

Adolescent Physical Growth and Development: Implications for Pregnancy

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Jamie Stang
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The process of physical growth and maturation is dynamic, encompassing a wide array of physiologic changes. Physical maturation begins and ends earlier than cognitive or psychosocial maturation (see Figure 1). The physiological changes that mark the onset of puberty in females include increases in height, weight and body fat percentage; breast formation; growth of pubic and axillary hair; and menarche. While the timing of these events varies considerably among adolescent females, the sequence remains consistent. This chapter will review the major physical changes that occur during adolescence and discuss how such changes affect pregnancy and pregnancy outcome in the growing adolescent.

PHYSICAL GROWTH AND DEVELOPMENT IN THE NONPREGNANT ADOLESCENT

The age of onset of puberty varies widely among young females. Because chronological age doesn't correlate well with the timing of endocrinological or physiological growth and development, sexual maturation is used to determine biological age in adolescents. Sexual

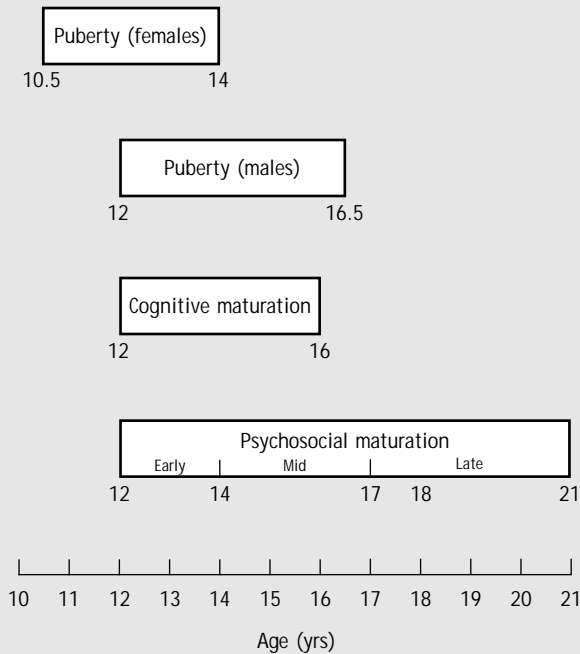
maturation is measured by rating the development of secondary sexual characteristics, such as breast development and growth of pubic hair. The most common method used is the Sexual Maturity Rating (SMR) scale, also known as Tanner Staging. The five point SMR scale for females is illustrated in Table 1.

The sequence of physiological changes that occur during puberty is relatively consistent within and among females, even though the timing of these events may vary greatly. Figure 2 illustrates the temporal relationships among the major physiological changes that occur during puberty, based on the SMR. Details on each of the major physiological changes that occur are listed below.

SEXUAL MATURATION AND ONSET OF MENARCHE

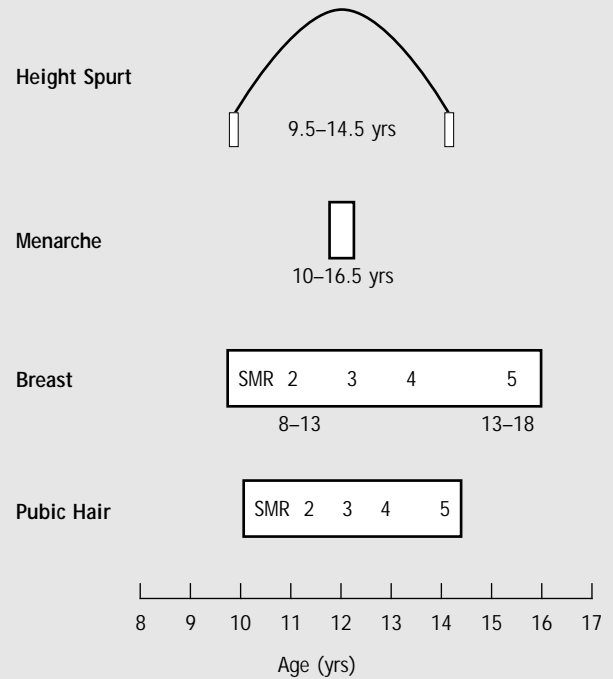
The appearance of secondary sexual characteristics is often the first noticeable sign of puberty. Such characteristics begin to appear between the ages of 10 and 14 years in most U.S. adolescent females but can occur earlier or later in some individuals.

FIGURE 1
Average Age Relationships of Pubertal, Cognitive, and Psychosocial Maturation in Adolescence



Source: Reprinted with permission from Johnson RL, Adolescent growth and development. In: Hofmann A, Greydanus D, eds. Adolescent medicine. Stamford, CT: Appleton and Lange, 1988.

FIGURE 2
Sequence of Physiological Changes During Puberty in Females



Source: Reprinted with permission from Slap G. Normal physiological and psychosocial growth in the adolescent. J Adolesc Health Care 1986;7:13S-23S.

TABLE 1
Sexual Maturity Rating

| Stage | Breast Development | Pubic Hair Growth |
|-------|--|--|
| 1 | Prepubertal; nipple elevation only | Prepubertal; no pubic hair |
| 2 | Small, raised breast bud | Sparse growth of hair along labia |
| 3 | General enlargement of raising of breast and areola | Pigmentation, coarsening and curling, with an increase in amount |
| 4 | Further enlargement with projection of areola and nipple as secondary mound | Hair resembles adult type, but not spread to medial thighs |
| 5 | Mature, adult contour, with areola in same contour as breast, and only nipple projecting | Adult type and quantity, spread to medial thighs |

Source: Adapted from Tanner JM. Growth at adolescence. Oxford: Blackwell, 1962.

- The growth of fine, sparse pubic hair is one of the first signs of sexual maturation. This occurs during Stage 2 of the SMR scale (average, 8-13 years old).
- Breast development in most females begins between 8 and 13 years of age (Stage 2 of the SMR scale) and continues throughout adolescence.
- One recent study has shown that the development of breasts and pubic hair begins at a younger age in African American females than in their white peers.¹ By age 8 years, 48% of African American girls had begun to develop breasts and pubic hair, compared to only 15% of white females.
- The mean age of initial breast development is approximately 8.8 years for African American and 9.9 years for white adolescent females while the mean ages for pubic hair development in these two groups is 8.7 and 10.5 years, respectively.¹
- Menarche occurs 2-4 years after the initial development of pubic hair and breasts (Stages 3 or 4 of SMR scale). Recent data suggests that menarche occurs between 10 and 16.5 years in most females (average age of 12.2 years for African American and 12.8 years for white adolescents).¹
- Studies of highly competitive female athletes^{2, 3} suggest that pubertal maturation, including menarche, can be delayed during periods of intense training, severe energy restriction and strict weight control.
- Menarche is often delayed in adolescent females who are diagnosed with eating disorders.
- The onset of the rapid growth spurt varies greatly among females, usually occurring between 9.5-14.5 years of age. The most rapid growth occurs during SMR Stage 3 (average age of 12 years) at which time females grow at a velocity of approximately 9 cm/yr (3.51 in/yr).^{4, 5}
- The period of rapid growth lasts 24-36 months on average, ceasing by 16 years of age in most females. Growth continues in smaller increments throughout adolescence in about half of all females, however, with some females continuing to grow past age 19.
- Adolescents who mature earlier and begin their growth spurt early demonstrate greater peak velocities in growth than do those who mature and grow later in life; however, there is no significant difference in final stature.
- Linear growth can be slowed or delayed in females who are highly competitive athletes or who severely restrict caloric intake. Catch-up growth is commonly seen in growing athletes during periods of less intense training or during the “off season.”

HEIGHT, WEIGHT AND BODY COMPOSITION

As with other aspects of physical development, the timing and tempo of changes in height, weight and body composition can vary greatly between and among adolescent females.

Changes in Height

- 15-25% of adult height will be gained during adolescence. The average increase in height during adolescence is 25 cm (9.75 in).^{4, 5}

Changes in Weight

- Peak weight gain coincides with or begins up to 6 months after the peak in linear growth in pubescent females.^{5, 6}
- During the period of peak weight gain (average age of 12.5 years) pubertal females gain approximately 8.3 kg/yr (18.3 lb/yr).^{5, 6}
- Weight gain continues into the latter stages of puberty, showing patterns of deceleration in rate of gain after menarche similar to the deceleration in linear growth. Adolescent females have been shown to gain as much as 6.3 kg (14 lbs) during mid- and late adolescence.⁷
- 25-50% of final adult ideal weight is gained during adolescence.^{5, 8}
- The timing and amount of weight gain in female adolescents can be greatly affected by caloric intake and energy expenditure. Highly competitive athletes or those who have clinical or sub-clinical eating disorders are particularly at risk of reduced or delayed changes in weight.

Changes in Body Composition and Skeletal Mass

- Shifts in body composition occur during adolescence, with average lean body mass in females decreasing from 80% to 74% while average body fat increases from 15.7% to 26.7% (at full maturity).⁸
- During adolescence females will gain approximately 1.14 kg (2.5 lb) of fat mass each year.⁸
- Peak body fat levels of young adult females are reached by age 15-16 years in most individuals.⁸
- Restriction of caloric intake and/or excessive energy expenditure can mediate normally expected increases in body fat levels.
- Body fat mass in the area of the triceps decreases in females during puberty while body fatness at the subscapular region appears to increase.⁷
- Excessive weight gain during late adolescence may exacerbate the deposition of central body fat, thus increasing long-term risk for development of chronic diseases.⁷
- Approximately 90% of skeletal mass is formed by age 18 in female adolescents.
- Adolescent females accumulate almost one-third of total skeletal mass in the 3-4 years following the onset of puberty.^{9, 10}
- Increases in height and weight are the strongest correlates of skeletal mass accretion during adolescence.⁸
- Females with secondary amenorrhea or environmentally delayed puberty fail to gain bone mass at a normal rate and show lower bone mineral density measurements as adults.¹⁰⁻¹²

MATERNAL GROWTH DURING PREGNANCY

Effects on Pregnancy and Pregnancy Outcomes

Many adolescent females continue to gain height, weight and body fat well into late adolescence. When the adolescent becomes pregnant her needs for energy and nutrients may be in direct competition with those of her fetus. Recent research has shown that growth

during pregnancy does occur in adolescent females and that it can have negative effects on pregnancy outcome if additional dietary and weight gain allowances are not made.

- Adolescent females who are considered to be biologically immature (less than 2 years past menarche) or who are < 16 years old may continue to experience linear growth and changes in weight and body composition.
- More than 50% of females will experience continued growth past age 16 years, and up to 10% of females will grow after age 19 years.^{13, 14}
- About half of all pregnant adolescents can be expected to experience growth during their pregnancy.¹⁴
- Height increases in pregnant adolescents may go undetected using standard height measurement methods due to the “shrinkage” in size that pregnant females experience secondary to vertebral compression and lordosis.
- In research studies linear growth in adolescents is commonly noted when measurements of the lower leg (using the knee height measurement), which does not experience shrinkage during pregnancy, are monitored.^{14, 15}
- Pregnant females who show gains in linear height during pregnancy also accrue additional body fat, almost exclusively during the third trimester, which is the period of most rapid growth by the fetus.¹⁶
- Pregnant adolescents who experience concurrent maternal and fetal growth deliver infants of lower birthweights than do comparable non-growing adolescents, suggesting that the mother and fetus may compete for energy and nutrients. In a recent study, infants born to growing adolescents were approximately 130 g lighter, on average, than those born to non-growing adolescents, despite the fact that the growing adolescents gained almost 2.5 kg (5.5 lb) more weight during pregnancy.¹⁶
- Blood flow to the uterus is lower in growing pregnant females than in their non-growing peers during the third trimester.¹⁷
- A reduction in the availability and transmission of nutrients from maternal circulation to the fetus has been noted in growing pregnant adolescents.¹⁷

- Birthweights of infants born to growing adolescents appear to be somewhat buffered by caloric adequacy; growing pregnant adolescents with inadequate energy intakes deliver infants with greater decrements in birthweight than do growing pregnant adolescents who have adequate energy intakes.¹⁶
- When compared to non-growing pregnant peers, growing pregnant adolescents experience higher gestational weight gains even when caloric intakes are similar.¹⁶
- Growing adolescents continue to deposit fat at the triceps and subscapular skinfold sites while non-growing gravida lose fat from these sites during late pregnancy.¹⁶ Central body fat stores may be increased in postpartum adolescents who grow during pregnancy.
- A larger percentage of gestational weight gain is retained by postpartum adolescents who experience growth during pregnancy when compared to non-growing postpartum adolescents.¹⁶

Clinical Implications and Recommendations for Health Care Professionals

- There is evidence that gestational weight gain in young, still-growing adolescents may have a greater impact on infant size than in older adolescents who have completed growth or mature women. Adolescents less than 16 years of age or those adolescents who are less than two years post-menarche may require higher weight gains during pregnancy than older adolescents and adults to achieve an infant of optimal birthweight (3500-4000 g).¹⁸
- If the adolescent is still growing, steps must be taken to assure adequate weight gain and nutrient intakes to prevent poor pregnancy outcomes, including low birth weight. Calorie and protein intakes will need to be increased beyond the traditional extra allowances to facilitate both maternal and fetal growth. Other nutrients involved in growth, such as zinc and vitamin B₆, may also need to be monitored by ensuring adequate dietary intakes.
- Because a significant amount of skeletal mass is accrued during adolescence, calcium and vitamin D intakes should be closely monitored during pregnancy.
- Health professionals should recognize that some growing pregnant adolescents will gain more weight

than their non-growing peers or adult pregnant women and that they will retain more of their gestational weight gain postpartum. When providing postpartum weight management counseling, normal changes in weight and body composition resulting from growth should be considered.

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