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Dynamic Changes of Adiposity During Puberty: Life May Not Be Linear

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The transition to puberty is dynamic and complex, and pubertal changes related to body composition appear to be of greater complexity in girls. This is not surprising, as child-bearing presents women with an additional set of metabolic challenges. In this issue of the *Journal of Adolescent Health*, the study by Mihalopoulos et al, "Expected changes in clinical measures of adiposity during puberty," concluded that there is no increase in the percent body fat content during puberty [1]. This study involved rigorous data collection from a large sample of adolescents during a critical period of development. The findings should be interpreted within the context of existing medical literature. Much of the previously published data on changes in adiposity among girls during puberty support the theory of an increase in fat mass relative to lean mass (i.e., percent body fat) during this transitional period.

The study by Mihalopoulos et al involved a large cohort (N = 633) of racially and socioeconomically diverse boys and girls with multiple observations over a period of 4 years [1]. The study analyzed six measures of adiposity as follows: body mass index, sum of two skinfolds, sum of six skinfolds, waist circumference, percent body fat from bioelectrical impedance, and waist/height ratio. Each measure represents a slightly different aspect of adiposity (i.e., central vs. peripheral). The study sample was recruited before the obesity epidemic in the United States and was therefore relatively lean compared with a contemporary adolescent cohort, in whom the prevalence of overweight and obesity is near 40% (compared with the 24% in the study by Mihalopoulos et al). This leaner study sample may have resulted in underestimation of the changes in adiposity during pubertal development. Because of multiple analyses, the authors used the Bonferroni correction for determining level of significance. They also included longitudinal observations of boys during puberty, adding to the limited number of longitudinal studies in this population.

Several studies have demonstrated an increase in fat mass during the pubertal transition in girls. In a cross-sectional study by Goulding et al, 140 healthy nonobese women and growing girls (aged, 8–27 years) were examined for changes in total and regional body composition by using dual energy X-ray absorptiometry [2]. The proportional differences between Tanner stages 1 and 5 were greater for fat mass than for lean mass. In addition, truncal fat mass increased, whereas leg (peripheral) fat decreased, thereby confirming that changes in regional fat distribution occur with maturity. A subsequent study confirmed these findings in females and noted different fat patterning between the genders [3]. A study of Dutch girls aged 9–12 years who were followed up at regular intervals for 10 years by using serial dual energy X-ray absorptiometry reported similar results [4]. Fat mass increased from 7.9 kg (23.6%) at breast stage 1 to 18.5 kg (29.3%) at breast stage 5. The increase in fat mass was statistically significant at consecutive breast stages except between stages 2 and 3, which most likely represented a period of high metabolic activity required to support accelerating linear growth. Vink et al also noted a similar significant increase in fat mass from menarche to 1 year after menarche [4], with continued increases at 3 and 4 years followed by a plateau at 6 years after menarche with no further increase in fat mass. Studies using other measures of adiposity support an increase in fat mass during puberty for girls [5,6]. Metabolic rates (resting energy expenditure) in girls decrease around the age of menarche [7]. Considering that peak height velocity typically occurs before menarche, accumulation of fat after reaching the peak height may represent a physiological event in girls.

In addition to epidemiological evidence, biological evidence supports an increase in fat mass during puberty in girls. Puberty includes a series of changes that ultimately leads to the ability to reproduce. It would be advantageous for women of childbearing age to maintain ample stores of energy in the form of fat tissue. In the past decade, scientists have discovered some neuroendocrine factors that regulate hunger, satiety, and metabolism. For example, leptin, which is secreted by mature adipocytes, increases exponentially with small increments in fat mass [8]. In midlife to late puberty, significant differences in leptin concentrations emerge between girls and boys, with girls having significantly higher concentrations even when adjusting for fat mass [9–11]. Gonadal steroid hormones are known to reach physiological levels by mid-puberty, and testosterone may exert a suppressive effect in boys and estradiol an augmentation effect in girls, on leptin secretion [9]. The sexual dimorphism in leptin concentration and adiposity between girls and boys during puberty exemplifies the complex orchestration between metabolic demands and the effects of hormonal changes. Leptin is highly sensitive to changes in fat mass and has been repeatedly shown to increase in the later stages of puberty among girls, thereby providing additional support to the contention that it is biologically normal for girls to accumulate fat mass during pubertal development.

When evaluating the dynamic processes occurring with puberty, one must consider the statistical and methodological issues. This is a critical point to acknowledge, especially when interpreting the findings presented by Mihalopoulos et al. The authors modeled changes in adiposity as a linear rather than a curvilinear function. Changes in adiposity during early puberty would most likely occur at a different rate or potentially in a different direction than the changes occurring during late puberty given the metabolic costs of early pubertal growth. After peak height velocity occurs and as long as nutrition remains constant, fat deposition would be most likely in girls. Statistical methods that account for the dynamic processes of puberty and their related systems are required. Hauspie proposed the use of statistical models that do not assume a particular growth curve, but rather provide a description of the pattern of growth during puberty through higher order polynomials or spline regression [12].

As in any study, lack of a significant finding does not mean that there is no difference in adiposity. One must consider whether the study was powered to identify a change by incorporating an appropriate sample size and statistical models, as well as ensuring the precision and reliability of measurements. Mihalopoulos et al amassed an impressive amount of longitudinal data that included both males and females, and they used several approaches to analyze body fat and fat distribution. However, multiple comparisons limited their ability to detect differences, and, most importantly, biological changes during puberty may not be best represented by linear models.

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