

## Changes in the Pattern of Body Components during Puberty

Éva B. Bodzsár and Annamária Zsákai

### INTRODUCTION

Puberty embraces all the processes leading to sexual and physical maturation that involve not only the development of sex organs and secondary sexual characteristics, but the modification of body composition and body shape too. These processes have a relatively independent trend line each but they are simultaneously mutually interrelated.

The endocrine changes in puberty have a strong impact on both the direction and rate of metabolism and on the proliferation of bone, muscle and fat. Because of the accelerated rate of growth more nutrients are needed. The specific requirements in nutrients are almost twice greater than in childhood. So the timing, rate and duration of the pubertal changes in the measurements and the sexual maturation depend on the nutrition status.

Our study dealt with the interrelations of sexual maturation and nutritional status. The goals of this study were to analyze body composition in children belonging to the same age group, but to different stages of maturation as well as displaying the same level of maturation characteristics, but varying in age.

### SUBJECTS AND METHODS

Cross-sectional data were collected in Middle-Hungary in 2003. The subjects of the present subsample of the main study were such children that had already begun pubertal development (Table 1).

Nutritional status was estimated by different ways: trunk skinfolds (sum of pectoral, subscapular, midaxillary, abdominal, suprailiac skinfolds), extremity skinfolds (sum of triceps, biceps, forearm, medial thigh, medial calf skinfolds), BMI, model of two components: percentage of body fat (Durnin and Rahaman, 1967; Siri, 1956), model

of four components: fat, bone, muscle and residual mass (Drinkwater and Ross, 1991).

The sexual characteristics (in girls: breast developmental stages, in boys: genitals developmental stages) were rated according to Tanner (1962). Data for menarche and spermarche were collected by the "status-quo" method.

The girls were subdivided by using menarcheal status and stages of breast development, while the factors for grouping the boys were spermarche, and stages of genital development.

The subgroups were compared by one-way ANOVA following which between-group differences were tested by F-tests at the 5% level of random error. Statistical evaluation was made by using the SPSS for Windows software (v. 12.0, 2003).

### RESULTS AND DISCUSSION

Contrasting pre- and post-menarcheal girls of the same chronological age, significant differences in body composition emerged:

Post-menarcheal girls had significantly greater trunk and extremity skinfolds (Fig. 1) as well as greater value of BMI than pre-menarcheal ones (Fig. 2) than pre-menarcheal age-peers.

The pattern of differences in percentage of body fat shows the same (Fig. 3). The percentage of body fat was practically the same in all post-menarcheal girls while the girls maturing late for their age displayed a decreasing series of relative fat content as their belatedness grew. All these observations prepare the way for the inference that the smaller the extent of fat accumulation, the later menarche would occur.

Post-menarcheal girls had not only a significantly greater amount of body fat than pre-menarcheal ones, but greater bone and muscle fractions of body mass too (Fig. 4). It means that the smaller fat content the lower growth-rate of bone and muscle.

When pre- and post-spermarcheal boys were

**Table 1: Distribution of subjects by age and gender.**

| Age (ys) |   | 10.0 | 10.5 | 11.0 | 11.5 | 12.0 | 12.5 | 13.0 | 13.5 | 14.0 | 14.5 | 15.0 | 15.5 | 16.0 | Total |
|----------|---|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| Girls    | n | 188  | 147  | 231  | 255  | 215  | 205  | 237  | 251  | 287  | 269  | 191  | 109  | 184  | 2769  |
| Boys     | n | 171  | 162  | 224  | 264  | 276  | 241  | 239  | 228  | 309  | 226  | 193  | 172  | 168  | 2873  |

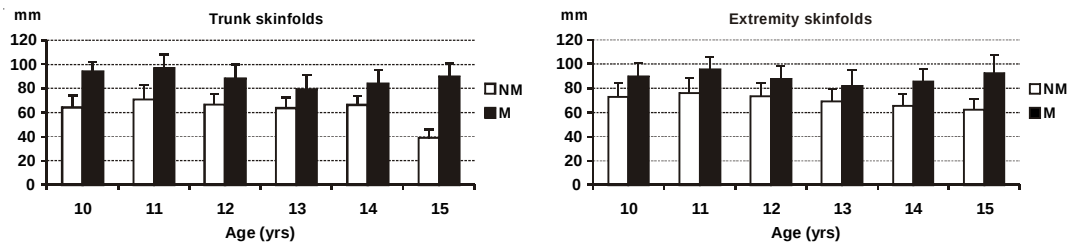


Fig. 1. Sum of trunk and extremity skinfolds of pre- (NM) and post-menarcheal (M) girls.

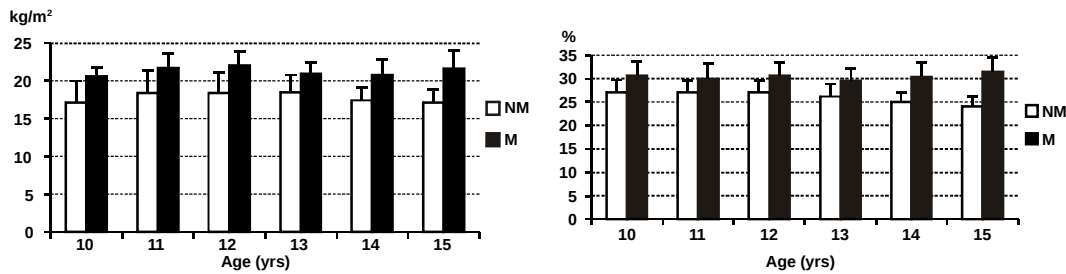


Fig. 2. BMI-values of pre- (NM) and post-menarcheal (M) girls.

Fig. 3. Body fat percentage of pre- (NM) and post-menarcheal (M) girls (Siri-method).

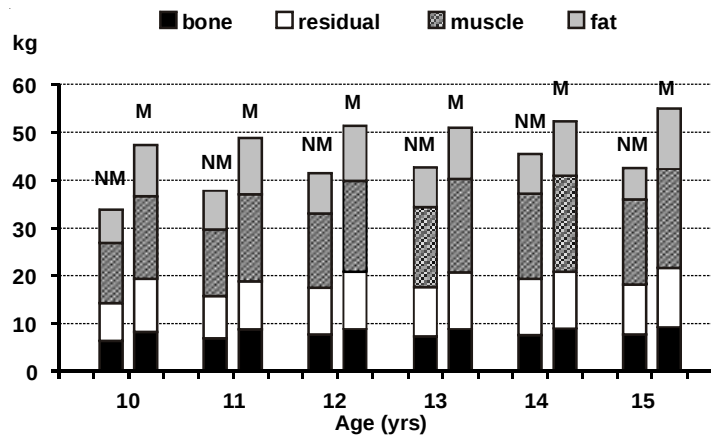


Fig. 4. Body components of pre- (NM) and post-menarcheal (M) girls (Drinkwater and Ross-method).

compared, the latter were found to have significantly greater BMI, but their trunk and extremity skinfolds, except in 11 age-group, were smaller (Figs. 5-6).

The relative body fat content of the early maturing boys also smaller than the later maturing age-peers, only boys maturing very early e.g. at

age 11, have a significantly larger amount of relative fat (Fig. 7).

The figure 8 shows the pre- and post-spermarcheal boys differed in all body components. The post-spermarcheal boys have greater bone and muscle mass than the pre-spermarcheal boys of the same chronological age.

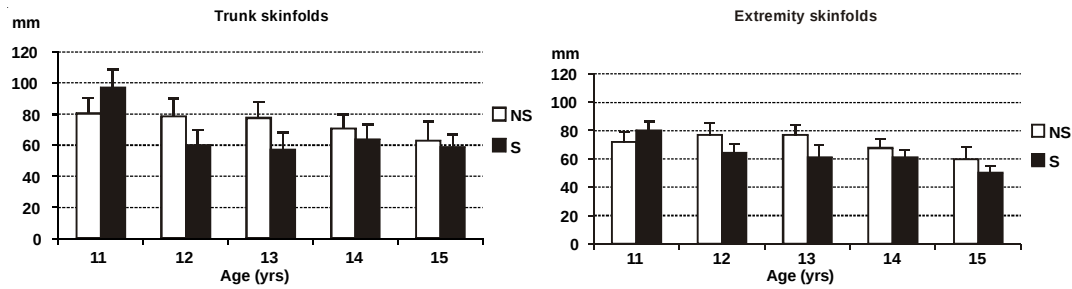


Fig. 5. Sum of trunk and extremity skinfolds of pre- (NS) and post-spermarcheal (S) boys.

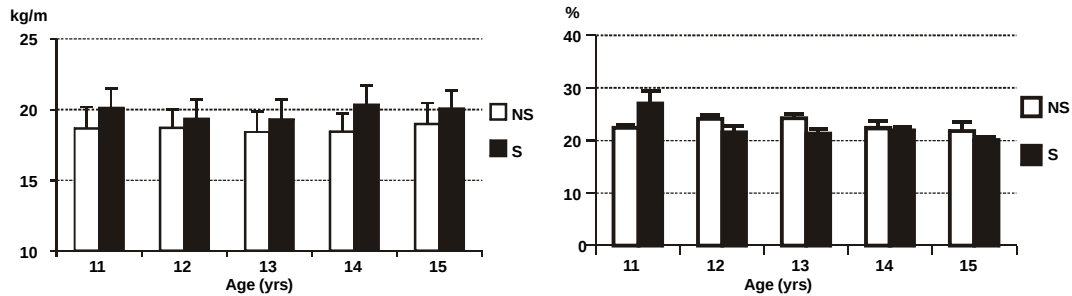


Fig. 6. BMI-values of pre- (NS) and post-spermarcheal (S) boys.

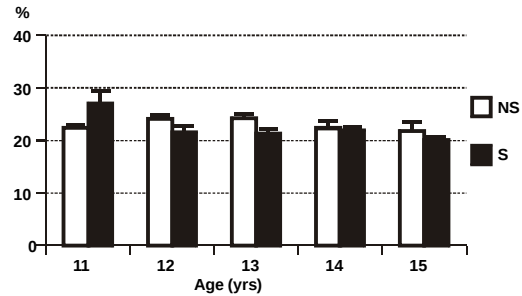


Fig. 7. Body fat percentage of pre-(NS) and post-spermarcheal (S) boys (Siri-method).

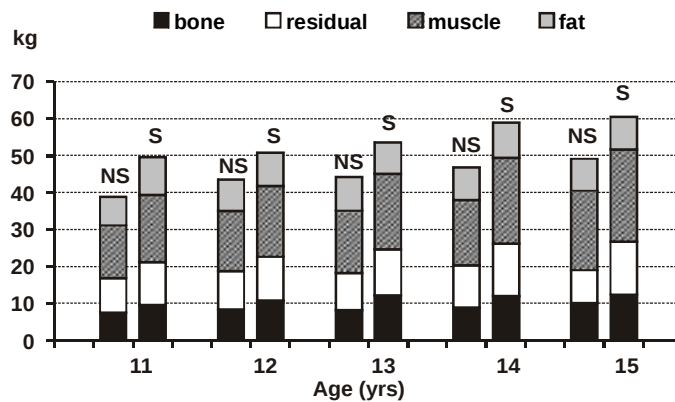


Fig. 8. Body components of pre- (NS) and post-spermarcheal (S) boys (Drinkwater and Ross-method).

In comparing the corresponding groups of sexual maturity in the two genders one obviously should be aware of the time difference when menarche, respectively spermarche occur,

namely, that they take place in a different phase of adolescent growth.

Menarche occurs when pubertal growth-rate decreases, while boys' growth-rate increases after

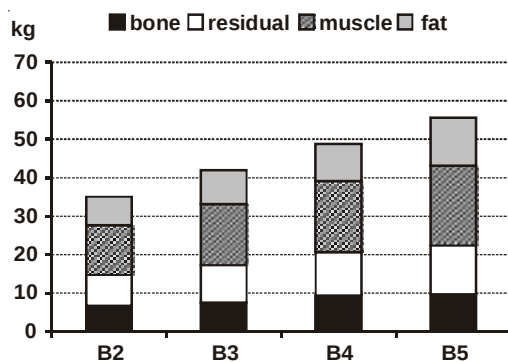


Fig. 9. Masses of body components by stages of breast maturation.

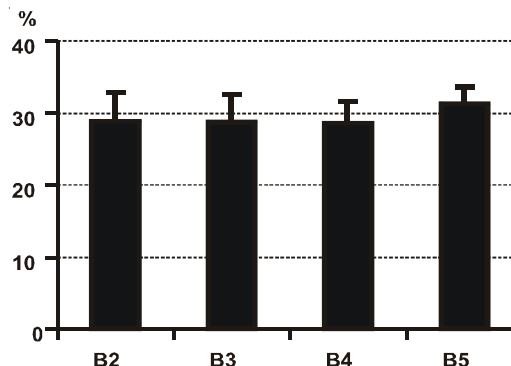


Fig. 10. Body fat percentage by stages of breast maturation

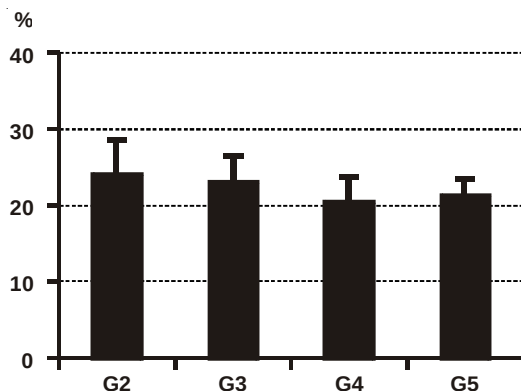


Fig. 11. Body fat percentage by stages of genitals maturation.

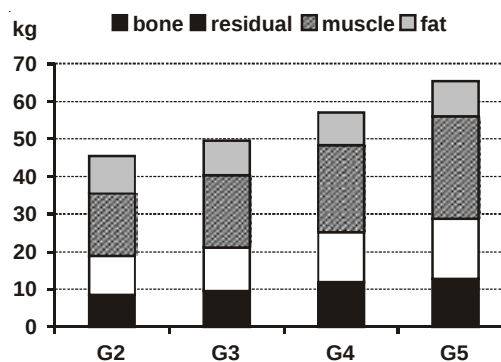


Fig. 12. Masses of body components by stages of genitals maturation.

occurrence of spermarche. The relative fat content of the body is smaller around the age of peak height velocity because of the fat loss. Pre-spermarcheal boys that have not yet entered the phase of peak height velocity tend to accumulate fat and very lean ones usually mature later.

Successive stages of female breast development displayed significant differences in bone and muscle mass while there was no marked difference of relative body fat content (Figs 9-10). The only exception was between breast stage 4 and 5.

The pattern of changes in body component the similar tendency figure shows according to successive stages of male genitals. The development of genitals is associated with a relative fat loss (Figs. 11-12).

In summary, these observations strongly confirm the inference that maturation status is reflected by body composition and also the age

change of body fat depends on it. Body composition and maturity status are closely interrelated in both genders while gender-specific tendencies increase dimorphism and the several factors making up the differences between maturation types. Fat content was greater in both sexes in the early maturers. The larger fat accumulation in prepuberty dues to earlier sexual maturation and higher rate of pubertal growth.

## REFERENCES

- Bodzsár, B.É.: Growth and sexual maturation in Hungary: Secular trends. Paper presented in 14th Congress of EAA in Komotini, Greece, September 1-4 (2004).  
 Drinkwater, D.T. and Ross, W.D.: Anthropometric fractionation of body mass, pp. 178-189, In: *Kinanthropometry II*. M. Ostry, G. Beunen and J. Simons (Eds.). University Park Press, Baltimore (1980).

- Durnin, J.V.G.A. and Rahaman, M.A.: The assessment of the amount of body fat in the human body from measurement of skinfold thickness. *Br. J. Nutr.*, **21**: 681-685 (1967).
- Eiben, O.G., Barabás, A. and Pantó, E.: The Hungarian National Growth Study I. Reference data on the biological developmental status and physical fitness of 3-18 year-old Hungarian youth in the 1980s. *Humanbiol. Budapest.*, **21** (1991).
- Siri, W.E.: *Body Composition from Fluid Spaces and Density. MS UCRL 3349*, pp. 187, Donner Lab. University of California, California (1956).
- Tanner, J.M.: *Growth at Adolescence*, pp. 219, Blackwell, Oxford (1962).

**KEYWORDS** Body Composition. Developmental Stages of Sexual Maturation. Menarche. Spermatarche

**ABSTRACT** The purposes of this study were to study the sexual differences in body components during puberty, to analyze age changes in body components and to study the effect of sexual maturity status on body composition in Hungarian adolescents. The subjects of the present sample of the 2nd Hungarian National Growth Study (Eiben et al. 1991; Bodzsár, 2004) were 5542 such children (2769 girls and 2873 boys aged 10-16 yrs) that had already begun pubertal development. The girls were subdivided by the maturation stages of the breast, while the boys by those of the genitals. Percentage of body fat was estimated by model of two components (Durnin and Rahaman, 1967; Siri, 1956), while masses of body components (fat, bone, muscle and residual mass) were assessed by the Drinkwater and Ross (1980) four-component anthropometric fractionation method. Sexual differences in body composition, present already in childhood, became more accentuated during puberty, due mainly to growing fat content in the girls and to increasing lean body mass in the boys. In the females early maturers were heavier and contained more fat than less mature girls. This increase in relative and absolute fat mass was proportionate to weight gain. In the males increasing fat mass lagged behind the gain in lean body mass both with advancing age and maturity status. Body composition and maturity status are closely interrelated in both genders while gender-specific tendencies increase dimorphism and the several factors making up the differences between maturation types. Fat content was greater in both sexes in the early maturers. Also the developmental rate of prepubertal fat accumulation was faster in the early maturers when compared to those maturing later. Standards for the age change of body composition can therefore inform us not only about the development of bone, muscle and fat in childhood, but also allow a short-range prediction of pubertal events.

**Authors' Address:** Éva B. Bodzsár and Annamária Zsákai, Department of Biological Anthropology, Eötvös Loránd University Budapest, Pázmány P. sétány 1/c, H-1117 HUNGARY,  
Fax: 36-1-381-2162, E-mail: bodzsar@ludens.elte.hu