

Quadrant II – Transcript and Related Materials

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Unit: I Nature of Adolescence

Module Name: Puberty: Determinants of Puberty – Part I

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Notes

PUBERTY

Puberty can be distinguished from adolescence. For virtually everyone, puberty ends long before adolescence is exited. Puberty is often thought of as the most important marker for the beginning of adolescence. Puberty is a brain neuroendocrine process occurring primarily in early adolescence that provides stimulation for the rapid physical changes that take place during this period of development. Although we do not know precisely what initiates puberty, a number of complex factors are involved. Puberty is accompanied by changes in the endocrine system, weight, and body fat, but we don't know if these are a cause or a consequence of puberty. Also, there is increased interest in the role that birth weight, rapid weight gain in infancy, obesity, and sociocultural factors might play in pubertal onset and characteristics. As discussed, next, heredity is an important factor in puberty.

DETERMINANTS OF PUBERTY

Heredity: - Puberty is not an environmental accident. Programmed into the genes of every human being is the timing for the emergence of puberty. Puberty does not take place at 2 or 3 years of age and it does not occur in the twenties. Recently, scientists have begun to conduct molecular genetic studies in an attempt to identify specific genes that are linked to the onset and progression of puberty. Nonetheless, as you will see later, puberty takes place between

about 9 and 16 years of age for most individuals. Environmental factors can also influence its onset and duration.

Hormones: - Behind the first whisker in boys and the widening of hips in girls is a flood of hormones, powerful chemical substances secreted by the endocrine glands and carried throughout the body by the bloodstream. Two classes of hormones have significantly different concentrations in males and females: androgens, the main class of male sex hormones, and estrogens, the main class of female hormones. Note that although these hormones function more strongly in one sex or the other, they are produced by both males and females. Testosterone is an androgen that plays an important role in male pubertal development. Testosterone is primarily secreted from testes in boys. Throughout puberty, rising testosterone levels are associated with a number of physical changes in boys, including the development of external genitals, an increase in height, and voice changes. Testosterone level in adolescent boys is also linked to sexual desire and activity. Estradiol is an estrogen that plays an important role in female pubertal development. Estradiol is primarily secreted from ovaries in girls. As estradiol levels rise, breast development, uterine development, and skeletal changes occur. The identity of hormones that contribute to sexual desire and activity in adolescents is less clear for girls than it is for boys. Boys and girls experience an increase in both testosterone and estradiol during puberty. However, in one study, testosterone levels increased 18-fold in boys but only 2-fold in girls during puberty; estradiol levels increased 8-fold in girls but only 2-fold in boys during puberty. Also, a recent study of 9- to 17-year-old boys found that testosterone level peaked at 17 years of age.

The Endocrine System: - Puberty is not a specific event but rather a process that unfolds through a series of coordinated neuroendocrine changes. Puberty onset involves the activation of the hypothalamic-pituitary-gonadal (HPG) axis. The hypothalamus is a structure in the higher portion of the brain that monitors eating, drinking, and sex. The pituitary gland is the endocrine gland that controls growth and regulates other glands. The gonads are the sex glands—the testes in males, the ovaries in females. How does the endocrine system work? The pituitary gland sends a signal via gonadotropins (hormones that stimulate sex glands) to the testes or ovaries to manufacture the hormone. Then, through interaction with the hypothalamus, the pituitary gland detects when the optimal level of hormones has been reached and maintains it with additional gonadotropin secretions. Levels of sex hormones are regulated by two hormones secreted by the pituitary gland: FSH (follicle-stimulating hormone)

and LH (luteinizing hormone). FSH stimulates follicle development in females and sperm production in males. LH regulates estrogen secretion and ovum development in females and testosterone production in males. In addition, the hypothalamus secretes a substance called GnRH (gonadotropin-releasing hormone), which is linked to pubertal timing. These hormones are regulated by a negative feedback system. If the level of sex hormones rises too high, the hypothalamus and pituitary gland reduce their stimulation of the gonads, decreasing the production of sex hormones. If the level of sex hormones falls too low, the hypothalamus and pituitary gland increase their production of the sex hormones. In males, the pituitary gland's production of LH stimulates the testes to produce testosterone. When testosterone levels rise too high, the hypothalamus decreases its production of GnRH, and this decrease reduces the pituitary's production of LH. When the level of testosterone falls as a result, the hypothalamus produces more GnRH and the cycle starts again. The negative feedback system operates in a similar way in females, except that LH and GnRH regulate the ovaries and the production of estrogen. This negative feedback mechanism in the endocrine system can be compared to a thermostat and furnace. If a room becomes cold, the thermostat signals the furnace to turn on. The action of the furnace warms the air in the room, which eventually triggers the thermostat to turn off the furnace. The room temperature gradually begins to fall again until the thermostat once again signals the furnace to turn on, and the cycle is repeated. This type of system is called a negative feedback loop because a rise in temperature turns off the furnace, while a decrease in temperature turns on the furnace. The level of sex hormones is low in childhood but increases in puberty. It is as if the thermostat is set at 50 degrees F in childhood and then becomes set at 80 degrees F in puberty. At the higher setting, the gonads have to produce more sex hormones, and they do so during puberty.

Growth Hormones: - We know that the pituitary gland releases gonadotropins that stimulate the testes and ovaries. For example, a recent study documented that the pituitary gland grows in adolescence and that its volume is linked to circulating blood levels of estradiol and testosterone. In addition, through interaction with the hypothalamus, the pituitary gland also secretes hormones that lead to growth and skeletal maturation either directly or through interaction with the thyroid gland, located in the neck region. At the beginning of puberty, growth hormone is secreted at night. Later in puberty, it also is secreted during the day, although daytime levels are usually very low. Cortisol,

a hormone that is secreted by the adrenal cortex, also influences growth, as do testosterone and estrogen.

Adrenarche and Gonadarche: - Two phases of puberty are linked with hormonal changes: adrenarche and gonadarche. Adrenarche involves hormonal changes in the adrenal glands, located just above the kidneys. These changes occur surprisingly early, from about 6 to 9 years of age in girls and about one year later in boys, before what is generally considered the beginning of puberty. During adrenarche and continuing through puberty, the adrenal glands secrete adrenal androgens, such as dehydroepiandrosterone (DHEA). A recent study revealed that DHEA concentrations increased 24 months prior to breast development in girls. However, adrenarche is not well understood. Gonadarche, which follows adrenarche by about two years, is the period most people think of as puberty. Gonadarche involves the maturation of primary sexual characteristics (ovaries in females, testes in males) and secondary sexual characteristics (pubic hair, breast, and genital development). “The hallmark of gonadarche is reactivation of the hypothalamic-pituitary-gonadal axis (HPG). The initial activation of the HPG axis was during the fetal and neonatal period”. In the United States, the gonadarche period begins at approximately 9 to 10 years of age in non-Latino White girls and 8 to 9 years in African American girls. In boys, gonadarche begins at about 10 to 11 years of age. Menarche, the first menstrual period, occurs in mid- to late gonadarche in girls. In boys, spermarche, a boy’s first ejaculation of semen, occurs in early to mid-gonadarche.

Weight and Body Fat: - Some researchers argue that a child must reach a critical body mass before puberty, especially menarche, emerges. A number of studies have found that higher weight, especially obesity, is linked to earlier pubertal development. For example, a recent study of more than 46,000 children and adolescents in 34 countries found that obesity was linked to earlier onset of menarche. Another recent study revealed that puberty began earlier in overweight boys and later in underweight boys. Other scientists have hypothesized that the onset of menarche is influenced by the percentage of body fat in relation to total body weight, although a precise percentage has not been consistently verified. However, both anorexic adolescents whose weight drops dramatically and females who participate in certain sports (such as gymnastics and swimming) may not menstruate. In boys, undernutrition may delay puberty.

Leptin and Kisspeptins: - Reproduction is an energy-demanding function and thus puberty is said to be “metabolically gated” as a way to prevent fertility when energy conditions are very low. Also, as we just indicated, obesity is linked to earlier menarche. The metabolic control of puberty, ranging from energy deficit to extreme overweight, results from the action of hormones and sends information to the GnRH neurons. The hormone leptin, which is secreted by fat cells and in abundance stimulates the brain to increase metabolism and reduce hunger, has been proposed to play an important role in regulating puberty, especially in females. Some researchers argue that leptin deficiency inhibits food intake and reduces body fat, thus delaying pubertal onset or interrupting pubertal advances, and that leptin treatment can restore puberty. Further, recently kisspeptins, which are products of the Kiss 1 gene, have been reported to regulate GnRH neurons and thus play a role in pubertal onset and change. Interestingly, the Kiss 1 gene was discovered by researchers in Hershey, Pennsylvania, and named in recognition of Hershey chocolate kisses! Are leptin and kisspeptins key factors in the onset of puberty and pubertal change? At this point, researchers aren’t sure whether leptin and kisspeptins precede puberty and have a causative role in pubertal onset or are the consequence of other pubertal changes.

Weight at Birth and in Infancy: - Might puberty’s onset and characteristics be influenced by birth weight and weight gain during infancy? There is increasing research evidence for this link. Low-birth-weight girls experience menarche approximately 5 to 10 months earlier than normal-birth-weight girls, and low-birth-weight boys are at risk for small testicular volume during adolescence. A recent study confirmed that rapid weight gain in infancy was associated with earlier menarche. A recent research review concluded that early growth acceleration soon after birth that reaches a peak in the first 2 to 4 years of life predicts very early pubertal onset for girls. This review also noted that this early growth acceleration is present in children who become overweight or obese later in childhood and adolescence.

Sociocultural and Environmental Factors: - Might sociocultural and environmental factors be linked to pubertal timing? Recent research indicates that cultural variations and early experiences may be related to earlier pubertal onset. Adolescents in developed countries and large urban areas reach puberty earlier than their counterparts in less-developed countries and rural areas. For example, a recent study of more than 15,000 girls in China revealed that menarche occurred much earlier in urban than rural girls. Children who have

been adopted from developing countries to developed countries often enter puberty earlier than their counterparts who continue to live in developing countries. African American females enter puberty earlier than Latina and non-Latina females, and African American males enter puberty earlier than non-Latino males. Early experiences that are linked to earlier pubertal onset include adoption, father absence, low socioeconomic status, family conflict, maternal harshness, child maltreatment, and early substance use. In many cases, puberty comes months earlier in these situations, and this earlier onset of puberty is likely explained by high rates of conflict and stress in these social contexts. One study revealed that maternal harshness in early childhood was linked to early maturation as well as sexual risk taking in adolescence. Another study found that early onset of menarche was associated with severe child sexual abuse.

References

- 1) Santrock, J.W. (2015). *Adolescence*. (16th Ed.). New York: Tata McGraw Hill.