

CHAPTER 9
TANNER STAGING

9.1 Introduction

Adolescence and puberty are terms generally used interchangeably when referring to the physiologic maturation of events that occur in an individual and culminate in that individual being capable of sexual reproduction. Although the age of onset and length of time of progression through puberty is highly variable, the events of puberty usually occur in a predictable sequence. In girls, this period normally encompasses the ages 10 to 15 and in boys, the ages 11 to 16. The adolescent growth spurt occurs approximately two years earlier in girls compared to boys. However, the onset of puberty in girls (breast budding) occurs only about six months before boys (early testicular enlargement).

DISC subjects will be eligible to enter this study if they are prepubescent (Stage 1). Evidence of beginning sexual maturation is an exclusion criterion from this study. The subjects will have their sexual maturation assessed frequently during the course of this study. Tanner Staging will be used to assess the sexual maturation of DISC subjects. Tanner plates are shown in Exhibit 9.1 and 9.2 and will be used for this purpose. The assessments of pubertal development will occur at SV2 and 6, 12, 24, 36, and annually in DISC II until the participant reaches Tanner 5. In girls, staging of breast and pubic hair development will be recorded and in boys, staging of genital and pubic hair development will be recorded. Breast and pubic hair in girls will be subjectively assessed and the diameter of the areola will be objectively measured. Scrotal and penile changes will be subjectively assessed in boys while testicular volume will be objectively measured using orchidometer beads.

9.2 Sequence of Pubertal Events in Girls

The sequence of events in puberty of the average American female is seen in Exhibit 9.3 (from Brookman, et al.). The appearance of the "breast bud" is usually the first sign of puberty in girls, though pubic hair growth can occur first in approximately 20%. On average, breast development begins at about age 11, the range being 8 to 13. As one can see from Exhibit 9.3, sequential changes in secondary sex development are breast 2, pubic hair 2, peak height velocity, breast 3, pubic hair 3, breast and pubic hair 4, menarche, pubic hair 5, and finally breast 5. The speed of progression through puberty in girls is variable. The average movement from Stage 2 breast development to Stage 3 is one year. Some girls traverse from Stage 2 to Stage 5 in 1-1/2 years, whereas others take eight to nine years to complete the process. Adult breast development is usually obtained by age 15. Breast development progresses from preadolescent (Stage 1) to the appearance of a breast bud with areolar widening (Stage 2). Unilateral breast development is normal in early puberty and may persist for as long as six months before the other breast bud appears. When there is a difference in staging, record the most advanced stage. Stage 3 is characterized by further breast and areolar enlargement without separation of the breast and areolar contours. Stage 4 is characterized by a secondary areolar mound which projects above the breast contour, and Stage 5 is characterized by areolar recession back into the contour of the breast. Development of the areolar mound, which defines Stage 4, never occurs in approximately 25% of girls and in many others, can be very slight. Therefore, when one examines a young woman for the first time it may be difficult to distinguish between Stages 3 and 5 breast development. The size of the breast is not relevant in staging beyond Stage 3, and is felt to be minimally influenced by nutrition, excluding the large breasts of obesity.

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Menarche usually occurs during a period of decelerating growth after the peak height velocity has passed. This generally occurs about two to two and one-half years after first appearance of breast development--average age 12-1/2 years. Menarche is considered normal if it occurs from ages 10 through 15. Most girls are in Tanner Stage 4 breast and pubic hair development at the time of menarche.

9.3 Instructions for Assessing Tanner Stage in Girls

9.3.1 Breast

Tanner Staging of the breast will occur during the course of the normal physical examination, specifically in conjunction with examination of the chest and abdomen. At SV2 breast development should be pre-adolescent (Stage 1). The breasts will be observed and palpated for breast budding. In Stage 1 there is no palpable glandular tissue and the areola is not pigmented. Except for the nipple, the breast does not project from the anterior chest wall. Tanner Breast staging will be assessed at each subsequent visit at 6, 12, 24, 36, and annually in DISC II until Tanner stage 5 is reached using Plates M-1 through M-5 (Exhibit 9.1) and the following descriptive information.

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3. Stage 3 (M-3). Further elevation of the mamma. Diameter of areola increased further. Shape of mamma now visibly feminine.
4. Stage 4 (M-4). Increasing fat deposits. The areola forms a secondary elevation above that of the breast. This secondary mound apparently occurs in roughly half of all girls, and in some cases persists in adulthood.
5. Stage 5 (M-5). Adult stage. The areola (usually) subsides to the level of the breast and is strongly pigmented.

9.3.2 Areolar Diameter

At each visit the areolar diameter will be measured bilaterally. With the subject supine, the horizontal diameter of each areola will be measured to the nearest 0.1 cm. Extend a plastic or fiberglass tape measure lightly across the areola. Record areolar diameter to the last completed 0.1 cm.

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4. Stage 4 (P-4). Hair "adult" in type, but not in extent.
5. Stage 5 (P-5). Lateral spreading; type and spread of hair adult.

9.4 Sequence of Pubertal Events in Boys

The sequence of pubertal events in the average American male is seen in Exhibit 9.4 (from Brookman, et al.). The vast majority of boys begin puberty with testicular enlargement, which is followed by pubic hair development usually within six months. Penis enlargement usually does not occur until 12 to 18 months after testicular enlargement and peak height velocity typically occurs two to two and one-half years following testicular enlargement. Minor variations in this pattern of development in pubertal boys are common, however, it is very unusual for marked discordance to occur in pubertal development in adolescent boys. Typically there is no more than one stage discordance between genital and pubic hair development.

Pubic hair development in the male usually progresses from Stage 2 to 5 over a two-year period (12 to 14 years). In general then, the sequence of pubertal development normally is highly predictable in boys while the age of onset and rapidity of progression are quite variable.

The descriptive standards for staging of genital maturity and pubic hair development in boys can be seen in Plates P-1 through P-5 and G-1 through G-5 (Exhibit 9.2). Genital development progresses from that of pre-adolescence (Stage 1) to the beginning of testicular and scrotal enlargement (Stage 2). Penile enlargement and continued testicular and scrotal enlargement characterize Stage 3. In Stage 4 further penile, testicular and scrotal enlargement occur and this process progresses to adult-size and shape genitalia at Stage 5.

The volume of each testis in pre-pubescent boys is usually 1 to 3 ml. When puberty begins, the testicular volume enlarges to 4 ml and is usually accompanied by reddening and thinning of the scrotum. Usually the penis enlarges and pubic hair appears during the year following this early testicular enlargement. During the course of puberty the testes enlarge approximately ten-fold, obtaining an adult size of 15 to 25 ml.

The timing of the pubertal growth spurt is different in boys and girls. As mentioned, girls usually demonstrate acceleration of linear growth at the onset of puberty and reach their peak height velocities relatively early in puberty. Boys typically start at genital and pubic hair Stage 3 (coinciding with beginning phallic enlargement) and generally reach their peak height velocity when their genital and pubic hair development is Stage 4.

Breast enlargement in boys is characterized by an increase in areolar diameter and occurs in about 1/2 to 3/4 of all normal boys. This is known as physiologic gynecomastia of adolescence and may be unilateral or bilateral. This pubertal gynecomastia occurs most commonly during genital Stage 4 and typically regresses after 12 to 18 months.

Pubic hair development in boys follows the same pattern as that described in girls.

9.5 Instructions for Assessing Tanner Stages in Boys

9.5.1 Genital

Tanner staging of male genitalia will be performed in conjunction with the general physical examination and will be performed at SV2 and visits at 6, 12, 24, 36, and annually until Tanner 5 is reached. Plates G-1 through G-5 (Exhibit 9.2) and the following descriptive information will be used for Tanner staging.

1. Stage 1 (G-1). Testis, scrotum and penis are the same size and shape as in the young child.
2. Stage 2 (G-2). Enlargement of scrotum and testis. The skin of the scrotum becomes redder, thinner and wrinkled. Penis no larger or scarcely so.
3. Stage 3 (G-3). Enlargement of the penis, especially in length; further enlargement of testis; descent of scrotum.
4. Stage 4 (G-4). Continued enlargement of the penis and sculpturing of the glans. Increased pigmentation of scrotum. This stage is sometimes best described as "not quite adult."
5. Stage 5 (G-5). Adult stage. Scrotum ample, penis reaching nearly to bottom of scrotum.

9.5.2 Testicular Volume

Test-size orchidometer beads are used to assess testicular volume. These graded ellipsoid plastic models are available in 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, and 25 ml sizes. They may be kept separately or joined together with a string.

The right testis is often slightly larger than the left, however, the left testis is usually situated lower in the scrotum than the right. With the boy supine on the examination table and in conjunction with a general physical examination usually following palpation of the abdomen, the assessment of testicular volume and Tanner Staging is performed. Gently isolate the right testis in the scrotum and stretch the scrotal skin over the testis without compressing it. The appropriate sized orchidometer bead can then be compared. Assess the volume of the left testis in a similar manner. Testicular volumes 1 to 3 ml will be considered Stage 1; 4 ml Stage 2; 5 to 6 ml Stage 3; 8 to 12 ml Stage 4; and 15 to 25 ml Stage 5.

If it is difficult to isolate the testis with the patient supine, it sometimes is possible to do so with the boy sitting cross-legged on the examining table. If the boy is asked to gently bear down, the testicle will often pop into the scrotum. Also, standing or squatting, facing the examiner will sometimes allow a bashful testicle to be evaluated. In the case of a unilateral hydrocele, assess the volume of the testis on the unaffected side of the scrotum only.

9.5.3 Pubic Hair

Tanner Staging of pubic hair development in the male will be assessed at SV2 and visits 6, 12, 24, 36, and annually until Tanner 5 is reached. Plates P-1 through P-5 (Exhibit through P-5 (Exhibit 9.2) and the following descriptive information will be used for Tanner Staging.

1. Stage 1 (P-1). No growth of pubic hair; that is to say, hair in pubic area no different from that on the rest of the abdomen.
2. Stage 2 (P-2). Slightly pigmented, longer, straight hair, often still downy; usually at base of penis, sometimes on scrotum. Stage 2 is difficult to photograph.
3. Stage 3 (P-3). Dark, definitely pigmented, curly pubic hair around base of penis. Stage 3 can be photographed.
4. Stage 4 (P-4). Pubic hair definitely adult in type, but not in extent (no further than inguinal fold).
5. Stage 5 (P-5). Spread to medial surface of thighs, but not upward.

9.6 Training of Nurse Practitioners, Physician Assistants, and Physicians in Maturity Staging.

9.6.1 Initial Training

An initial training session occurred in September 1987 in Portland, Oregon. Dr. Stephen LaFranchi, a board certified pediatric endocrinologist, presented a didactic session with written materials. He demonstrated the measurement procedures; observed clinicians collecting measurements; supervised the clinical training of clinicians in maturity staging of breast, pubic hair, genital development; and the measurement of areolar diameter and testicular volume. All trainees in attendance are considered trained in maturity staging of DISC subjects. Physicians trained at this initial session or subsequently by those at this session are considered master trainers for DISC maturity staging.

9.6.2. Subsequent Training

Training will be required in maturity staging for those who were unable to attend the initial training session. This training can be provided by either master trainers for DISC maturity staging, or by board eligible or board certified pediatric endocrinologists, or by pediatric adolescent specialists and will consist of the following:

- 1) Read and study the DISC protocol and manual of operations regarding maturity (Tanner) staging.
- 2) Review the vanWieringer, et al., color plates in Growth Diagrams, 1965, Netherlands, Walters-Nierchoff Publishing, Gronigen, 1971.
- 3) Obtain a passing grade on the DISC maturity staging quiz.
- 4) Observe experienced trainers conducting maturity staging on two individuals.
- 5) Conduct maturity staging on four individuals (two males and two females) while being observed by an experienced trainer.

9.7 Certification

9.7.1 Requirements

1. Complete training 9.6.1 or 9.6.2.

(This should be documented in the clinician's file, including name of trainer and date of training.)

2. Complete Maturity Staging Checklist.
3. Score 80% or higher on Maturity Staging Quiz.

9.8 Skill Maintenance

Perform maturity staging on at least twenty (20) subjects each year to maintain skills. If the staging is performed on non-DISC subjects, a signed statement by the clinician is required.

9.9 Re-Certification

9.7 and 9.8 are required on a yearly basis. The Maturity Staging Measurement Checklist Form must be completed on two separate subjects, one male and one female. These needn't be DISC subjects.

DISC MATURITY STAGING MEASUREMENT CHECKLIST FORM

This form is required for DISC maturity staging certification and recertification. Study or non-study children may be used in the certification and recertification process. Certifying and recertifying individuals (trainers) will be either board-eligible or board-certified pediatric endocrinologist adolescent specialists, or master trainers.

Trainees will examine for maturity staging two males and two females for initial certification, or one male and one female for recertification. These examinations will be observed by one of the above M.D. trainers.

1. Clinic location

Check one:

- Iowa
- John Hopkins
- Kaiser Permanente
- LSU
- New Jersey
- Northwestern

2. Individual to be certified or recertified

Name: _____

DISC I.D. _____

Check one:

- P.N.P.
- P.A.
- M.D.

3. Trainer:

Name _____ M.D.

Check one:

- Pediatric endocrinologist
- Adolescent specialist
- Master trainer

MATURITY STAGING CHECKLIST

REVIEW OF WRITTEN MATERIALS

| | YES | NO | COMMENTS |
|--|-----|-----|----------|
| 1. Read DISC protocol and manual of operations on maturity staging? ----- | ___ | ___ | _____ |
| 2. Reviewed pages 108-120 of Chapter V in, "Growth and Maturity in Adolescents" in <u>Growth Disorders in Infants, Children and Adolescents</u> , by Marvin L. Rallison, M.D., John Wiley & Sons, Inc., New York, 1986? -- | ___ | ___ | _____ |
| 3. Reviewed vanWieringer, et al., color plates in <u>Growth Diagrams, 1965</u> , Netherlands, Walters-Nierdhoff Publishing, Gronigen, 1971? ----- | ___ | ___ | _____ |
| Subject: Male ____/Birth date _____ (Answer Questions 9-19) | | | |
| Female ____/Birth date _____ (Answer Questions 4-10, 15-19) | | | |

| BREAST | YES | NO | COMMENTS |
|---|-----|-----|----------|
| 4. Was the stage of breast development accurately assessed and recorded? ----- | ___ | ___ | _____ |
| AREOLAR DIAMETER | | | |
| 5. Was a plastic or fiberglass tape measure used? ----- | ___ | ___ | _____ |
| 6. Was the subject supine when the areolar diameter was measured? ----- | ___ | ___ | _____ |
| 7. Was the horizontal diameter of each areolar measured and recorded to the nearest 0.1 cm.? ----- | ___ | ___ | _____ |
| 8. Was there agreement within 0.2 cm. between trainee and trainer on (at least) two separate areolar diameter measurements? --- | ___ | ___ | _____ |
| PUBIC HAIR | | | |
| 9. Was the stage of pubic hair development accurately assessed and recorded? ----- | ___ | ___ | _____ |

| | YES | NO | COMMENTS |
|---|------------|------------|------------|
| GENITALIA | | | |
| 10. Was the stage of genitalia development accurately assessed and recorded? ----- | ___ | ___ | _____ |
| TESTICULAR VOLUME | | | |
| 11. Are orchidometer beads available in 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 25 cc. volumes? | ___ | ___ | _____ |
| 12. Was the subject supine during the assessment of testicular volume? ----- | ___ | ___ | _____ |
| 13. Was there agreement within 2 cc. between the trainee and trainer regarding testicular volume for each testis? ----- | ___ | ___ | _____ |
| 14. Were these measurements accurately recorded? | ___ | ___ | _____ |
| 15. Overall assessment of performance. (Check one) | | | |
| EXCELLENT _____ | GOOD _____ | FAIR _____ | POOR _____ |
| 16. Trainer's comments | | | |
| _____ | | | |
| _____ | | | |
| 17. Signature of trainee | _____ | | |
| 18. Signature of trainer | _____ | | |
| 19. Today's date | _____ | | |

QUIZ FOR CERTIFICATION IN DISC MATURITY STAGING

1. Girls generally start their growth spurt before boys, and usually have higher peak height velocities. ----- TRUE FALSE
2. In boys, peak weight velocity occurs at the same time as peak height velocity, while in girls peak weight velocity lags peak height velocity by about 6 months. ---- TRUE FALSE
3. The average age for beginning breast development ("breast budding") in girls is 11 years. Beginning breast development in girls can be as early as 8 years and as late as 13 years. ----- TRUE FALSE
4. Pubic hair development can be the first sign of puberty in over 10% of boys. ----- TRUE FALSE
5. Menarche usually occurs within 1 to 1-1/2 years following the beginning of sexual development in girls. ----- TRUE FALSE
6. Testicular enlargement is usually the first sign of puberty in boys and testicular volumes less than 4 cc. are considered pre-pubescent. ----- TRUE FALSE
7. In 15 - 30% of girls, the first sign of puberty is pubic hair growth. ----- TRUE FALSE
8. At SV2 the presence of breast buds in girls or testes greater than or equal to 4 cc. in boys, or pubic hair in boys or girls, makes the subject not eligible for continuation in DISC. ----- TRUE FALSE
9. Isosexual precocious puberty is properly defined as the onset of puberty in a girl less than 8 years of age or in a boy less than 9 years of age. ----- TRUE FALSE
10. Delayed puberty is properly defined as no sign of puberty in a girl by 13 years of age, or in a boy by age 14-1/2 years of age. ----- TRUE FALSE

- | | | | |
|-----|--|------|-------|
| 11. | Axillary hair in boys and girls usually occurs about 2 years after the onset of pubic hair growth. ----- | TRUE | FALSE |
| 12. | The pubertal growth spurt is a late event in boys and an early event in girls. ----- | TRUE | FALSE |
| 13. | The onset of puberty begins about six months later in boys than in girls. ----- | TRUE | FALSE |
| 14. | The growth spurt begins about 2 years earlier in boys than in girls. ----- | TRUE | FALSE |
| 15. | The exact mechanism by which puberty is initiated is not known as yet. ----- | TRUE | FALSE |
| 16. | Reddening and thinning of the skin of the scrotum usually accompanies early testicular and scrotal enlargement. This is considered Tanner Stage 2 Genital Development in Boys. ----- | TRUE | FALSE |
| 17. | The first sign of puberty in most girls is the development of "breast budding" and areolar enlargement. This is considered Tanner Stage 2 Breast Development in Girls. ----- | TRUE | FALSE |
| 18. | Unilateral breast development for three months or more in girls is abnormal. ----- | TRUE | FALSE |
| 19. | The testes increase about ten-fold from the pre-pubescent size to final maturity. ----- | TRUE | FALSE |
| 20. | Premature adrenarche is properly defined as the isolated appearance of pubic and/or axillary hair prior to age 8 in girls or prior to age 9 in boys. It is more common in girls than boys and usually represents early androgen secretion of the adrenal cortex. ----- | TRUE | FALSE |

KEY FOR MATURITY STAGING CERTIFICATION QUIZ

1. FALSE. Girls do start their growth spurt first, however, boys have higher peak height velocities.
2. TRUE.
3. TRUE
4. FALSE. In approximately 98% of boys, pubic hair development occurs after testicular enlargement (usually within six months).
5. FALSE. The first menstrual period (menarche) is a relatively late pubertal event. It usually occurs about two year following breast budding.
6. TRUE.
7. TRUE.
8. TRUE.
9. TRUE.
10. TRUE.
11. TRUE.
12. TRUE.
13. TRUE.
14. FALSE. The growth spurt usually begins two years earlier in girls versus boys.
15. TRUE.
16. TRUE.
17. TRUE.
18. FALSE. Unilateral breast development may persist as long as six months.
19. TRUE.
20. TRUE.

9.10 References

1. Copeland KC, Brookman RR, Rauh JL: Assessment of Pubertal Development. Ross Laboratories, Columbus, Ohio, 1986.
2. Van Wieringer JC, Wafelbakker F, Verbrugge HP, DeHass JH: Growth Diagrams 1965. Wolters - Noordhoff Publishing, Groningen, Netherlands, 1971.
3. Rallinson ML: Chapter 5, pp. 108-120, in Growth Disorders in Infants, Children, and Adolescents. John Wiley & Sons, Inc., New York, 1986.

March 27, 1995

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The descriptive standards for staging of genital maturity and pubic hair development in boys can be seen in Plates P-1 through P-5 and G-1 through G-5 (Exhibit 9.2). Genital development progresses from that of pre-adolescence (Stage 1) to the beginning of testicular and scrotal enlargement (Stage 2). Penile enlargement and continued testicular and scrotal enlargement characterize Stage 3. In Stage 4 further penile, testicular and scrotal enlargement occur and this process progresses to adult-size and shape genitalia at Stage 5.

The volume of each testis in pre-pubescent boys is usually 1 to 3 ml. When puberty begins, the testicular volume enlarges to 4 ml and is usually accompanied by reddening and thinning of the scrotum. Usually the penis enlarges and pubic hair appears during the year following this early testicular enlargement. During the course of puberty the testes enlarge approximately ten-fold, obtaining an adult size of 15 to 25 ml.

The timing of the pubertal growth spurt is different in boys and girls. As mentioned, girls usually demonstrate acceleration of linear growth at the onset of puberty and reach their peak height velocities relatively early in puberty. Boys typically start at genital and pubic hair Stage 3 (coinciding with beginning phallic enlargement) and generally reach their peak height velocity when their genital and pubic hair development is Stage 4.

Breast enlargement in boys is characterized by an increase in areolar diameter and occurs in about 1/2 to 3/4 of all normal boys. This is known as physiologic gynecomastia of adolescence and may be unilateral or bilateral. This pubertal gynecomastia occurs most commonly during genital Stage 4 and typically regresses after 12 to 18 months.

Pubic hair development in boys follows the same pattern as that described in girls.

9.5 Instructions for Assessing Tanner Stages in Boys

9.5.1 Genital

Tanner staging of male genitalia will be performed in conjunction with the general physical examination and will be performed at SV2 and visits at 6, 12, 24, 36, and annually until Tanner 5 is reached. Plates G-1 through G-5 (Exhibit 9.2) and the following descriptive information will be used for Tanner staging.