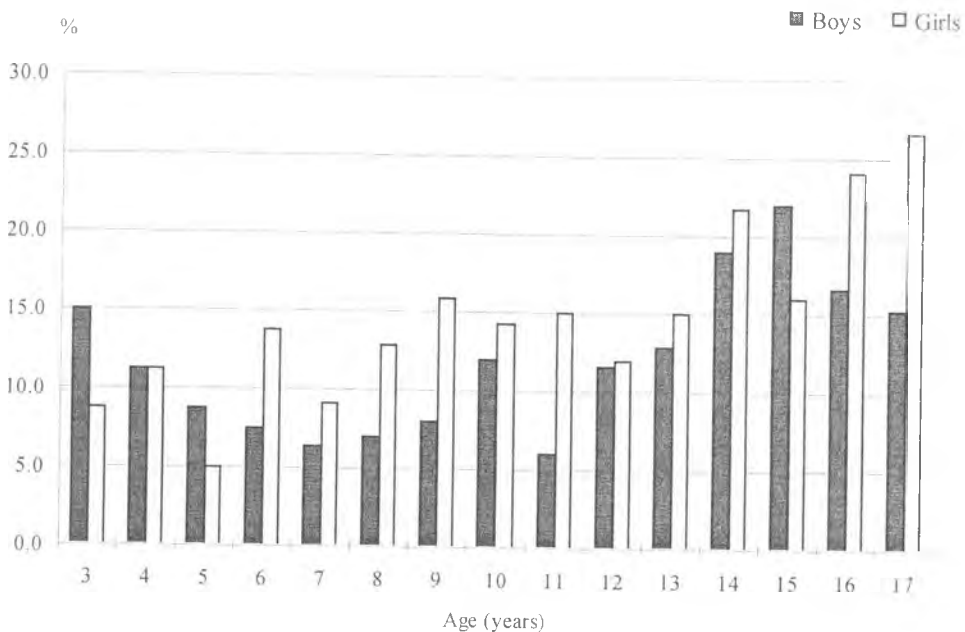


Fig. 2. Frequency of boys and girls with underweight

Table 4. Frequency of the separate underweight categories

Age (years)	BOYS							GIRLS						
	n	Thinness grade III		Thinness grade II		Thinness grade I		n	Thinness grade III		Thinness grade II		Thinness grade I	
		n	%	n	%	n	%		n	%	n	%	n	%
3	80	-	-	3	3.75	9	11.25	80	-	-	1	1.25	6	7.50
4	80	1	1.25	2	2.50	6	7.50	80	-	-	-	-	9	11.25
5	80	-	-	-	-	7	8.75	80	-	-	-	-	4	5.00
6	80	-	-	-	-	6	7.50	80	1	1.25	2	2.50	8	10.00
7	110	-	-	1	0.91	6	5.45	110	-	-	3	2.73	7	6.36
8	100	-	-	1	1.00	6	6.00	101	1	0.99	4	3.96	8	7.92
9	100	-	-	3	3.00	5	5.00	101	2	1.98	1	0.99	13	12.87
10	100	-	-	-	-	12	12.00	98	1	1.02	2	2.04	11	11.22
11	100	-	-	1	1.00	5	5.00	100	-	-	3	3.00	12	12.00
12	97	-	-	1	1.30	10	10.31	100	1	1.00	1	1.00	10	10.00
13	101	-	-	2	1.98	11	10.89	99	2	2.00	5	5.00	8	8.00
14	99	1	1.00	5	5.00	13	13.00	101	2	1.98	4	3.96	16	15.84
15	100	-	-	4	4.00	18	18.00	100	1	1.00	2	2.00	13	13.00
16	120	3	2.50	6	5.00	11	9.17	120	1	0.83	7	5.83	21	17.50
17	118	4	3.39	3	2.54	11	9.32	118	1	0.83	11	9.17	20	16.67

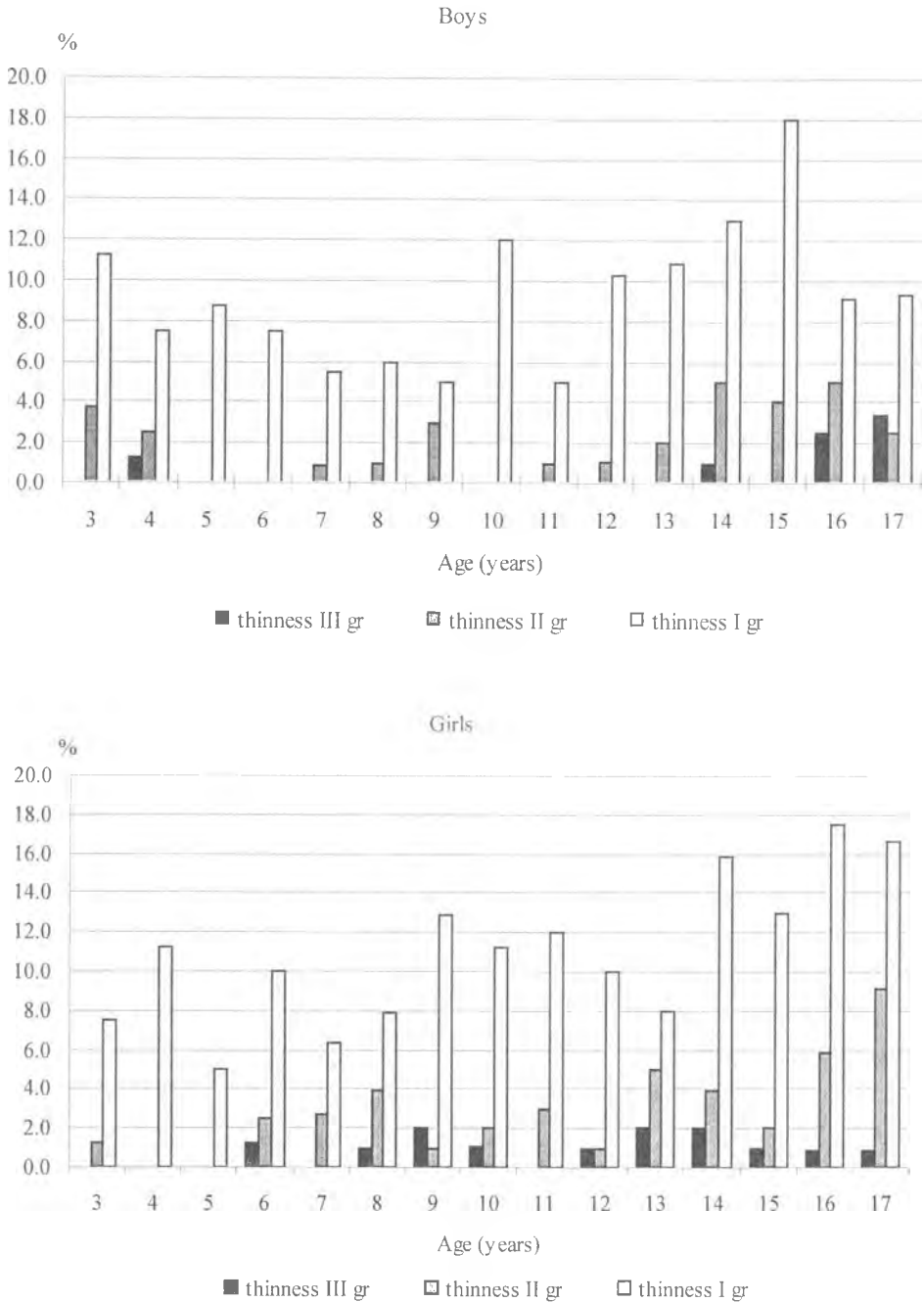


Fig. 3. Frequency of the separate underweight categories

Almost in all ages between 6 and 17 years there are underweight girls — thinness grade III, i.e. skinny ones, as their frequency at 9, 13 and 14 years reaches 2.0%. Boys with such nutritional status (thinness grade III) are found only at the end of the studied period (14, 16 and 17 years), the frequency of those ones being 3.4% at 17

Discussion

The analysis and evaluation of our results are conformed to the decision of international scientists concerning application of the age and gender specific criteria for BNS categorisation during growth [19]. It is the period from birth till body maturity during which in specific manner for both genders, the two basic components of body weight — Fat Tissue (FT) and Lean Body Mass (LBM) developed. Something more, the morphological body maturity, which during pre-puberty begins to developed more quickly and its basic realisation happens in puberty, naturally goes along with the accumulation of more FT in girls while in boys it is accompanied with the increment of LBM too. By these processes, the formation of typical for adult man and women body structure and body composition come true [3, 10].

The followed age changes of BMI means in our study confirm the underlined dependence of these values from children's age and gender. Concerning Bulgarian children and adolescents the interage and the respectively BMI gender differences follow as a whole the stage decrease or increase of BMI during growth described by many authors and summarized by Cole et al. [5, 6]. The established age BMI curves in our study reflect the dependences between specific life conditions in Bulgaria and the specificity of growth and body maturity in Bulgarian children. The borderline of childish Body Nutritional Status and the coming formation of youth Body Nutritional Status could be found between 8 and 9 years. Reliable changes in Body Nutritional Status during active puberty in the Bulgarian girls come between 11 and 12, and in boys they come one year later reflecting later puberty in them.

Concerning gender differences of interest is the permanently higher BMI in boys till puberty. During active puberty (11-13 years) the BMI values are higher in girls reflecting the specificity of body maturity in them. The quicker accumulation of subcutaneous fat tissue in female individuals during this period is an initial period that later drive to the formation of Body Nutritional Status type pear in them.

From medico-biological point of view most interesting are the results about frequency of both unhealthy categories Body Nutritional Status. Both underweight and overweight dissemble enough high risk for health, as during growth, so being predisposition for some illnesses in adult ages. Unfortunately, in Bulgaria and in other European countries, the only direction in which are going on discussions concerning Body Nutritional Status in growing up boys and girls is obesity. On the other hand, the results published in international journals very often are generalized affecting large age periods that doesn't correspond to the accepted and natural age stages of growth [14, 20]. From medico-biological point of view, however, such age generalization is not correct because it is not clear to which age group are belonged the corresponding data. Such generalisation periods couldn't be able to give possibility for a connection between specificity of growth process and body nutritional status to be sought.

Of special interest in national aspect is the established frequency of underweight among present growing up Bulgarian population. Our results have also international meaning because they are made according to the unified criteria of IOTF and WHO and could be compared to similar data elaborated in other countries.

It is established that if till 13 years a big part of the Bulgarian boys and girls are predisposed to obesity, not very few of them are predisposed to illnesses as a result from underweight. More serious health problem is the one concerning high frequency of underweight in post puberty period, mainly for girls.

Important result from medical point of view is the established presence of thinness grade III in girls (i.e. skinny girls) for nearly all ages between 6 and 17. In our opinion this result is an alarm at necessity of profound investigations elaborating respective national strategy concerning prevention from forthcoming health complications.

Similar results for increment of the underweight frequency in children were already published in other European countries. The cited team of Czech scientists [17] established that during last decade increases considerably the frequency of underweight children in the lowest age categories (till 14.0%) and among older adolescents (till 13.0%). Martinez et al. [13] reported about increment of the underweight frequency in Spanish children from both genders — from $\approx 3.0\%$ during 1992 till $\approx 10.0\%$ during 2004.

Conclusion

The established frequency of underweight and overweight among present generation of Bulgarian children and adolescents could serve as a base for analyses, evaluations and prognoses for their health status. The frequency rise of thinness with ages among adolescents represents a special interest, as well as necessity of profound investigations and wide discussion in parallel with the problem of obesity.

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