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Tanner Stages

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Introduction

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Puberty is a time of rapid and complex changes involving overlapping components: hormonal, physical, and cognitive. Tanner Staging, also known as Sexual Maturity Rating (SMR), is an objective classification system that providers use to document and track the development and sequence of secondary sex characteristics of children during puberty. It was developed by Marshall and Tanner while conducting a longitudinal study during the 1940s to the 1960s in England. Based on observational data, they developed separate scales for the development of external genitalia: phallus, scrotum, and testes volume in males; breasts in females; and pubic hair in both males and females.

The physical changes of puberty require a concerted effort from many organs; these changes are initiated by the activation of the hypothalamic-pituitary-gonadal (HPG) axis (gonads refer to ovaries in females and testes in males). The first hormonal change in puberty is the pulsatile release of GnRH triggered by disinhibition of the hypothalamic-pituitary-gonadal (HPG) axis. Although the cause of this disinhibition is largely unknown, the subsequent release of GnRH then stimulates the pulsatile release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). LH and FSH act on specific gonadal cells to stimulate the release of androgens, estrogens, and the process of gametogenesis. LH stimulates the theca cells in the ovary to produce estrogen precursors and the Leydig cells of the testes to produce testosterone. On the other hand, FSH works on the ovarian follicle to convert the thecal estrogen precursors to estrogen and on the Sertoli cells in the seminiferous tubules of the testes to help create sperm. This complex process leads to increased estrogen and testosterone production that then facilitates the development of breasts and the formation of adult male genitalia.[1][2][3]

The adrenal glands also contribute to the formation of secondary sex characteristics, particularly pubarche, which is the development of pubic and axillary hair. Although adrenal maturation often coincides with HPG axis maturation, it is important to note that these processes occur independently of each other and that pubarche itself is not the best indicator of pubertal development.[4]

Function

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The normal onset and sequence of physical maturation vary greatly based on sex, race and ethnicity, and environmental factors. Tanner Stages are utilized in pediatric and adolescent practice to counsel patients about the timing of anticipated body changes, perform appropriate medical screenings, and monitor for deviations in normal timing and sequence of physical signs of puberty that may represent physiologic problems. Changes that are associated with but not directly measured by Tanner staging include bone growth and fusion, body composition and linear growth, and hematocrit values. Tanner Staging, rather than chronological age, should be used in assessing pubertal development. Clinical examples of use include delivering timely anticipatory guidance on menstrual hygiene needs (menarche occurs about 2 years post-thelarche/tanner 2 breasts) or targeting scoliosis exams at well-visits before and during peak height velocity (Tanner 2 to 3, depending on sex).[4][5][6]

In females, the normal onset of puberty ranges from 8 to 13 years old, averaging age 10 years in White Americans and age 8.9 years in African-Americans. Puberty in females begins with the development of breast buds under the areola, also known as thelarche, and represents entry into Tanner Stage 2. As puberty progresses, the glandular tissue of the breast increases in size and changes in contour. In females, thelarche is followed in 1 to 1.5 years by the onset of sexual hair (pubic and axillary), known as pubarche. Menarche, the onset of menses, arrives on average at age 12.5 years, regardless of ethnicity, following thelarche on average by 2.5 years (range 0.5 to 3 years). Between Tanner Stage 2 and 3 breast development, females experience peak height velocity. African-American females have closer to 3 years between their thelarche and menarche, accounting for greater height potential.

In males, the onset of puberty ranges from 9 to 14 years of age. The first secondary sexual characteristic visible is gonadarche when the testicular volume reaches greater than or equal to 4 mL (or long axis greater than or equal to 2.5 cm) and enters tanner stage 2. During Tanner Stage 3 genital development, males undergo peak height velocity. Spermarche, the counterpart of menarche in females, is the development of sperm in males and typically occurs during genital Tanner Stage 4.

Issues of Concern

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Pubertal development generally follows a predictable pattern of onset, sequence, and velocity. However, population norms are published to help clinicians determine which adolescents fall outside two standard deviations of the mean and require further investigation. Precocious puberty is defined as the onset of Tanner 2 secondary sexual characteristics before age 8 years in females or age 9 years in males if the continued progression of pubertal development occurs soon after. Delayed puberty should be considered if females have not reached Tanner 2 thelarche by age 13 years old or if males have not reached Tanner 2 gonadarche by age 14 years. Primary amenorrhea is defined as a failure to start menses within 3 years of Tanner Stage 2 (thelarche) or by age 15 years. It is important to note that some males will temporarily develop glandular breast tissue (pubertal gynecomastia) between genital tanner stage 3 and 4, which may be emotionally troubling but not physically harmful. Abnormalities may be caused by idiopathic conditions, nutritional deficiencies,[7][8] HPG axis variations, or neoplastic and genetic disorders. Describing these disorders is outside the scope of this article.

Clinical Significance

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Below are the Tanner Stages described in detail for clinical reference. Tanner Stage 1 corresponds to the pre-pubertal form for all three sites of development with progression to Tanner Stage 5, the final adult form. Breast and genital staging, as well as other physical markers of puberty such as height velocity, should be relied on more than pubic hair staging to assess pubertal development because of the independent maturation of the adrenal axis.

Pubic Hair Scale (both males and females)

- Stage 1: No hair
- Stage 2: Downy hair
- Stage 3: Scant terminal hair
- Stage 4: Terminal hair that fills the entire triangle overlying the pubic region
- Stage 5: Terminal hair that extends beyond the inguinal crease onto the thigh

Female Breast Development Scale

- Stage 1: No glandular breast tissue palpable
- Stage 2: Breast bud palpable under the areola (1st pubertal sign in females)
- Stage 3: Breast tissue palpable outside areola; no areolar development
- Stage 4: Areola elevated above the contour of the breast, forming a "double scoop" appearance
- Stage 5: Areolar mound recedes into single breast contour with areolar hyperpigmentation, papillae development, and nipple protrusion

Male External Genitalia Scale

- Stage 1: Testicular volume < 4 ml or long axis < 2.5 cm
- Stage 2: 4 ml-8 ml (or 2.5 to 3.3 cm long), 1st pubertal sign in males
- Stage 3: 9 ml-12 ml (or 3.4 to 4.0 cm long)
- Stage 4: 15-20 ml (or 4.1 to 4.5 cm long)
- Stage 5: > 20 ml (or > 4.5 cm long)

Enhancing Healthcare Team Outcomes

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An interprofessional team of clinicians and nurses should provide the screening evaluation of pediatric patients. All healthcare workers, including nurses, nurse practitioners, physician assistants, and physicians who evaluate pediatric patients, should know the Tanner stages. This will allow them to know if sexual development is normal or abnormal; the earlier the referral to the appropriate specialist, the better the outcomes.[6]

Review Questions

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References

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