ANTHROPOLOGICAL CHARACTERISTICS OF BODY COMPOSITION IN CHILDREN AND ADOLESCENTS FROM PLOVDIV

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ABSTRACT
This article studies the development of body weight components on the basis of anthropometric determination of the dynamics of the amount of fat, muscles and bones in 2094 children and adolescents aged 7 to 17 years (1054 girls and 1040 boys). The data were transversely collected at some schools in Plovdiv. The results were obtained for the differentiation in the change of body building, both in individuals of the same age and in the process of growth and development. Our results indicate that namely in the puberty period there is a change in the developmental processes of fat and muscle mass, which determines the further architecture of the male or female body. In girls the development of skeletal muscles and bone tissue practically stops after the puberty period (14–15 years), while in boys these two components of body composition continue to increase after this age with relatively high intensity.

Keywords: body composition, body weight, adipose tissue, non-adipose tissue

Introduction
One of the main tasks of the specialists in medico-biological disciplines is to combine their efforts to develop and improve the system of assessment and prevention of children’s and adolescents’ health (2, 7, 8). In this aspect it is especially important to follow the age changes in body composition during the most active period of growth and development – 7-17 years of age. The specificity of these changes during the stages of ontogenesis depends on the continuous coordination and relationship between the body hereditary makings and the big eco-sensitiveness of a growing organism towards the changing environmental conditions (1, 3, 4, 10). It must be borne in mind that environmental and socio-economic conditions are different for the different regions of the country and together with the type and quality of food certainly cause a strong influence on the changes in body composition. Characterization of body composition is related to the study of the constituent parts of the body, and to look for the connections between the structure and function at different levels, from the atomic to organism levels (6, 11). In this respect, over the years, the researchers have developed various regression equations (including data of certain anthropological properties), through which it is possible to determine the absolute (in kg) and relative (in %) shares of the two major components of body weight – the active body mass and subcutaneous fat tissue in various population-territorial studies (5, 9).

In this connection THE PURPOSE of this study is to characterize the body composition of children and adolescents from Plovdiv, aged 7 to 17, through anthropological methods in inter-sexual and inter-age plan.

Materials and Methods
For the realization of the objective we used transversely collected data from schools in Plovdiv. We tested a total of 2094 children and adolescents, aged 7 to 17 years (1054 girls and 1040 boys). They were divided into 11 one-year age groups. We measured the weight of all children with an electronic balance “TANITA”. The bone mass was calculated through the method of Matiegka (7): \( o = \sigma^2 \times H \times k \), where \( o \) is the average values of epicondylar diameters of the elbow, wrist, knee and ankle; \( H \) – height, \( k \) – 1.2.

We measured calliper-metrically the thickness of the 9 skin folds (SF) on the body and limbs (subscapular SF, SF – biceps, SF – triceps, SF – forearm, SF – X rib, SF – abdomen, suprailiac SF, SF – thigh, SF - shank).
Based on them, we calculated the following ratios through regression equations.

The percentage of BF (BF%) was calculated by the formula of Slaughter et al. (1988)

If the sum of the two SF > 35, we use the following formulas:

\[ BF% \, \text{(♀)} = 0.783 \times (\SigmaSF \, \text{triceps and subscapula}) + 1.6 \]
\[ BF% \, \text{(♂)} = 0.546 \times (\SigmaSF \, \text{triceps and subscapula}) + 9.7 \]

If the sum of the two skin folds < 35, we use the following formulas:

\[ BF% \, \text{(♀)} = 1.21 \times (\SigmaSF \, \text{triceps and subscapula}) - 0.008 \]
\[ BF% \, \text{(♂)} = 1.33 \times (\SigmaSF \, \text{triceps and subscapula}) - 0.013 \]

Body fat in kg is calculated by the formula

\[ BF \, \text{(kg)} = \text{body weight} \times \% \, BF / 100 \]

The percentage of ABM (%ABM) is calculated as the difference between 100% and %BF.

The active body mass in kg is calculated: \[ ABM = \text{body weight} - \text{body fat} \]

The results were statistically processed with software package "SPSS".

**Results and Discussion**

In population studies, the main indicator of body obesity and body composition is the total body mass or body weight. The body weight (Fig. 1) is one of the signs with highest ec-sensitivity and largest variations throughout the postnatal human ontogeny. It is the most accessible sign to be studied, which presents the changes in a regimen of diet, the motive and health statuses of children and adolescents, and it is a vivid reflection of the processes of growth and development. For the period from 7 to 17 age years, the body weight increased with 44.3 kilograms for boys, and for girls – 28.3 kilograms, which represents respectively 64.11% and 48.45% of its initial values for 7-year-olds.

The interage differences in the increase of body mass in girls are reliable between the ages 11-12 and 12-13, and in boys – only between 14-15 (p < 0.05). By the age of 13 the intersexual differences are minor, but after that age till the end of the investigated period, boys are significantly heavier. In girls we observed a well-expressed puberty jump in weight increase - between 11-14 year of age, and after that age, the increase is little (average 0.5 kg). In boys, the jump in the increase of body mass is more deployed in time; the intersexual differences in 17-year-olds are 17.9 kg. According to the anthropological two-component model of body composition of Behnke, the two main components of body weight are body fats (BF) and fat-free tissues (non-adipose tissue- NAT).

The BF in both sexes in the investigated age period are characterized with high variability (Fig. 2). The age dynamics of this body component shows two well-expressed criss-crosses of the growth curves - at the age of 12, when the amount of body fats increases significantly for girls and after the 15th year for boys. It is interesting to note that at the beginning and end of the growth period, the amount of body fat has a priority in boys, while in girls – at the puberty period. The intersexual differences were statistically significant in the age range 11-15 years (p ≤ 0.05).
In the investigated growth period, body fat increased with 7.11 kg for boys, and for girls with 8.08 kg.

Between the 16th and 17th year in girls body fat decreased with 2.67 kg, while in boys it continued to increase, though slightly.

The absolute share of non-adipose tissue in both sexes increases with age, in parallel with the increasing body weight (Fig. 3). At all ages, boys have more non-adipose tissue than girls, as up to the 13th year the intersexual differences are insignificant. After that age, the NAT increase significantly in boys, as it is evident from the strong divergent growth curves after this period. In both sexes, we observed well expressed puberty jump in the increase of this body component, which coincides with the surge in weight increase (average in boys 5.67 kg more, and 4.62 kg more in girls). Reliable interage differences in boys were found in the range between the 11th and 15th year, and in girls between 9-10th, 11-12th and 12-13th year. The intersexual differences were statistically significant at 7, 9 and after 13 years of age (p ≤ 0.05). During the investigated age period, in boys NAT increased with 37.44 kg and 22.87 kg for girls.

It is necessary to note that in the eleven-year period, the proportion of NAT increased with 58.39% in boys and 47.20% for girls, i.e. the intersexual differences are insignificant, while the increase in fat mass as a percentage of body weight is almost twice as big in girls than in boys (14.42% in girls, and 8.43% in boys).

![Fig. 3. Non-adipose tissue (kg)](image)

We received interesting results for the two main components of the non-adipose tissue - skeletal muscles and bone tissue. The growth curves for the development of skeletal muscles show two not well-expressed criss-crosses at the ages 10 and 12, when girls are slightly ahead in their development than boys (Fig. 4). After that age, till the end of the growth period, the skeletal muscles have a priority in boys. In girls we found a proportional increase in skeletal muscles up to the age of 13 (on average about 2 kg per year). There is abatement in growth processes between the 13th and 16th year of growth, and new increase in the 17th year with 2.39 kg. In boys, skeletal muscles increases till the end of growth period, as maximum annual growth rate was recorded again during the period of puberty between the 14-15th year - 4.12 kg. In the period from the 7th to 17th year, the skeletal muscles of girls rise with 14.34 kg, and 6 kg more in boys. In girls we found reliable interage differences in annual addition to the skeletal muscles between the 9-10th year and 11-12th year (p ≤ 0.05). In boys, the interage differences are significant between the 10-11th, 12-13th and 14-15th year. Statistically significant intersexual differences were recorded in 7- and 11-year-olds and after the 14th year until the end of the age period (p≤0.05).

![Fig. 4. Skeletal muscles (kg)](image)

In girls, there are two distinct age periods with intensive increase in bone tissue – between the 11 and 12th and between the 16-17th year with reliable interage differences (Fig. 5). In the age interval between the 12th and 16th year the changes in them are little. In boys, we did not find well-expressed jump in the increase of bone tissue. By the age of 16 it increases proportionally with age, and thereafter the annual additions are minor. We identified interage
statistically significant differences in the increase of bone tissue between the 10th and 12th year and between the 12-13th. With the exception of the 10th and 12th years of age, the intersexual differences have high degrees of reliability (p ≤ 0.003; p ≤ 0.0001).

**Conclusions**

1. At all ages, boys are heavier than girls, and the intersexual differences are reliable after the age of 13.
2. The amount of body fats is more in girls, which is especially well manifested in the puberty period, while the amount of non-adipose tissues is more in boys and it is more distinct at the end of growth period.
3. In girls the development of skeletal muscles and bone tissue practically stops after the puberty period (14-15 years of age), while in boys, these two components of body composition continue to increase after this age and with relatively high intensity.

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