Puberty

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Abstract:
Puberty is the transition between childhood and adulthood. A number of physical, cognitive, and emotional changes take place during this time. Both the physical and the cognitive changes proceed in a predictable manner. Physical changes are evaluated using the Sexual Maturity Rating based on breast, pubic hair, and male genital growth. Cognitive and behavioral changes are classified as early, middle, and late adolescence. There is concern that puberty is occurring earlier than in years past. The role of endocrine disrupting chemicals is currently being investigated as a potential cause of earlier puberty. Puberty that occurs earlier or later than expected can have negative psychological consequences on the individual.

Main Text
Puberty is the period of time in which a child's body becomes a sexually mature adult's body. A number of physical, cognitive, and psychosocial changes take place during this time. Puberty occurs as the result of a series of hormonal and neurobiological interactions. How an individual fares during this turbulent time has a profound effect on their future adult life.

The physical changes that occur during puberty proceed in a predictable pattern. In the female, breast buds are often the first sign of puberty, although a small percentage of females will develop pubic hair first. The appearance of breast development is called "thelarche." Next is pubic hair development, also called "pubarche." After pubic hair development, a female will typically have a growth spurt and reach her peak height velocity. Finally, after her growth spurt, menstruation occurs. The first period is called "menarche." Menarche occurs approximately two years after breast buds develop. After menarche, females may grow a little more, approximately 6 centimeters. In the final stages of puberty, females develop underarm (also called axillary) hair, full breast development occurs, pubic hair is in an adult-type distribution (spreads to the thighs), and growth in height is complete.

Sexual maturity rating (SMR), also called Tanner Staging, is a way to evaluate the stage of puberty in a male or female. There are separate ratings for female breast and pubic hair development, and also for male genital development. For female breast development, SMR 1 is a prepubertal breast with only the nipple projecting. In SMR 2, "breast buds" appear. The areola (colored part around the nipple) is widened and projects as a small mound. During SMR 3, enlargement of the entire breast occurs, with protrusion of the nipple. In SMR 4, the breast further enlarges and the areola and nipple (also called papilla) protrude as a secondary mound. The breast develops an adult configuration with the areola no longer projecting as a secondary mound during SMR 5 (Carswell and Stafford 2009, 4).

As mentioned previously, pubic hair development in females has a separate sexual maturity rating (SMR) than breast development. For pubic hair, SMR 1 is prepubertal with

no pubic hair present. In SMR 2, straight hair appears on the labia majora. (the larger skin folds at the opening of the vagina) and toward the end of SMR 2, appears on the pubis (the bone in the front of the pelvis). The hair increases in quantity and becomes darker in SMR 3. During SMR 4, the hair has further increased in quantity, and is more dense and curled. Hair becomes abundant in the adult-type pattern and extends to the thighs in SMR 5, the final stage (Carswell and Stafford 2009, 3).

The sequence of events for an adolescent male also follows a predictable pattern. The first sign of puberty in males is testicular growth. Following initial testicular growth, pubic hair (the appearance of which is known as pubarche) occurs. The next change is further testicular and also penile growth. After the growth in testicular and penile size, nocturnal emissions start to occur. This is followed by a male's midpubertal growth spurt. The growth spurt corresponds with a rise in testosterone. At this time, acne begins to appear, underarm (also called axillary) hair emerges, the male's voice changes, and facial hair starts to appear. Facial hair starts to appear approximately three years after pubic hair growth. Hair on other areas, such as the chest, back, and abdomen may continue to appear into adulthood (Carswell and Stafford 2009, 4-5).

As for females, there is a sexual maturity rating (SMR) scale for males. Genital and pubic hair development will be summarized together but may be staged separately. Similarly to the female rating scales, SMR 1 is prepubertal, with no pubic hair and genitals unchanged from early childhood. During SMR 2, hair that is soft and light in color develops in the pubic region. The testes and penis enlarge slightly and the scrotum becomes more textured. In SMR 3, the testes and scrotum further enlarge and the penis increases more in size, especially in length. Pubic hair also extends across the pubis (bone in the front of the pelvis) in this stage. During SMR 4, the pubic hair becomes more abundant and curly. The genitalia at this stage are similar to an adult's genitals. The final stage, SMR 5, is evident when the pubic hair has an adult pattern and extends to the thighs (similar to SMR 5 in females) (Carswell and Stafford 2009, 5).

In addition to the changes in pubic hair, genitals, and breasts that occur during puberty, the brain is also undergoing extensive development. The brain is made up of cells called neurons and glia. Neurons receive and transmit chemical and electrical signals. Glial cells surround and support the neurons. Humans are born with billions of brain cells. These cells undergo aggressive pruning and structuring during young childhood and early adolescence. By age 2, three-fourths of the brain growth in weight is complete (Greydanus 2012, 12). Part of this process is myelination, or coating the neurons with a protective covering that increases the efficiency of nerve conduction. After birth, cells begin to reduce in a process called apoptosis, or programmed cell death. The hormones of puberty accelerate the rate at which apoptosis occurs. As a result, during puberty there is a massive death of neurons and half the synaptic (connection points between neurons) connections are removed (Greydanus 2012, 12).

The pubertal hormones that influence growth of the brain include estrogen and testosterone. There is especially growth in the areas of the brain that control impulsivity and social behavior. As an individual progresses through the stages of adolescence changes in behavior and cognition occur. All of these changes work together to form and prepare an adult-like individual who will be taking his or her place in society (Greydanus 2012, 12).

Cognitive changes can be divided into three time periods: early adolescence (ages 10-13 years), middle adolescence (ages 14-16 years), and late adolescence (ages 17-21 years). Early adolescence is a time when the gray matter (nerve cell bodies) of the brain proliferates. The adolescent continues to think concretely. Secondary sexual characteristics appear (pubic and axillary hair). This young adolescent is very interested in developing interpersonal social relationships. At this age, they tend to value peer's opinions over those of their parents.

Their former body image is disrupted. They tend to be preoccupied with their rapidly changing bodies and tend to compare themselves to others of the same age. They may start risk taking behavior and have difficulty perceiving long-range consequences of their actions (Greydanus 2012, 10).

The next stage is middle adolescence, ages 14-16 years. At this time, the brain begins its pruning process. This occurs especially in areas of self-control, judgment, emotions, organization, multitasking, and goal-directed behaviors (Greydanus 2012, 11). The brain strengthens connections that are used most often and loses those that aren't. The thinning-out process continues into the twenties. The brain at this age also becomes more able to think abstractly. This teen is better able to grasp future consequences of their actions but may have difficulty applying this information to all situations. Emotionally, teens continue to value peers opinions over their parents and peer relationships are of utmost importance. There is interest in the opposite gender followed by group dating, individual dating, and possibly sexual intimacy. They often acquire experiences with the opposite sex which may be as short as 1-2 days and are often intense. They reestablish their body image. They also develop a sense of invincibility and omnipotence. This time tends to be the peak of risk taking behavior and impulsivity. (Greydanus 2012, 10-11).

Late adolescence occurs between the ages of 17-21 years. The late adolescent's brain is undergoing myelination (forming a protective coating around nerve cells that make them more efficient). As the brain matures it becomes more selective. At this time, the intellectual and functional identity is established. Emotions are more under control. A late adolescent is able to understand and apply long term consequences of decisions and is adept at abstract thinking. This is the time when independence from the parents is completed. This adolescent is either physically mature or mostly physically mature (Greydanus 2012, 15).

All of these physical and cognitive changes are regulated by hormones. Within the brain, the hypothalamus releases gonadotropin releasing hormone (GnRH) in a pulsatile fashion which stimulates luteinizing hormone (LH) and follicle stimulating hormone (FSH) in the pituitary gland (also located in the brain). These hormones affect the gonads (ovaries in females, testes in males). GnRH, FSH, LH, and estrogen regulate the menstrual cycle in the female. These hormones lead to maturation of the gonads and gonadal tissues. Pubic and axillary hair growth is regulated by a similar system. From the hypothalamus, corticotropin releasing hormone (CRH) stimulates the pituitary to secrete adrenocorticotropic releasing hormone (ACTH). ACTH stimulates the adrenal gland to secrete androgens. Androgens stimulate axillary and pubic hair growth as well as the development of acne.

There is concern in scientific literature that puberty is occurring earlier over time. Currently, puberty may start at 6 years in black American females, 7 years in Caucasian females, and 8 years in European females. Puberty that occurs before these ages is considered to be early, or precocious. From the late 1800s to the mid-1900s there was a trend toward earlier menarche. Disagreement exists in the literature as to whether that trend has continued from the mid-1900s to the present time. There does not seem to be a similar trend in boys. Ethnicity, nutrition, environmental, and genetic factors may influence the timing of puberty (Golub et al. 2008, S218).

Within the environment, endocrine disrupting chemicals (EDCs) are being studied as a possible cause of the trend of early puberty. In 1996, U.S. Congress recognized EDCs as a public health concern and passed the Food Quality Protection Act and amendments to the Safe Drinking Water Act. This act includes a mandate to the U.S. Environmental Protection Agency to develop a program to identify EDCs. Consequently, over the last 10 years, the Environmental Protection Agency has developed the Endocrine Disruptors Screening Program. The program consists of a formal system of screens and tests used to identify possible EDCs in the environment (Lee and Styne 2013, 255) .

Puberty that occurs earlier than expected may pose physical and emotional risks to an adolescent. Children with early puberty are at risk for early skeletal maturation which results in shortened adult height, early sexual debut, and possible sexual abuse. Difficulties with peers may also emerge. Early menarche (first period) in girls is a risk factor for breast cancer. In boys, some studies have shown that early puberty is a risk factor for testicular cancer, although this is controversial. Early adrenarche (pubic and axillary hair, and acne) is a risk factor for developing metabolic syndrome and polycystic ovarian syndrome. Features of these syndromes may include obesity, type 2 diabetes, and cardiovascular disease later in life. Conduct disorders and behavior disorders have been found to have a higher incidence in those individuals with earlier maturation (Golub et al. 2008, S218).

There are a number of psychological consequences if puberty occurs earlier or later than same-sex peers. The consequences seem to be more profound for girls who mature early and for boys who mature late. For girls, early puberty is associated with higher rates of depressive disorders, substance disorders, and eating disorders (Graber 2013, 263-64). Postulated reasons for the development of eating disorders in females during puberty include genetic effects as well as hormonal effects on the developing brain (Klump 2013, 406). However, more studies are needed in this area. Effects of early puberty seem to be more severe for girls than for boys. Late maturation for boys has been found to be related to depressive symptoms, substance use, and disruptive behavior disorders. Reasons for these psychopathologies may be related to psychosocial stressors during a period of vulnerability (Graber 2013, 263-64). Children or teens with puberty that is early or later than expected should be evaluated by an experienced medical provider.

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