

## Relation between the Nutritional Status Type and the Arterial Blood Pressure in 9-15-year-old Schoolchildren from Sofia

*Z. Mitova*

*Institute of Experimental Morphology and Anthropology with Museum,  
Bulgarian Academy of Sciences, Sofia*

The aim of the present work is to investigate the age-dependent changes of Nutritional Status (NS) and Arterial Blood Pressure (ABP) in 9-15-year-old schoolchildren from Sofia, the generation living at the beginning of the 21st century and to evaluate the relationships between ABP and the anthropologically determined NS. The analyzed data represent a part of complex cross-sectional anthropological study including 1142 schoolchildren, attending three schools in Sofia. The study was carried out during the years 2001 and 2002. It was established that the "hypertension" ABP was found to be four times more often among the overweighed schoolchildren than among the ones with normal NS. The frequency of girls with "hypertension" Systolic Blood Pressure (SAP) between 9 and 14 years was consistently higher than it was in the boys between these ages. Among obese schoolchildren the frequency of those with "hypertension" SBP has increased markedly, better expressed in girls.

*Key words:* adolescents, anthropometric, anthropometrical nutritional status, arterial blood pressure, relationships

### Introduction

The morphological and functional entity of organism determines the scientific interest in the revelation and the impartial assessment of relationship between basic and important for the human health characterizations. Purposeful investigations into this direction are important especially when covering the period of growth, within which the childish and/or adolescent organism transforms itself into a mature one [3, 5, 10, 12, 14, 21]. Recently more and more specialists report on the established trend about the predisposition towards considerable and socially important diseases for adulthood to be detected since the period of growth [8, 9, 16, 20]. Among clinical specialists is accepted the existence of such a trend about two important characteristics in the human physical development. Cardiologists established the so called

“trace phenomenon” concerning Arterial Blood Pressure (ABP), i.e. if a borderline or raised ABP have been revealed for a person during his childhood and adolescent ages, the expectancy for him to suffer from hypertension in his adulthood increases [1, 6, 8, 13, 18, 26]. The same trend is also established about overweight in young ages, which more often goes deeper into obesity in adulthood [4, 5, 8, 17, 26]. The close relation between ABP and the type of Nutritional Status (NS), which exists regularly, gave reason for numerous investigators to apply different approaches for an objective evaluation of this connection [7, 8, 11, 17, 18]. The detailed literature review made by us pointed out that articles dealing with purposive evaluation of the relationship between the NS type expressed by Body Mass Index (BMI) (“normal” or healthy NS, “overweight” NS and “obesity” NS) and the ABP categories (“hypotension”, “normal tension”, “heightened tension” or “pre-hypertonic” and “hypertension”) could be found rarely, and in the Bulgarian scientific literature such articles weren’t detected at all.

The aim of the present work is to evaluate the relationship between nutritional status type and arterial blood pressure level in 9-15-year-old in boys and girls from Sofia city who are representatives of the young Bulgarian generation living at the beginning of the 21<sup>st</sup> century.

## Subjects and Methods

The data analyzed are part of a complex cross-sectional anthropological study (Mitova, 24) including 1142 schoolchildren aged 9-15 years from three schools in Sofia city, carried out during the years 2001 and 2002. The boys and girls under investigation were separated uniformly each sex in seven age groups — mean ages of 9.5, 10.5, 11.5, 12.5, 13.5, 14.5, and 15.5 years. The groups of the 9-year-old children comprise 81 boys and 81 girls, aged from 9.00 years to 9.99 years. The rest investigated boys and girls were ranged according to the same age affiliation.

The data concerning each schoolchild comprise: stature and body weight utilized to compute the BMI (body weight/height<sup>2</sup> in kg/m<sup>2</sup>), Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). The stature was measured using a standard anthropometer (allowance of 0.1 cm), and the body weight, using a Body Fat Monitor “Tanita TBF 612” (allowance of 0.1kg), respectively. The Arterial Blood Pressure was measured on the right hand in a seating position, after 10 minutes rest, using mercury sphygmomanometer according to the method of Korotkov (reading I and V phase with exactness of 0.1mmHg). When a value outside the norm for the physiological ABP was registered, two additional measurements were performed, at intervals of 5 minutes each, and the average value of the three trials were used.

The differences in ABP categorization of the students who belong to the three types NS — using respectively  $\chi^2$  (at  $p < 0.05$ ). To project the interrelations of the three types NS and the ABP was used the z-score procedure ( $SDS = X_i - X / SD$ , by norm for  $SDS = 0$ ).

The NS type was defined in three categories according to the data about BMI (normal, with overweight and with obesity) on the ground of the recommended by WHO and published by Cole et al. [2] cut off points for BMI about each age-gender group.

To classify the examined schoolchildren into different ABP-categories were used the borderline values for SBP and DBP on the generally accepted normative percentile values ( $P_5$ ,  $P_{90}$ ,  $P_{95}$ ) for each age-gender group and computed according to the data in the present study (Table 1). The values for  $ABP < P_5$  showed presence of

“hypotension”; the ABP values between  $P_5$  and  $P_{90}$  showed “normal tension”; those between  $P_{90}$  and  $P_{95}$  showed normal-but-higher tension that is not pathological for the respective age, defined also as “heightened tension” (a risky tension, pre-hypertonic, normal but higher); and values for  $ABP > P_{95}$ , which marked a “hypertension” for the concerned age.

## Results

### *Distribution of the investigated schoolchildren into types concerning NS*

The data analysis concerning distribution of the examined schoolchildren into NS types (Tabl. 1 and Fig. 1) showed that in all the investigated age-gender groups the schoolchildren with normal nutritional status prevail, their frequency being established to increase from the beginning to the end of the examined period. For the NS type “overweight” the frequency was rarer in the 15-year-old boys (6.3%) and girls

Table 1. Distribution of schoolchildren into NS types according to the data of BMI

BOYS							
Age (yrs)	Total	Normal NS		Overweight		Obesity	
	N	n	%	n	%	n	%
9	81	66	81.5	13	16.0	2	2.5
10	80	68	86.1	10	11.4	2	2.5
11	82	62	75.6	17	20.7	3	3.7
12	83	69	83.1	13	15.7	1	1.2
13	75	64	84.2	11	14.7	1	1.3
14	83	68	81.9	13	15.7	2	2.4
15	80	72	90.0	5	6.3	3	3.8
GIRLS							
Age (yrs)	Total	Normal NS		Overweight		Obesity	
	N	n	%	n	%	n	%
9	78	66	81.5	10	12.3	5	6.2
10	80	62	77.5	15	18.8	3	3.8
11	80	68	85.0	12	15.0	0	0.0
12	85	77	90.6	8	9.4	0	0.0
13	83	72	86.8	11	13.3	0	0.0
14	82	72	87.8	9	11.0	1	1.2
15	82	81	98.8	1	1.2	0	0.0

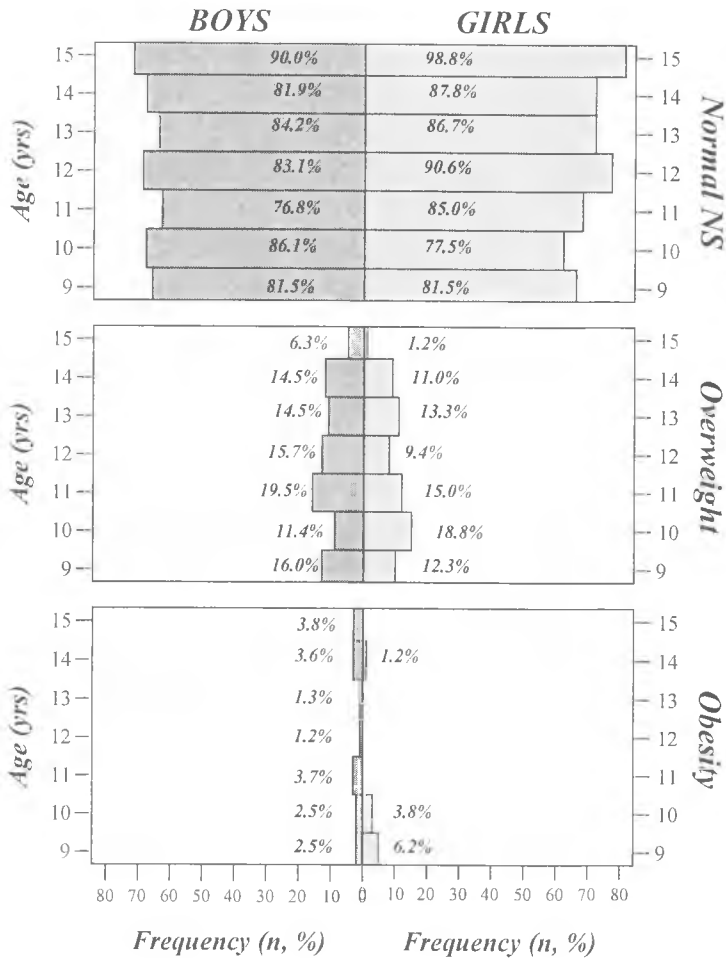


Fig. 1. Distribution of schoolchildren into NS types according to the data of BMI

(1.2%). Most often this NS category was found in the boys at 11 years (20.7%) and in the girls at 10 years of age (18.8%). Boys who got into the NS type “obesity” was revealed rarely concerning all age groups (between 1.2% at 12 years and 3.8% at 15 years of age), while opposite to them the girls with NS type “obesity” was revealed only for three age groups (at 9, 10 and 14 years of age), their frequency being higher – 6.2%, 3.8% and 1.2% respectively.

#### Distribution of the schoolchildren into categories of ABP

The schoolchildren with “normal” SBP and “normal” DBP were met most frequently in all the investigated age groups (Tabl. 2). The frequency of individuals having normal SBP varies between 82.3% in the 10-year-old and 92.8% in the 14-year-old boys, and between 81.7% in the 14-year-old and 97.5% in the 11-year-old girls.

Table 2. Distribution of the schoolchildren into ABP categories

Systolic Blood Pressure																			
BOYS										GIRLS									
Age (yrs)	N	Hypotension		Normotension		Heightened tension		Hypertension		N	Hypotension		Normotension		Heightened tension		Hypertension		
		n	%	n	%	n	%	n	%		n	%	n	%	n	%	n	%	
9	81	4	4.9	73	90.1			4	4.9	81	1	1.2	74	91.4	1	1.2	5	6.2	
10	79	3	3.8	65	82.3	10	12.7	1	1.3	80	4	5.0	70	87.5			6	7.5	
11	82	6	7.3	71	86.6			5	6.1	80	1	1.3	78	97.5			1	1.3	
12	83	2	2.4	75	90.4			6	7.2	85	8	9.4	71	83.5	3	3.5	3	3.5	
13	80	3	3.8	68	85.0	8	10.0	1	1.3	83	1	1.2	75	90.4			7	8.4	
14	83	2	2.4	77	92.8			4	4.8	82	8	9.8	67	81.7			7	8.5	
15	80	3	3.8	69	86.3	1	1.3	7	8.8	82	4	4.9	69	84.1	4	4.9	5	6.1	
Diastolic Blood Pressure																			
BOYS										GIRLS									
Age (yrs)	N	Hypotension		Normotension		Heightened tension		Hypertension		N	Hypotension		Normotension		Heightened tension		Hypertension		
		n	%	n	%	n	%	n	%		n	%	n	%	n	%	n	%	
9	81	5	6.2	69	85.2			7	8.6	81	3	3.7	70	86.4	4	4.9	4	4.9	
10	79	1	1.3	77	97.5			1	1.3	80	3	3.8	65	81.3	11	13.8	1	1.3	
11	82	3	3.7	78	95.1			1	1.2	80	8	10.0	59	73.8	11	13.8	2	2.5	
12	83	5	6.0	75	90.4			3	3.6	85	5	5.9	77	90.6			3	3.5	
13	80	4	5.0	72	90.0			4	5.0	83	4	4.8	75	90.4			4	4.8	
14	83	4	4.8	71	85.5	6	7.2	2	2.4	82	4	4.9	74	90.2			4	4.9	
15	80	4	5.0	71	88.8	1	1.3	4	5.0	82	4	4.9	68	82.9	6	7.3	4	4.9	

The frequency of boys having SBP and DBP hypotension varies between 2.4% at the age of 12 and 14 years and 7.3% at the age of 11 years, while the frequency of corresponding girls varies between 1.2% at the age of 9, 11 and 13 years and 9.8% at the age of 14 years.

Schoolchildren of only three age groups have fallen into the category "heightened tension" SBP and their frequency decreased in the ages — in boys at the ages of 10 (12.7%), 13 (10.0%) and 15 (1.3%). The frequency of girls going to this SBP category was three times lower but was registered as early as at the age of 9 (1.2%), followed by the 12 (3.5%) and 15 (4.9%) years old girls and their frequency increased in the ages. The frequency of boys with hypertonic values of SBP varies between 1.3% at 10 years and 8.8% at 15 years, and the frequency of girls — between 1.3% at 11 years and 8.5% at 14 years respectively.

The distribution of schoolchildren into the DBP categories was analogous to this one concerning the categories of SBP. Hypotonic DBP was registered in both genders, as the frequency varies for boys from 1.3% in the 10-year-old ones and 5.0-6.0% in boys from the rest age groups. The lowest frequency of girls with hypotension DBP was revealed at the ages of 9 and 10 years (3.8%), while the maximal frequency about this characteristic was observed — at the age of 11 years (10.0%). Within the age interval 12-15 years, like it is in boys, the frequency of girls with hypotension DBP is about 5.0%. The DBP of the category "heightened tension" were found only in boys at 14 years (7.2%), while in the 15 years old ones it was 1.3%. Unlike boys, the girls fall 2.5 times more frequently in this category — 4.9% at the age of 9 years, 13.8% at the age of 10 and 11 years, and 7.3% at the age of 15 years. Into the category "hypertension" DBP were met nearly 1.0% less schoolchildren than the ones with "hypotension" DBP. The frequency of individuals with "hypertension" DBP varied between 8.6% at 9 years and 1.2% at 11 years in boys, and between 1.3% at 10 years and 4.9% at 9, 14, and 15 years in girls.

### *Relation of NS type and ABP in the investigated schoolchildren*

In schoolchildren having normal NS, the normal ABP tension was established again most frequently (Figs. 2 and 3). In this NS category, the frequency of boys with hypotension SBP was about 5.0% and the frequency of those with hypertension SBP and DBP was 3.0% (lower by 2.0%). The frequency of boys with "pre-hypertonic" SBP was 3.0%, while only 1.0% of them displayed a "heightened tension" DBP.

The distribution of SBP and DBP among girls who have normal nutritional status is similar to that in boys. Pathologically high SBP values were found in 4.0% of the girls (1.0% more than in boys), while the "heightened tension" DBP were more frequent (3.6%) in girls than the "heightened tension" SBP (1.4%).

About NS type "overweight" the impression was made that in both sexes the frequency of schoolchildren with "hypotension" SBP was lower than the frequency of those ones who fall into the "normal" type of NS (by nearly 3.0% in boys and 2.0% in girls), while the schoolchildren with "hypotension" SBP were several times more frequent (12.2% in boys and 16.5% in girls). The frequency of schoolchildren with "hypotension" DBP, however, decreased only in boys, and in girls it increased if only by 1.0%. Concerning the NS-type "overweight", boys with "hypertension" DBP were twice more frequent (6.1%) than girls (3.0%).

Interesting was also the distribution of schoolchildren after different ABP categories towards NS-type "obesity". In both gender groups were not found obese schoolchildren who have hypotension ABP. On the other hand, relatively lower was

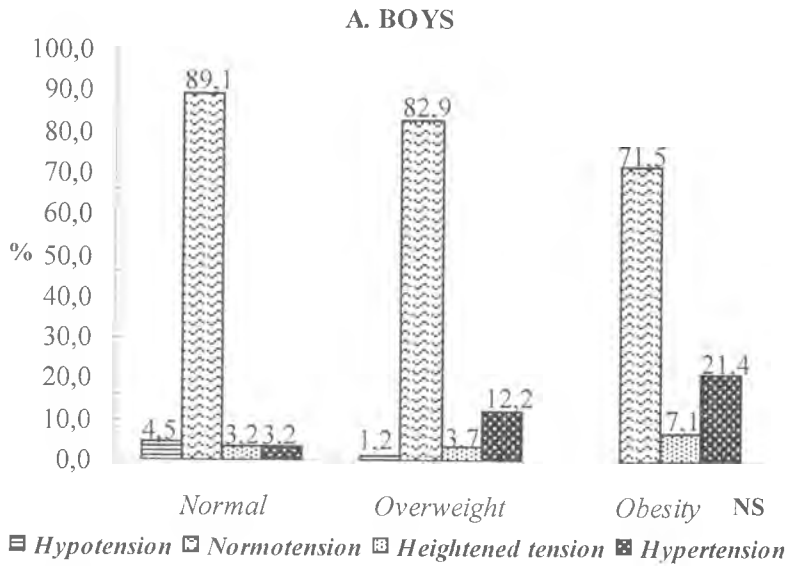


Fig. 2. A) Relation of NS type and SBP categories in boys

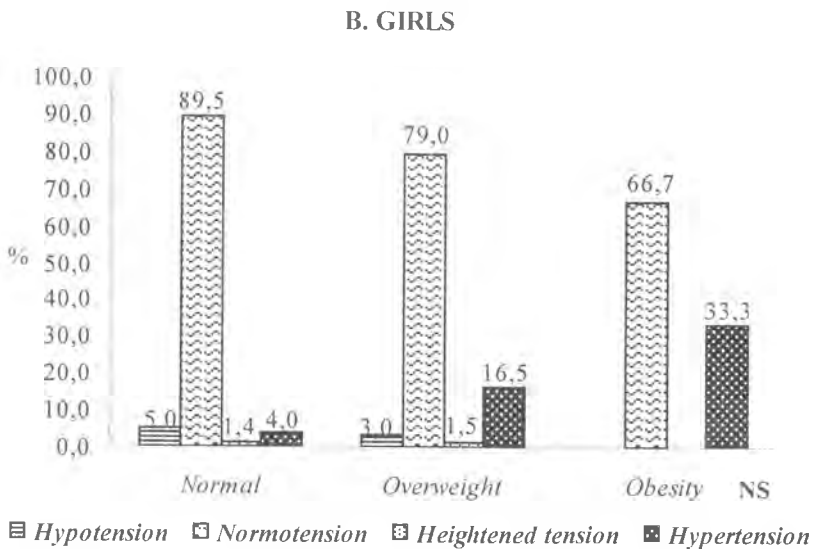


Fig. 2. B) Relation of NS type and SBP categories in girls

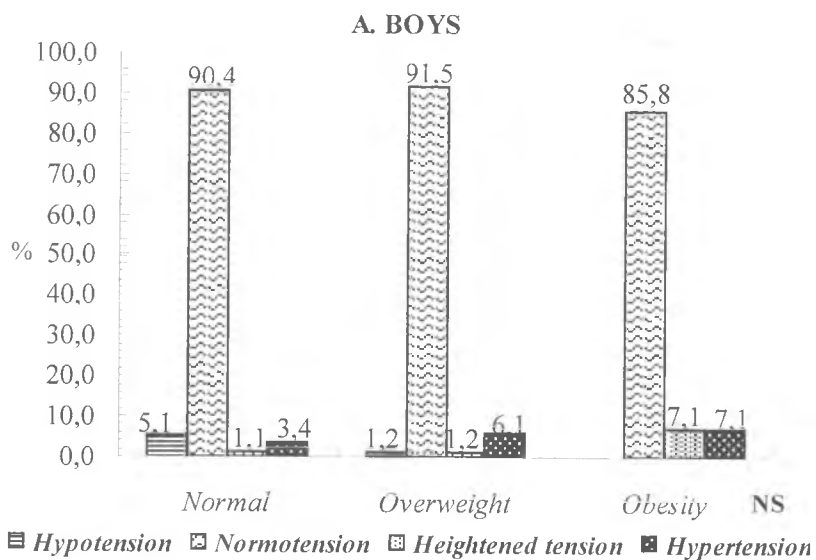


Fig. 3. A) Relation of NS type and DBP categories in boys



Fig. 3. B) Relation of NS type and DBP categories in girls



the frequency of schoolchildren with “normal” ABP concerning SBP — 71.5% for boys and 66.7% for girls, as with “normal” ABP concerning DBP the frequency was 85.8% for boys and 44.4% for girls. Into this NS type the boys with “hypertension” SBP were at three times more frequent (21.4%) compared to the ones with “hypertension” DBP (7.1%). Concerning obese boys, the frequency of those who have “heightened tension” SBP and the ones with “heightened tension” DBP was identical (7.1%). In obese girls, the frequency of those with “hypertension” SBP and “hypertension” DBP was again identical (33.3%). Obese girls who have “hypertension” SBP were established 1.6 times more frequently, while obese girls who have respectively “hypertension” DBP were 4.6 times more frequently. Among obese girls such with “heightened tension” SBP were not found, while 22.2% of them had “heightened tension” DBP.

The results obtained, about interconnection of the NS type evaluated by BMI and the SBP and DBP values in 9-15 years old schoolchildren, could be shown clearly by the z-score procedure (Fig. 4). In comparison with schoolchildren having normal NS, in the adolescents being overweighted the Standard Deviation Score (SDS) increased progressively (up to SDS~0.5 for SBP and up to SDS~0.3 for DBP), as in those having “obesity” NS — the SDS values came to~0.9 for SBP and SDS>1.0 for DBP (in the investigated by us schoolchildren having normal NS the SDS<0, as in the same category were incorporated the individuals with “undernutrition” NS). By the  $\chi^2$  procedure about reliability of the differences in the distribution of ABP categories concerning the three types NS were established that the obesity boys and girls had higher values (statistically significant) for SBP compared to the children with normal NS (boys at  $p<0.01$ ; girls at  $p<0.001$ ). Reliably higher DBP for the schoolchildren with normal NS were found only in the obesity girls ( $p<0.001$ ). According to the  $\chi^2$  procedure concerning ABP, the differences between overweighted and obesity adolescents, as the difference between adolescents with normal and overweighted NS were not statistically significant.

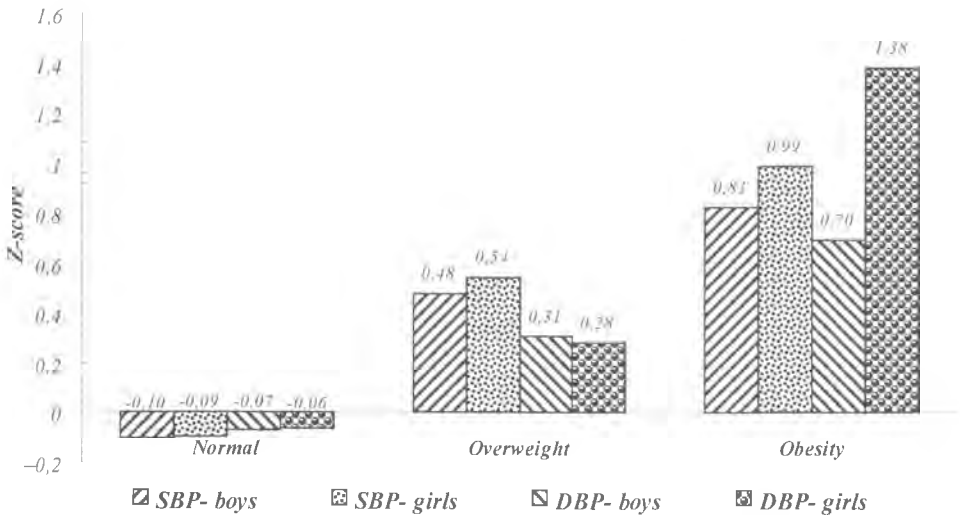


Fig. 4. Z-score values of nutritional status type and arterial blood pressure

## Discussion

Our results that concerned the frequency of schoolchildren into different NS categories were similar to those found by Stanimirova [27]. She studied the changes of obesity's frequency in children and adolescents (from 0 till 20 years) using norms elaborated by her, which concern three populations from the region of Pleven town during a period of 20 years (1973, 1988 and 1993). According to the author mentioned above, the frequency of obese children was found to be different for all ages throughout childhood and youth, during which three maximums were established. The first maximum was found to be between the ages 3 and 6 years, when the obesity's frequency reached 10.0%, the second had coincide with the beginning of puberty and the pubertal growth acceleration (frequency of 15.0-16.0%), and the third maximum was established to lie respectively in the period 15-16 years of age — the end of puberty. In the investigated by us 9-15-year-old schoolchildren from Sofia were established also a maximal frequency of overweighted and obese children at the beginning of children's puberty and pubertal growth acceleration. The next frequency's maximum was established only in boys at 15 years of age.

According to the international data collected by Cole et al. [2], about the age period from 2 till 18 years, the frequency of overweight NS vary between 5.0% and 18.0%, and that of obesity NS — between 0.1% and 4.0%. The established by us frequency of "overweight" and "obesity" NS types has followed the same framework of the quoted authors. In our study, the maximal frequency of overweighted boys was higher by nearly 3.0% only at the age of 11, and the maximal frequency of obese girls was higher by nearly 2.0% at the age of 9 years.

Compared with the scarce data from Bulgaria obtained on the basis of the same cut-off values by Cole et al. [2], the overweight and obesity in 9-15-year-old schoolchildren from Sofia appear to have low frequency than in children of the same age in Plovdiv (frequency of 18.0% for overweight and 5.0% for obesity) [15] and some of the smaller towns (frequency of 20.5% for overweight and 8.2% for obesity) as Haskovo, Lyubimets, and Svilengrad [28].

Growth dynamics of arterial blood pressure in investigated 9-15-year-old schoolchildren corresponds to the data published in literature [8, 9, 10, 12, 13, 21, 22, 23, 26]. The comparison of our results that concerned the frequency of SBP and DBP hypertensions in schoolchildren studied during 2001-2002 with the results found by Rahneva [26], correspondingly for 6-15-year-old schoolchildren from Sofia city investigated in the years 1972/3 and 1982/3, showed that the frequency of hypertension ABP was equal in all three generations (about 6.0%). The average frequency of boys and girls with ABP hypertension at 10-14 years found in the present study was lower (from 2.0 till 4.0%) compared to the average frequency found in their coevals studied at the beginning of the 70s and 80s of the 20th century. At the age of 15 years, however, the schoolchildren with hypertension ABP represented 6%, i.e. they were about two times less than the schoolchildren with hypertension ABP established in the years 1973 and 1983 (12.2% and 11.2%, respectively). This could be explained by the fact that among the investigated by us boys and girls at 15 years during 2001-2002, the overweighted ones were 6.3% and 2.4% respectively and obesity were established only in 3.8% of the boys.

The results obtained by us, concerning relationship between the type of NS determined through BMI data, and the SBP and DBP categories, confirmed the fact that "heightened tension" and "hypertension" ABP have been found considerably more frequently in schoolchildren with overweight and obesity NS, the same being established by many authors who used other methodological approaches, as well [6, 7, 16, 17, 19, 20, 21, 22, 25].

## Conclusions

The results in the anthropological investigation of 9-15-year-old schoolchildren from Sofia city show that:

The frequency of schoolchildren with overweight and obese NS was higher at the beginning of the growing up period (9-11 years of age) for both sexes, while at the age of 15 the frequency of boys and girls with overweight NS was found to be considerably smaller, and the obese NS was established only in boys.

It was established that the frequency of girls with "hypertension" SBP between 9 and 14 years was consistently higher than it was in the boys between these ages.

The "hypertension" ABP was found to be in times more often among the overweighted schoolchildren than among the ones with normal NS.

Among obese schoolchildren the frequency of those with "hypertension" SBP has increased markedly, better expressed in girls.

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