

# Chapter 2

## Growth and Development in the Young Athlete

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### Stages of Adolescence

There are three general stages of adolescence—early, middle, and late—distinguished by common physical, cognitive, and psychosocial changes. Table 2.1 outlines various facets of early, middle, and late stages of development. Rate of progression through these facets varies among individuals but generally follows a predictable pattern. This developmental sequence is shaped both by biological factors, particularly hormonal changes, and psychosocial factors, particularly support from parents, peers, and other role models. Understanding the typical progression from childhood to adulthood is essential for promoting healthy physical and mental growth among young athletes.

### Physical Development

Puberty, a biological process primarily governed by hormonal changes, marks the beginning of adolescence and the progression to reproductive maturity. The process of sexual maturation is governed by two hormonal axes—the

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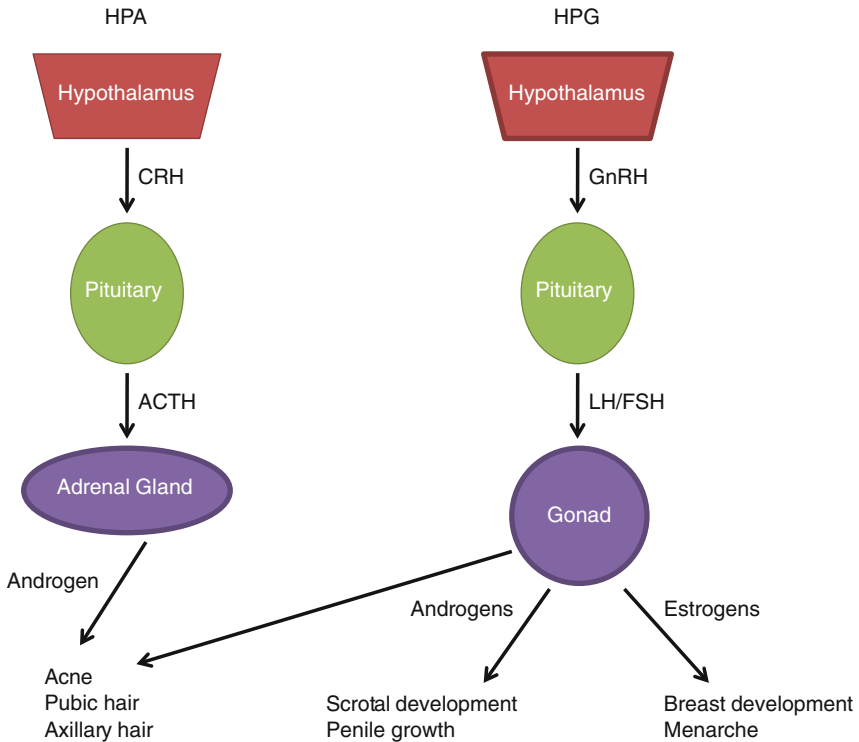
**Table 2.1** Characteristics of early, middle, and late adolescence [1]

	Early (11–14 years)	Middle (15–17 years)	Late (18–21 years)
Central question	Am I normal?	Am I liked?	Am I loved?
Physical	Onset of puberty Growth acceleration	Continued sexual development (maturation in most girls) Continued growth	Sexual maturity Slowed growth
Cognitive	Concrete thinking	Emerging abstract thinking Emotion-driven behavior	Formalized abstract thinking Future-driven behavior
Self-perception	Self-conscious about appearance	Exploration of different personas	More stable self-identity
Family relationships	Increased need for privacy	Peak of parental conflict	Independence from family
Peers relationships	Same-sex peer groups	Mixed-sex peer groups Dating relationships	One-on-one relationships

hypothalamic-pituitary-adrenal axis and the hypothalamic-pituitary-gonadal axis (Fig. 2.1). The adrenal axis is typically activated first, resulting in a rise in androgen production. This rise may occur as early as 6 years of age and is sometimes associated with body odor and, in a small number of children, premature adrenarche or the appearance of sexual hair in girls younger than 8 years of age or boys younger than 9 years of age [2]. The true onset of puberty, however, coincides with activation of the gonadal axis. A rise in pulsatile gonadotropin-releasing hormone (GnRH) secretion from the hypothalamus stimulates secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary. LH and FSH then stimulate gonadal production and secretion of androgens and, in females, estrogens.

### ***Female Sexual Maturation***

In the United States, girls usually begin puberty earlier than boys, with the typical onset of breast development, or thelarche, between the ages of 8 and 12 years. Thelarche, which is primarily under the control of estrogens secreted by the ovaries, is divided into five developmental stages described by the Tanner scale (Fig. 2.2a). Tanner 1 is prepubertal. Tanner 2 indicates the start of thelarche with the formation of a breast bud localized to the nipple. In Tanner 3, the breast bud extends beyond the nipple and areola (the darker pigmented area around the nipple). In Tanner 4, the areola becomes a separate mound on top of the primary mound of the developing breast. Tanner 5, the adult breast, is achieved when the areola becomes flush with the breast with a protruding nipple. In normal boys ages 11–15 years, breast buds may develop and then regress by age 14–16 years. Progression to Tanner 3 breasts in a male, however, indicates gynecomastia and deserves attention from a pediatrician or endocrinologist.

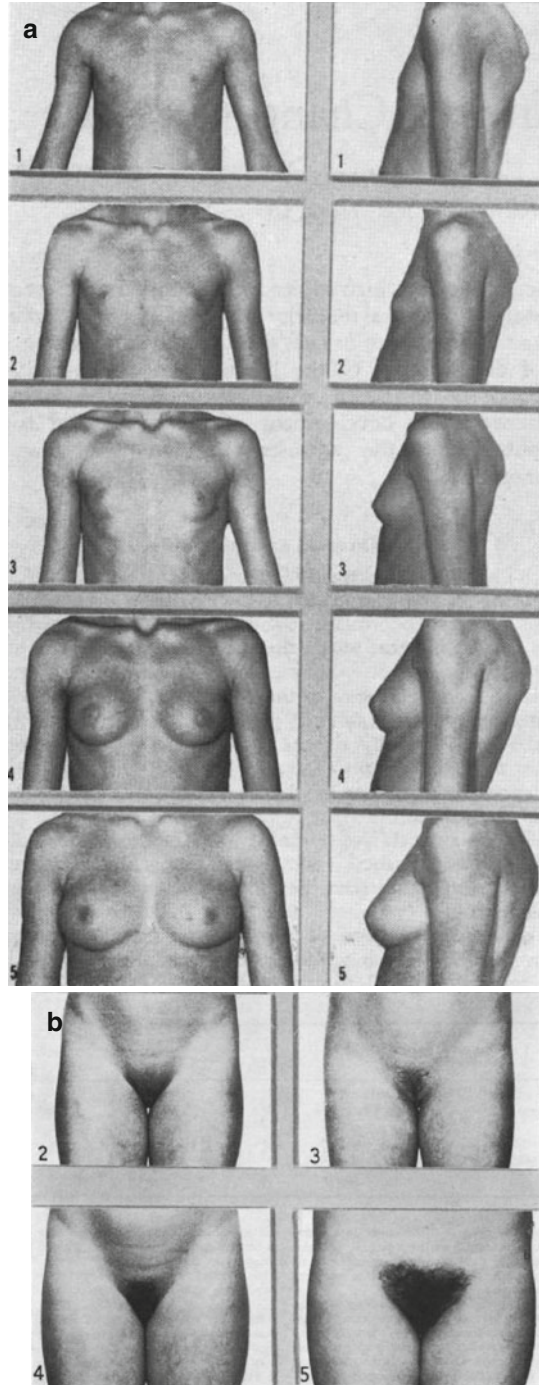


**Fig. 2.1** Regulation of hormonal changes during puberty by the hypothalamic-pituitary-adrenal (HPA) axis and the hypothalamic-pituitary-gonadal (HPG) axis

Pubic hair development (Fig. 2.2b), called adrenarche, generally progresses along with breast development. However, because pubic hair development is predominantly controlled by androgens secreted by the adrenal glands, the two developmental processes are not always simultaneous. Adrenarche follows a similar trajectory for girls and boys. Tanner 1 is prepubertal with no pubic hair. Tanner 2 occurs with the first appearance of downy hair (easily countable). In Tanner 3, hair becomes more coarse and curly and extends laterally into an upside-down triangle (countable only if obsessive compulsive). In Tanner 4, hair extends across pubis and forms a more dense upside-down triangle (too many to count) and, by Tanner 5, extends to the thighs. A majority but not all adolescents progress to Tanner 4 or 5 pubic hair.

Menarche, the onset of menstruation, occurs about 2 years following the onset of female puberty, usually between the ages of 10–14 years. The timing of puberty is not completely understood but appears to be influenced by genetic as well as environmental factors, including adiposity, nutrition, physical activity, and exposure to endocrine-disrupting chemicals [4, 5]. Changes in these factors, such as the rise in obesity in developed countries, are thought to contribute to the decreasing age of menarche observed over the past few decades [6, 7].

**Fig. 2.2** Tanner stages of sexual maturity in girls. **(a)** Tanner stages of breast development. *Stage 1*, preadolescent; *stage 2*, breast bud forms with elevation of areola and papilla; *stage 3*, enlargement of breast and areola; *stage 4*, projection of areola to form a secondary mound above the level of the breast; and *stage 5*, areola returns to the general contour of the breast. **(b)** Tanner stages of pubic hair development in girls. *Stage 2*, sparse downy hair chiefly on labia (base of penis for boys); *stage 3*, hair extends laterally and becomes more coarse and curly; *stage 4*, adult-like hair extending across pubis but sparing thighs; and *stage 5*, hair extends to medial thighs (Reprinted with permission from [3])

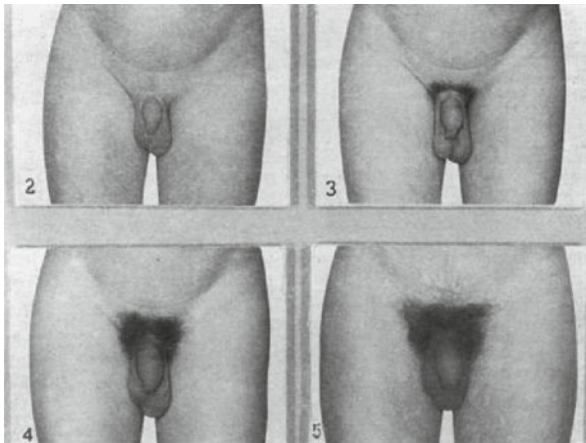


### ***Male Sexual Maturation***

In males, puberty begins with an increase in testicular volume between the ages of 9 and 14 years (Fig. 2.3). Tanner 1, prepubertal, progresses to Tanner 2 with scrotal enlargement and thinning of the scrotal skin. Tanner 3 is marked by initial penile growth, primarily in length, and further scrotal enlargement. In Tanner 4, the penis grows in girth as well as length and the scrotal skin darkens. By Tanner 5, the genitals have reached their adult size and appearance. Pubic hair develops as described in the previous section on female puberty (Fig. 2.2b). In males, pubic hair growth is closely correlated to the growth of the penis since both processes are governed by androgens. Discordance between these two sequences can occur with some disease conditions that affect the adrenal glands or testicles and therefore deserves medical attention.

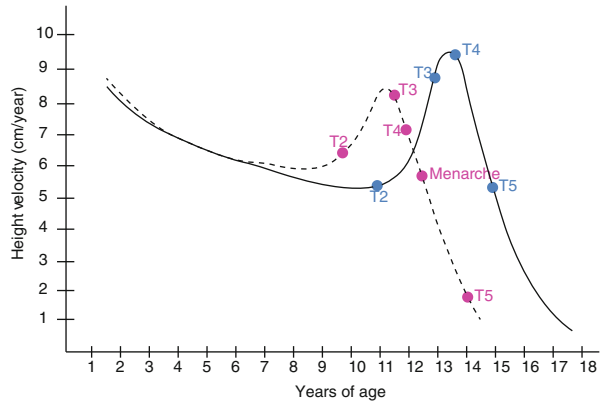
### ***Growth Acceleration***

Growth acceleration begins in early adolescence for both girls and boys but reaches its peak velocity, known as the “growth spurt”, at different times depending on gender. In girls, the peak height velocity typically occurs during Tanner stage 2 (Fig. 2.4). The peak height velocity in girls is about 8.3 cm/year. Boys, in contrast, reach their peak height velocity around the time of Tanner stage 4, 2–3 years later than girls, and reach a higher velocity of about 9.5 cm/year (Fig. 2.4). This



**Fig. 2.3** Tanner stages in gonadal and pubic hair development in boys. *Stage 2*, enlargement of testes and scrotum with thinning and reddening of scrotal skin; *stage 3*, enlargement of penis in length and further enlargement of scrotum; *stage 4*, enlargement of penis in length and circumference and further enlargement scrotum with darkening of scrotal skin; and *stage 5*, adult genitalia (Reprinted with permission from [8])

**Fig. 2.4** Sequence of sexual maturation during puberty in males (*solid line*) and females (*dashed line*) (Adapted from [9, 10])



difference in velocity and timing eventually results in higher stature in males compared to females.

The sequence of musculoskeletal growth creates a vulnerable period of reduced balance, flexibility, and bone strength. Growth acceleration occurs first in the distal limbs followed by the proximal limbs and, in late adolescence, the trunk [11]. This asynchronous growth pattern results in long limbs with little axial support, leading to a decline in balance and coordination during early and middle adolescence. In addition, because bone growth outpaces the growth of muscle and tendons, adolescent joints have reduced flexibility. As bone grows, it initially forms a matrix that is later mineralized to improve strength and rigidity. In adolescents, bone mineralization lags behind matrix formation by up to a year, resulting in a period where the new bone is soft and more prone to fracture [12, 13]. Thus, especially during peak height velocity, adolescents have an increased risk of strains, sprains, and fractures.

### ***Coaching the Developing Body: Preventing Injury During Growth***

Sports are the main cause of injury in adolescents. As described above, adolescence is a period of particular risk of injury due to the rate and sequence of musculoskeletal growth. Injury can have both short-term and long-term consequences, including economic costs, inability to participate in sporting activity, and early osteoarthritis [14]. Nearly two million US adolescents go to the emergency department each year for injuries related to sports or recreation activities [15]. In adolescent tennis players, ankle sprains are the most frequent cause of acute injury, followed by knee injuries such as anterior cruciate ligament (ACL) tears [16]. Chronic overuse injuries, including lateral epicondylitis (i.e., “tennis elbow”), shoulder pain, back pain, and metacarpal stress fractures, are also common in young tennis players [16–19].

Preventing injuries relies on having sport programs that emphasize proper technique, conditioning, rest, and psychological health. Research on preventive strategies in adolescent sports has shown that preseason and in-season conditioning programs have the potential to decrease the risk of injury. The most effective programs are those that include strength, flexibility, balance, and sport-specific technique training [14]. Adequate rest, particularly following an injury, is also important to avoid overuse injury and long-term damage. Current recommendations are that young athletes take off 1–2 days a week and 2–3 months a year from their sport [20]. In addition, incorporating strategies to combat the emotional and psychological stress of sport participation can help to protect adolescents from overtraining and burnout, as discussed in later sections.

## **Cognitive Development**

Adolescence is a period of rapid change in brain structure and function. During this period, more complex thinking processes emerge as adolescents transition from concrete thinking (i.e., thinking focused on actual objects and experiences) to abstract thinking (i.e., thinking characterized by the use of concepts and generalizations). This transition leads to improved judgment, risk assessment, emotional regulation, and self-direction. In addition to improvements in reasoning, adolescents also exhibit improvements in information processing, particularly processing efficiency and capacity, and improvements in visuospatial control of movement.

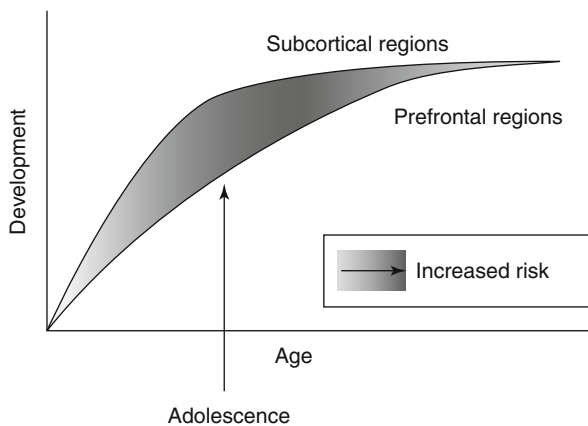
### ***Executive Function***

Cognitive changes in adolescents are largely attributed to the development of brain regions involved in executive function, particularly the prefrontal cortex [21]. The prefrontal cortex is essential for planning, decision-making, and regulating social behavior. Numerous studies in cognitive behavioral research have demonstrated better performance on tasks that involve the dorsolateral prefrontal cortex, a region involved in working memory and planning, and the ventromedial prefrontal cortex, a region involved in evaluating risk and reward, in adolescents compared to children [22–24]. These behavioral studies are further corroborated by neurostructural studies that have shown increased growth and improved connectivity in these regions throughout adolescence [25]. The effects of these changes can also be observed in the sport environment. During middle adolescence, for example, young tennis players may be able to study their opponent and think through strategies that would utilize their own strengths while minimizing those of their opponent. This process involves abstract thought (the ability to apply knowledge to hypothetical situations) as well as executive function (the ability to plan and execute a game strategy). As described in the next section, however, these newfound skills are typically not applied to all realms of thought or action until late adolescence.

## Risk Seeking

Despite evidence of development within brain regions associated with executive function, adolescents continue to exhibit impulsive and irrational behavior well into middle adolescence. This apparent paradox is explained by a theory that, while the brain is rapidly developing, it continues to be immature [26]. Therefore, like a toddler who is cognitively ready to walk but lacks coordination due to inexperience, a teenager may be cognitively ready to regulate his or her behavior but lacks coordination to effectively use those skills. In addition, research suggests that subcortical regions of the brain involved in emotion and reward, particularly the amygdala and the nucleus accumbens, mature earlier than the prefrontal cortex [25, 27]. This mismatch in brain development leads to increased risk-taking and sensation-seeking behavior during adolescence (Fig. 2.5). While both sexes follow this general pattern of development, female adolescents generally exhibit lower risk-taking behavior and higher impulse control compared to males and, similar to pubertal development, reach peak levels of risk taking earlier than males [28].

Continuing the example from the previous section, while middle adolescents may be able to develop strategies to succeed in their next match, they may not have the foresight to avoid distractions the night before a match that will interfere with their performance. The immediate satisfaction from staying up late to text friends, browse the internet, or watch TV often overrides the decision to sleep in order to perform better tomorrow. Strategies to oppose these drives might include setting time limits on distracting behaviors or setting aside designated time for these distractions. On a more serious level, some adolescents may also choose to drink alcohol or do drugs for the immediate gratification they receive from their peers and the substance itself. They often understand the risks, including expulsion from the team or physical harm, but adhere to the “it won’t happen to me” mindset. Minimizing this type of risk-taking behavior requires limiting



**Fig. 2.5** Model representing the different rates in maturation of the subcortical and prefrontal regions of the brain. The size of the gap (*shaded*) in maturity between these regions correlates with increased risk of emotionally driven behavior (Reprinted with permission from [27])



access to adverse influences and improving access to safe environments, such as organized sport activities or clubs through the school or community.

### ***Visuospatial Processing***

Changes in the parietal lobe, which is responsible for integrating auditory, visual, and tactile signals, are also observed during adolescence. The parietal lobe combines sensory information, such as the shape of an object, its relation to surrounding structures, and body position, to create a visuospatial map and coordinate a motor response. Brain remodeling in the parietal lobe typically peaks in middle adolescence with earlier development in girls than in boys. This development is essential for improving visuospatial control of movement during sports and helps to explain the improvements in coordination seen in older adolescent athletes. In tennis, for example, parietal function allows a player to adapt his or her body and racket movement to different circumstances, resulting in a more accurate stroke. Adolescence is therefore an ideal time to refine motor skills and control in young athletes.

### ***Coaching the Developing Brain: Adapting to Different Abilities***

Rates of brain development can vary widely among individuals, with variations both in global cognition and in specific brain regions. In the athletic setting, it is important to assess the cognitive stage of individual athletes and to adapt coaching methods accordingly. Younger adolescents, for example, may have difficulty accurately performing complex movements or planning hypothetical strategies for an upcoming match. An effective coach will recognize these limitations to avoid frustration while continuing to build on the athlete's current skill set. In addition, anticipating potential challenges, such as impulsive behaviors or emotional volatility during matches, can help to reduce adverse effects on individual and team morale. Coaches should, for example, set clear guidelines for behavior and consequences for violating those guidelines. Participation in sports provides opportunities for teens to further develop their cognitive abilities, both by improving physical and mental coordination and by practicing group cooperation. Coaches hold the unique position to create an environment that accepts individual variations in ability and promotes good choices both on and off the court.

### **Psychosocial Development**

Adolescence is characterized by significant changes in social relationships as teens attempt to establish identities that are independent from their parents and family. During the typical progression of psychosocial development, adolescents shift their focus from more superficial concerns of external appearance and peer acceptance to

more reflective questions about who they are, who they want to become, and who they want to spend their lives with. This process often involves changes in self-expression, inner turmoil, and risky experimentation that can strain relationships with parents and other family members.

### ***Self-Perception***

Early adolescence is typically plagued by self-consciousness in response to the physical changes of puberty. During this stage of development, individuals are often preoccupied with external appearance, constantly comparing their bodies to those of their peers and those portrayed in the media. Young adolescents may also experience a “personal fable” in which they believe that they are the focus of everyone else’s attention, adding to their feelings of both uniqueness and self-consciousness. As teens progress into middle adolescence, they often become more accepting of their changing bodies and, as a result, start to experiment with different personas. Frequent changes in styles of dress, friend groups, and interests are common during this stage as adolescents start to ask the question, “Who am I?” In late adolescence, as physical changes slow down, individuals develop a more stable body image and self-identity. Older adolescents begin to think more independently and typically become less self-centered.

### ***Coaching the Developing Mind: Detecting Body Image Dissatisfaction***

Young athletes, like all adolescents, experience challenges with body image. In females, this body distress can manifest as a syndrome referred to as “the female athlete triad”—disordered eating, menstrual dysfunction, and decreased bone mineral density. At least one component of the triad is present in up to three-fourths of female adolescent athletes [29]. This triad is most common in sports that emphasize low body weight, such as long-distance running, gymnastics, figure skating, and dancing. Other sports, including tennis, have also been associated with an increased risk of different components of the female athlete triad, particularly disordered eating and menstrual irregularities [30]. Recently, the 2014 International Olympic committee introduced a new term, “Relative Energy Deficiency in Sport” (RED-S), to encompass those athletes who do not fully meet the criteria for the female athlete triad, including males, but may still experience its consequences [31, 32]. Relative energy deficiency is defined as energy expenditure that outweighs energy intake, which can have adverse effects on nearly every body system, including the reproductive, musculoskeletal, cardiovascular, and immune systems. Athletes are at increased risk of relative energy deficiency because of increased caloric requirements from regular strenuous activity and increased pressure to maintain a particular physique.

Prevention of RED-S and the female athlete triad requires early detection of warning signs, including weight loss, mood changes, dissatisfaction with appearance, decline in performance, and frequent illness, injury, or fractures. Energy repletion is the cornerstone of treatment along with multidisciplinary support from physicians, dietitians, mental health professionals, coaches, and family members [33]. Young athletes exhibiting warning signs should be referred to a health-care professional with experience in disordered eating as soon as possible. Early recognition is essential to prevent irreversible effects on physical and psychological health, growth, and sport performance.

### ***Social Relationships in Early Adolescence***

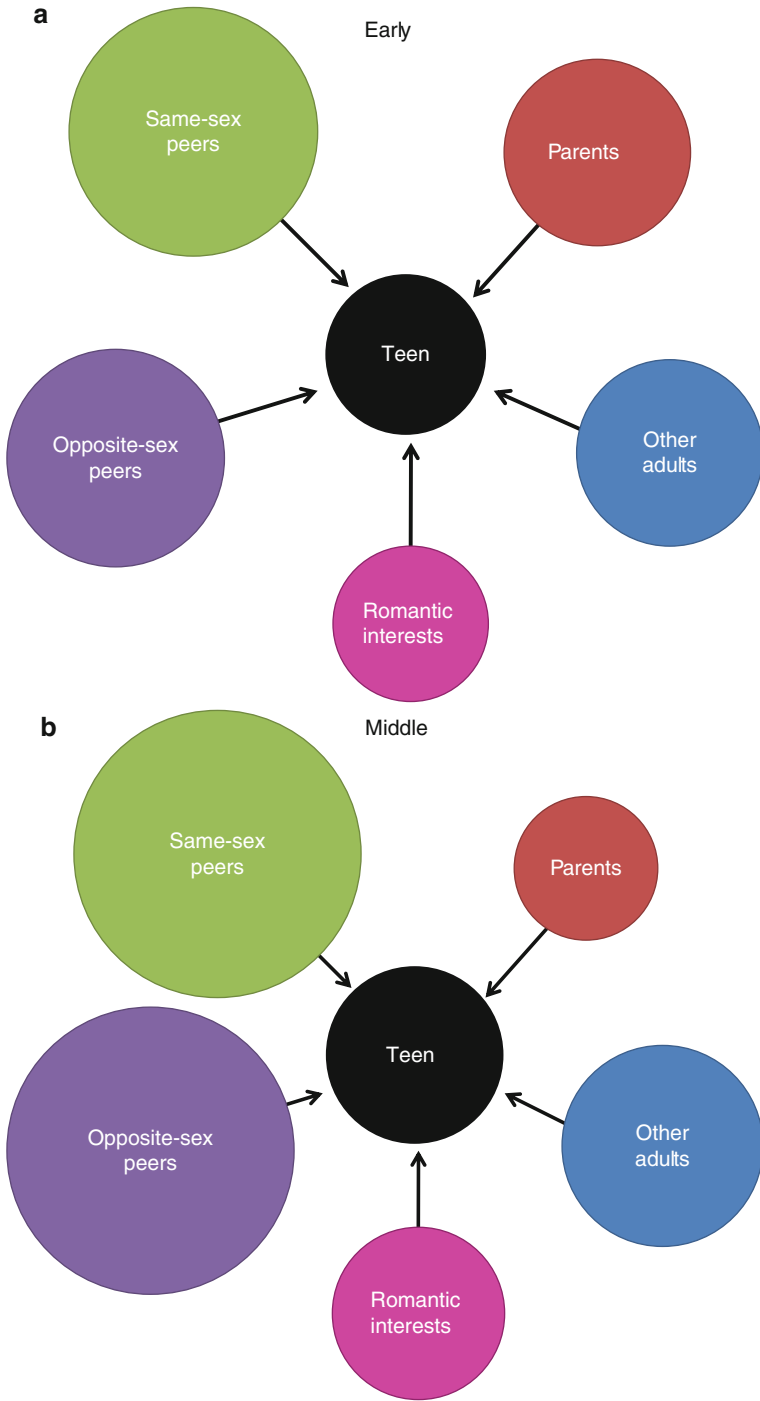
The transition from childhood to adulthood involves a gradual separation, both emotionally and economically, from parents and the family. This process begins in early adolescence with the formation of primarily same-sex peer groups [34]. These peer groups are often idealized and strongly influence how adolescents express themselves, such as through clothing, language, and activities, to fit in with the group (Fig. 2.6a). During this period, adolescents will often have an increased desire for privacy, a decreased interest in family activities, and a blatant disregard for parental advice regarding behavior or appearance. As a result of this separation, adolescents may seek role models outside of the family, such as through coaches, personal trainers, or older athletes. Sport participation can therefore provide a sense of belonging without disrupting the natural drive for autonomy.

### ***Social Relationships in Middle Adolescence***

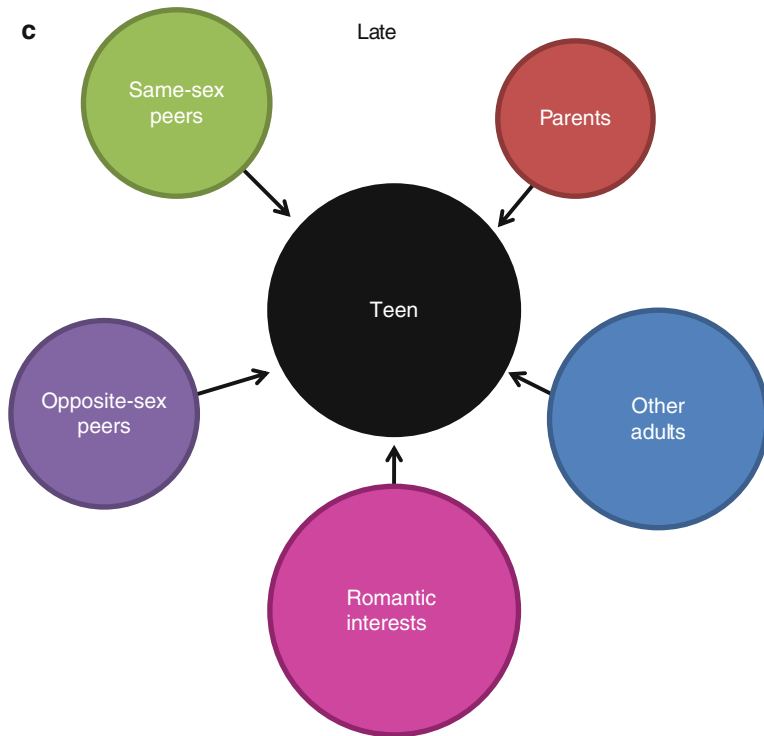
In middle adolescence, peer relationships gain increasing importance as adolescents become involved in mixed-sex peer groups and seek further independence from the family (Fig. 2.6b) [34]. Dating often begins at this stage, usually with short relationships characterized by intense emotion, physical attraction, and sexual experimentation. Middle adolescence is also when many youth acknowledge their sexual identity and orientation. This time of development is often the peak of teen-parental conflict. It is also a particularly sensitive period for the development of anxiety, depression, and loneliness as a result of perceived rejection by peers, potential romantic partners, and particularly in adolescents with same-sex attractions, family members [35, 36]. These stressors can impact athletic performance and concentration.

### ***Social Relationships in Late Adolescence***

By late adolescence, most adolescents have established a separate identity from their parents. They begin to place less importance on the peer group and more importance on intimate one-on-one relationships (Fig. 2.6c) [34]. These



**Fig. 2.6** Degree of influence from different social groups during (a) early, (b) middle, and (c) late adolescence



**Fig. 2.6** (continued)

relationships tend to be less superficial than those of middle adolescence with more emphasis on intimacy and increasing commitment. In preparation for adulthood, late adolescence is also a period when individuals often make career goals and future plans for their role in society. This shifting perspective correlates with the development of more mature thinking processes along with a firmer self-identity, allowing late adolescents to apply their values and goals to future ambitions.

### ***Coaching the Developing Individual: Supporting Athlete Autonomy***

Social development during adolescence involves an increasing need for both acceptance and independence. Sports provide an opportunity for young athletes to interact with peers who share a common interest, often creating a sense of belonging. In addition, mentoring relationships between coaches and athletes can help compensate for the guidance adolescents no longer seek from their parents. Coaches can also make sport training a chance for adolescents to exercise their autonomy in a safe environment. Studies show that supporting independence in sports is an effective way to improve self-esteem, maintain intrinsic motivation, and decrease dropout

[37, 38]. Multiple tactics can be used to create a climate that promotes autonomy, including providing choices for practice activities or match strategies, offering rationales for planned activities, acknowledging athletes' feelings and perspectives, and providing constructive feedback [39]. This approach allows adolescents to take responsibility for their own development both as athletes and as individuals.

## **Parental Role in Young Athlete Development**

Adolescence is a transitional period for parents as well as their children. Parents no longer experience the same level of companionship or maintain the same level of authority they had during earlier stages of childhood. Navigating this new role requires parents to let go of their old relationship and, gradually, their child as he or she experiments with independence. For the parents of young athletes, this process involves finding ways to support adolescents in their sport without attempting to control their performance. Sports can be a healthy venue for adolescent growth and development, but the greatest benefit comes when young athletes participate on their own accord and set their own goals. Parents play an important role by providing appropriate encouragement while helping athletes navigate the challenges of sport participation, such as failures and stress.

### ***Support Without Pressure***

There is a fine line between creating an environment of support and creating an environment of pressure. Studies looking at how young athletes view parental participation in sports consistently show that players want their parents to be involved in their sport [40–42]. Players who perceive pressure from their parents to perform, however, tend to have less motivation and less enjoyment [40]. A study in young tennis players found that athletes preferred their parents to provide comments on non-tactical aspects of performance, such as attitude and effort, rather than critiquing their performance and attempting to coach [42]. As part of the adolescent drive for independence, young athletes generally prefer parents to take on an observational role in their sport. Being overly controlling can discourage participation by making the court an extension of the home rather than a place for teens to find structure and support outside the family.

### ***Achievement by Proxy***

One of the dangers of parental over-involvement is “achievement by proxy.” This phrase describes a condition where a parent or other involved adult lives vicariously through the accomplishments of his or her child. As a result, the underlying motivation for sports participation is skewed toward the goals of the adult rather

than those of the athlete. This skewed perspective of success leads not only to excess pressure on the teen but also, potentially, to neglect and abuse as parental ambitions take precedence over the desires, needs, and health of the child [43]. It is therefore crucial that parents monitor their motivations by asking, “Am I doing this for my child or for myself?”[44] Supporting a young athlete requires maintaining realistic expectations based on his or her stage of development as well as regularly reassessing the goals of sport participation for the child, the parent, the coach, and other involved individuals. Parents and coaches should work together to provide a positive sport experience that matches the desires and physical abilities of the athlete.

### ***Preventing Burnout***

Burnout—physical or emotional exhaustion leading to decreased sport enjoyment and accomplishment—is a common problem among young athletes [45]. The condition is considered a response to chronic physical and psychological stress. Risk factors include both environmental factors, such as high time demands and high performance expectations, and personality traits, such as perfectionism, low self-esteem, and high anxiety. Stress reduction techniques lie at the center of both prevention and treatment of burnout. Daily tools, such as deep breathing or reciting affirmations (Box 2.1), can help athletes to relax and maintain a positive attitude [46]. In addition, taking regular breaks from their sport will allow adolescents to rest their bodies and avoid overuse injuries. Current recommendations are that adolescents take off 1–2 days per week from organized sports and 2–3 months a year from training and competition [20]. Lastly, it is essential that both parents and coaches maintain reasonable expectations based on the physical, cognitive, and psychosocial stage of an athlete.

#### **Box 2.1. Helpful Affirmations for Young Athletes**

- I let any stress just flow over or past me, without absorbing it into my body.
- I can do my work quickly and well, while staying physically relaxed.
- I am able to deal well with stress, extra work, or excitement, without triggering any uncomfortable symptoms.
- I have the power to choose how I respond to everything in my life.
- I handle any problems with a calm mind and relaxed body.
- I am able to change anything in my life.
- All my old habits and thoughts are just memories. I can replace them at any time with new habits of positive thoughts and peacefulness.

Reprinted with permission from [46]

## Conclusion

Adolescence is a period of change and passage. Supporting young athletes as they transition from childhood to adulthood requires a delicate balance of providing guidance and permitting independence. As their bodies grow, adolescents must learn to adapt their motor skills in order to take into account new abilities as well as new limitations. As their brains develop, they must learn to practice behavioral control and consider other perspectives in order to achieve personal goals and function as a team. As their social relationships shift, they must learn to find support from outside the family in order to establish their own individual identities. Sport participation can have a positive impact on each aspect of adolescent development by providing young athletes with a safe environment to express and challenge themselves. At the same time, however, working with young athletes comes with unique challenges, including increased risk of injury, rebellious behavior, emotional volatility, and a growing desire for independence. Successfully navigating these challenges requires understanding and support from family members, coaches, and other figures involved in the adolescent's life.

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