millions of children and adolescents participate in public and private school athletics each year. Additionally, millions more enjoy organized community-based sports. Originally, the preparticipation physical examination was established to identify life-threatening or disabling conditions that placed athletes at increased risk in certain athletic activities. Today, many schools and communities depend on the yearly preparticipation physical examination to meet legal and insurance requirements. The preparticipation physical examination was never intended nor designed to replace the athlete's regular health maintenance examinations or to inappropriately exclude athletes from participation. Unfortunately, most parents and athletes perceive the preparticipation physical examination as a complete medical evaluation and make it the only contact that the athlete has with a physician.

Among state and community organizations that have guidelines directing the preparticipation physical examination, wide variation is seen in length, composition, content, and comprehensiveness. To counter this discrepancy, five major medical societies have developed a monograph, Preparticipation Physical Evaluation, 2nd edition,\(^1\) that establishes a baseline content for scholastic preparticipation physical examinations. In addition, many medical organizations have developed guidelines, usually based on expert opinions and consensus, to assist and support physicians in making appropriate recommendations regarding athletic participation.\(^2,3\)

Primary and secondary objectives for the preparticipation physical examination have been developed. The primary objectives are to (1) detect conditions that may predispose to injury; (2) detect conditions that may be life threatening or disabling; and (3) meet legal and insurance requirements. Secondary objectives are to (1) determine general health; (2) counsel on health-related issues; and (3) assess fitness level for specific sports.

The medical history serves as the cornerstone of any preparticipation physical examination. Almost 80% of all major medical and orthopedic problems that lead to restriction or disqualification are detected by a review of the athlete's personal and family history.\(^1\) Pediatricians should handle most conditions identified during the preparticipation physical examination. The objective of this article is to demonstrate how pediatricians who care for young athletes can use the medical history to maximize the effectiveness of the preparticipation physical examination.

EXERCISE-INDUCED ASTHMA

A mildly overweight 13-year-old girl in the seventh grade is scheduled for a preparticipation physical examination. She is trying out for basketball this year. She reports not being active because she has trouble keeping
up with her friends. She denies any knowledge of anyone in her family having asthma. Otherwise, her history and the results of her physical examination are normal.

Important questions to be asked during the preparticipation physical examination include:

1. Do you cough, wheeze, or have trouble breathing during or after activity?
2. Do you have asthma?
3. Do you have seasonal allergies that require medical treatment?
4. Does anyone in your family have asthma?
5. Do you get chest pains with exercise?
6. Do you tire before your friends do while playing?

Approximately 5 million children and adolescents in the United States have asthma. Asthma ranks first among chronic conditions limiting physical activity. However, it goes undiagnosed in many children and adolescents. Exercise-induced asthma occurs in almost 90% of children and adolescents who have asthma and in approximately 40% of individuals who have allergic rhinitis. Unrecognized exercise-induced asthma has been demonstrated in 5% to 15% of all children and adolescents, as well as in many college and Olympic athletes.

An exercise challenge can be used to establish the diagnosis of exercise-induced asthma. Exercise must be sufficiently strenuous to increase the baseline heart rate to 80% of maximum (calculated as 220 – age in years) for a continuous 4- to 6-minute period. A decrease of 15% or greater in peak expiratory flow or forced expiratory volume in 1 second using measurements taken before and after exercise at 5-minute intervals for 20 to 30 minutes is compatible with the diagnosis of exercise-induced asthma.

Many types of exercise challenges have been used to demonstrate bronchial responsiveness to exercise. The two most common laboratory methods use either a treadmill or a bicycle ergometer. However, neither is feasible in most pediatric offices. Free-run challenges have been shown to be a practical, objective epidemiologic test to measure bronchial responsiveness in children. However, these require a safe place to run and depend on the child to use maximal effort to complete the task.

In contrast, many researchers have shown that a submaximal step-test is a simple, portable, and reproducible means for detecting changes in pulmonary function and thus identifying children with exercise-induced asthma. This form of testing requires little space, can be completed in an office or school setting, and is easily monitored to ensure appropriate effort on the part of the child. An added advantage is that, when necessary, the step-test can usually be transported to the site where the previous symptoms occurred. Equipment required to complete a step-test exercise challenge includes an 8- to 10-inch step, a belt heart rate monitor, a metronome or music to step by, and a portable spirometer.

The step-test exercise challenge involves stepping up and down on a single step for 4 to 6 minutes at an intensity that maintains the heart rate at the predicted 80% of maximum level. A belt heart rate monitor can continuously monitor the level of intensity. The stepping rate should be varied to maintain the target heart rate for the entire period of exercise. Pulmonary function should be tested at 5-minute intervals following cessation of exercise for up to 30 minutes. Rescue treatment should be immediately available if an asthmatic episode is induced.

Following the identification of exercise-induced asthma, counseling about avoidance and control of triggers, in conjunction with an asthma-management plan and appropriate asthma medications, will allow children to participate in physical activity. Exercise-induced asthma should not limit either participation or success in vigorous activities. Individuals with asthma whose physical fitness is good and whose asthma is well controlled respond to physical activity in the same way that their peers do. In addition, they have fewer exacerbations of their asthma, use less medication, and miss less school and work.

Coaches need to be notified when a child has exercise-induced asthma. Individuals participating in competitive athletics need to be aware that they should disclose their use of medication and should adhere to appropriate standards.

Beta₂-agonists will prevent exercise-induced asthma in more than 80% of children. Short-acting inhaled beta₂-agonists used shortly before exercise (or as close to exercise as possible) may be helpful for 2 to 3 hours. Salmeterol has been shown to prevent exercise-induced asthma for 10 to 12 hours. Cromolyn and nedocromil taken shortly before
exercise are also acceptable for preventing exercise-induced asthma. A warm-up period (5 to 10 minutes of activity at 50% to 60% of maximum heart rate) before exercise may benefit patients who can tolerate continuous exercise with minimal symptoms. The warm-up may preclude a need for repeated medications. Appropriate long-term control of asthma with anti-inflammatory medications can reduce the frequency and severity of exercise-induced asthma.

**MILD TRAUMATIC BRAIN INJURY**

A healthy 15-year-old boy is being seen for his annual health supervision visit prior to starting school. You have been his pediatrician since birth. Once you have completed the evaluation, he asks for a letter clearing him to play football. Before you do this, you ask his mother whether there have been any changes in his health since his last visit. She reports only that he had a slight concussion during spring football but he is all right now.

Important questions to be asked during the preparticipation physical examination include:

1. Have you ever had a head injury or concussion?
2. Have you ever been knocked out, become unconscious, or lost your memory?
3. Have you ever had a seizure?
4. Do you have frequent or severe headaches?

It is conservatively estimated that 250,000 high school football players sustain a sport-related brain injury each year. Twenty percent of high school football players and 40% of college football players have a head injury at some point in their careers. Those who do have a two to four times greater risk of reoccurrence. More than 90% of athletically related head injuries are mild traumatic brain injuries that require physicians to make a decision concerning further participation in athletic activities. It is believed that return to play before full recovery of the brain can lead to second impact syndrome, prolonged cognitive deficits, or post-concussion syndrome. Multiple concussions, particularly close together, have led to long-term and sometimes permanent cognitive deficits. Football players often return to play although they may still be symptomatic or have not received appropriate discharge instructions following release from a hospital for a concussion.4810

Assessing a head injury, whether simple or catastrophic, is never simple. Whether on the sideline or during a preparticipation physical examination, evaluation is often complicated by the reluctance of the young athlete to be honest because he or she is afraid of being held from play. Multiple recommendations have been published regarding treatment and return to play for such athletes. Historically, these recommendations have been based on experience, anecdotes, and published consensus guidelines of experts with little scientific data to support them.

Pediatricians should be familiar with at least one grading scale to assist with evaluation and treatment of the athlete with a concussion. Examples are provided in Tables 1 and 2.10

Pediatricians asked to clear an athlete to participate or return to play following a head injury are faced with a difficult decision. Because mild traumatic brain injury is an evolving process rather than a static event, it should be evaluated with serial examinations. Although some concussion scenarios present challenges to the physician, there is no question that a symptomatic athlete should not return to participation in a contact or collision sport. Unfortunately, there is no evidence that neurocognitive function returns to normal when symptoms have subsided in humans.

A physician should evaluate all athletes who have sustained head trauma and are asking to be cleared to participate or return to play. Eager athletes and their parents are often in a rush to return to play or obtain clearance. Pediatricians assessing an athlete following an acute athletic-related traumatic event should proceed cautiously. Following a loss of consciousness, persistence of symptoms for longer than 15 minutes or delayed onset of any symptoms (eg, headache, dizziness, or slowness to respond mentally or physically) precludes return to play that day. Any deterioration in physical or mental status within 48 to 72 hours after the initial trauma warrants transport to an emergency facility. In most athletes, symptoms that persist for more than 1 week should be evaluated by computed tomography or magnetic resonance imaging to rule out structural pathology.

More commonly, the pediatrician is confronted with a history of mild traumatic brain injury that may or may not have included a loss of consciousness in the past. In these cases, the preparticipation
physical examination should include a thorough neurologic examination, assessment of concentration and short-term and long-term memory, and a history of school performance and interpersonal relationships. Any deficit in these areas requires further assessment and withholding clearance. Evaluations should include tests in both a static and a dynamic state. Any appearance of associated symptoms is abnormal and should result in withholding clearance. External provocative (dynamic) tests could include sprints, pushups and sit-ups, knee bends, and sport-specific activities (e.g., jumping, hitting a ball, or kicking).

Neuropsychological testing is currently used clinically and as a research tool by a limited number of professional teams and college programs to assess the effects of head trauma and its use in management. Currently, general use of these tests for the management of mild traumatic brain injury is limited because of the lack of availability of baseline testing, lack of validation of the test battery, and problems involving repeated testing and interpretation. However, some of these tests may be incorporated into practice in the future. They may provide important information to assist the pediatrician in making a decision about return to play, especially for patients with multiple concussions or persistent symptoms.

Final decisions about participation should be based on established guidelines and the clinical judgment of the examining pediatrician.

**FEMALE ATHLETE TRIAD**

A 16-year-old competitive cross-country runner presents for her annual physical examination. She has been free of injury during the past year. Pertinent positive results on the history include menarche at 14 years of age but no menstrual period during the past 6 months and a desire to lose 5 to 10 pounds. Her current height and weight are 5 feet 6 inches and 105 pounds, respectively. This corresponds to a body mass index (BMI) of 17. Her examination is notable for a sinus bradycardia at 56 beats per minute, extreme thinness, and cold and mottled extremities. The mid-shaft of her right tibia is painful to palpation.

Important questions to be asked during the preparticipation physical examination include:
1. What do you consider your ideal weight? What is the most you have weighed?

2. Have you engaged in any of the following behaviors as a weight loss mechanism: dieting, avoidance of specific food groups, excessive exercise, or ingestion of diet pills, diuretics, laxatives, or ipecac?

3. Do you vomit to avoid weight gain?

4. Do you have a history of stress fractures?

5. Have you noticed a change in your mood or energy level?

Body mass index (weight in kg/height in m²) is a good marker for degree of thinness. The “normal” postmenarchal BMI is above 19. A BMI below 18 has been correlated with decreased bone mineral density. A BMI below 17 is considered at risk for anorexia if other behavioral components are present. An individual with a low BMI who desires further weight loss should be considered at risk for an eating disorder.

Secondary amenorrhea is generally defined as an absence of three to six consecutive menstrual cycles or fewer than three menstrual cycles in a year after a regular cycle has been established. Although athletes with amenorrhea may be frequently encountered in pediatric practice, amenorrhea should not be considered “normal” and requires further evaluation. Studies using patient self-report surveys have demonstrated a frequency of amenorrhea in the athletic population of between 34% and 66%. “Athletic” amenorrhea should be considered a diagnosis of exclusion of secondary amenorrhea. Other medical conditions (eg, prolactinoma, hypothyroidism, chronic medical illness, polycystic ovarian dysfunction, pregnancy, and premature ovarian failure) need to be ruled out.

Finally, the presence of tenderness on the midshaft of the right tibia raises concerns of an overuse injury (ie, stress fracture). This can reflect the amount of exercise this athlete is performing to achieve her low body weight or be a consequence of low bone mineral density due to her restrictive dietary practices and her hypoestrogenic state. A patient with signs or symptoms of a stress fracture should not be cleared for sports participation until a fracture is ruled out. Furthermore, restrictions should be placed on an athlete with an eating disorder and amenorrhea.

The female athlete triad, as defined by the American College of Sports Medicine, is a constellation of disorders (disordered eating, amenorrhea, and osteoporosis) that develop as a consequence of excessive exercise and maintenance of an unnatural body weight.

**Disordered Eating**

Disordered eating is a spectrum ranging from abnormal eating behaviors (restrictive diet) to clinically defined anorexia and bulimia nervosa. Certain sports place athletes at increased risk for eating disorders. These include those that involve subjective judging (eg, gymnastics, diving, figure skating, and ballet), weight classes (eg, lightweight crew and martial arts), and low weight for performance enhancement (eg, long-distance running and swimming). The prevalence of eating disorders in athletes has been reported to be between 15% and 62% (1% to 5% is the frequency in the general population).

**Amenorrhea**

As described earlier, amenorrhea is defined as the absence of menstruation for 3 to 6 consecutive months or fewer than 3 menstrual cycles in a year. It is generally secondary to other causes in the athlete.

**Osteoporosis**

Osteoporosis is defined by the World Health Organization as a condition of skeletal fragility due to low bone mass, micro-architectural deterioration of tissue, or both. It is clinically defined as a bone mineral density of more than 2.5 standard deviations below the mean. Osteoporosis is generally identified in postmenopausal women, elderly individuals with underlying medical conditions, or individuals receiving high-risk medications (eg, steroids or thyroid medications). Research has demonstrated that athletes with exercise-induced amenorrhea for a duration of even 1 year are at risk for irreversible trabecular bone loss. Young women exhibiting signs or symptoms of this disorder must be identified early because prognosis and risk for long-term complications depend on it.

**Evaluation and Treatment**

The female athlete triad can have devastating immediate and long-term health complications. Immediate consequences include decreased perfor-
mance, nutritional deficiencies, and an increased risk of injury and illness with diminished healing potential. The risk of a stress fracture is 4.5 times greater for the athlete with amenorrhea than for the eumenorrheic athlete. Long-term complications include infertility, depression, suicide, cardiac abnormalities, and osteoporosis. Osteoporosis has the greatest long-term morbidity because of its increased risk for vertebral compression fractures, hip fractures, and wrist fractures. Some young elite athletes who participate in weight-bearing activities (e.g., figure skating and gymnastics) have been found to have site-specific increases in bone mineral density despite amenorrhea. However, many studies have demonstrated that women with amenorrhea have irreversible decreases in bone mineral density despite resumption of menses, hormone replacement therapy, and calcium and vitamin D supplementation. Finally, a recent study presented at the American College of Sports Medicine annual meeting raises questions of premature cardiovascular disease in athletes with prolonged amenorrhea.

The evaluation of the athlete with this clinical scenario should include an x-ray to rule out a stress fracture. If radiographs yield negative findings, a triple-phase radionuclide study should be obtained or the radiographs should be repeated in 2 weeks. The evaluation of secondary amenorrhea should include a physical examination and routine screening blood work, including follicle-stimulating hormone level, prolactin level, complete blood cell count, thyroid-stimulating hormone level, and a pregnancy test. If the patient appears hirsute or has severe acne, luteinizing hormone, dehydroepiandrosterone sulfate, and testosterone levels should also be obtained. A progesterone challenge with 10 mg of medroxyprogesterone for 7 to 10 days for withdrawal bleeding is helpful to assess estrogen sufficiency. A baseline dual energy x-ray absorptiometry scan is recommended for patients with prolonged amenorrhea (> 1 year). If the results of the aforementioned evaluation are unremarkable, treatment for secondary amenorrhea can be considered. Finally, an evaluation by an eating disorder specialist (psychologist or psychiatrist) and a sports nutritionist is recommended because these disorders can eventually be fatal if not corrected.

Treatment for stress fractures is dependent on location. A tibial stress fracture requires restriction from any activity that produces pain. If the patient has pain with weight bearing, crutches are required for 7 to 10 days. These fractures generally heal within 6 to 8 weeks with non-impact activity (e.g., swimming). Some studies have shown improved healing if a leg air stirrup is used for additional support.

The method of treatment for amenorrhea is controversial. The American Academy of Pediatrics generally counsels against using hormone replacement therapy during the first 3 years of menarche or before 16 years of age. Eating disorder specialists are hesitant to prescribe hormone replacement therapy, because they feel it provides a false sense of security. In contrast, many sports medicine specialists do prescribe hormone replacement therapy, especially for the athlete with documented osteopenia or osteoporosis, because there is evidence that it may prevent further bone loss. Resolution of natural menstrual cycles can be achieved by weight gain and limiting activity. Drinkwater et al. have demonstrated that resumption of menstruation can be induced by a minimal weight gain (1.9 kg) and a 10% decrease in training.

Eating disorders should be managed under the direction of the primary care physician, a nutritionist, and a therapist. The primary care physician's role is to establish a contract with the athlete and monitor his or her physical well-being. The contract should include an acceptable weight range, the required weekly weight gain, and a determination of the weight at which exercise will have to be restricted and hospitalization will be required. If the patient has an associated mood disorder, obsessive-compulsive disorder, or anxiety disorder, medications such as a selective serotonin reuptake inhibitor may be warranted.

Treatment of osteoporosis is beyond the scope of this article. However, general recommendations include increasing calcium intake to between 1,200 and 1,500 mg/d and vitamin D to 400 to 800 IU/d and limiting the intake of soda because its high phosphate levels inhibit calcium absorption.

Scoliosis
A previously healthy 13-year-old girl, whom you have observed in your practice for years, presents for a preparticipation physical examination. The interim history is unremarkable except that she started menstruation 2
months ago and her mother has noticed that her right shoulder appears “higher” than the left.

Important questions to be asked during the preparticipation physical examination include:

1. Do you have any history of back problems or pain?
2. Does one leg seem longer than the other when you buy clothes?

Scoliosis is defined as a lateral curvature of the spine greater than 10° as measured via the Cobb angle on a standard radiograph. The Cobb angle is the angle formed by the perpendicular lines from the top of the superior vertebral endplate and the bottom of the inferior endplate of the two most tilted vertebrae. Scoliosis is present in approximately 2% to 4% of the adolescent population. Checking for a rib hump or scapular asymmetry as the patient touches his or her toes or measuring spine curvature with a scoliometer is the basis of scoliosis screening. A tilt of 7° as measured on a scoliometer corresponds to a radiographic curvature of approximately 20°.24

Idiopathic adolescent scoliosis is a diagnosis of exclusion and further workup is required if the scoliosis is atypical. A careful history, physical examination, and radiographs can eliminate secondary or atypical causes of scoliosis. The presence of systemic signs or symptoms, nighttime pain, abnormal skin stigmata over the spine, or neurologic abnormalities warrants further evaluation. Painful scoliosis has been associated with osteoid osteomas, osteoblastomas, spondylolysis, intraspinal tumors, infections, and disc herniation. Furthermore, rapid progression of a previously stable spinal curvature or atypical curvature (left-sided thoracic curve or right-sided lumbar curve) requires further evaluation by magnetic resonance imaging.

Generally, skeletally immature individuals with a curvature of less than 20° can be treated using radiographs and observation every 4 to 6 months until skeletal maturity. Only 10% of individuals diagnosed as having scoliosis have curves that require medical intervention. Skeletally immature individuals with a curve of 20° or greater should be referred to an orthopedic surgeon. Risks for progression include female gender, degree of curvature on presentation, and level of skeletal immaturity. Risser staging (0 to 5) of the iliac apophysis or Tanner staging is used to estimate skeletal (spinal) immaturity in females. Spinal growth continues for approximately 18 months after the onset of menses.24 The lifetime risk for progression of scoliosis is thought to be minimal for curves less than 30°, 10° to 15° for curves between 30° and 50°, and 1° annually for curves greater than 50°.23 Life-threatening alterations in pulmonary function develop with curves greater than 100°.

Idiopathic adolescent scoliosis does not preclude participation in sports. This athlete may require further evaluation by an orthopedic surgeon, but could be cleared for participation in the interim. If bracing is required, participation may be limited in sports that require excessive spinal mobility (eg, gymnastics), but this determination should be made by a physician familiar with the limitations associated with scoliosis.

**Spondylolysis**

A 15-year-old football lineman presents with the acute onset of right-sided lumbar pain after a scrimmage. He requests clearance to return to football. The pain is exacerbated with back extension. He denies dysuria, fever, neurologic symptoms (eg, sciatica, weakness, or numbness), or prior back pain. The physical examination demonstrates excessive lumbar lordosis, tight hamstrings, and reproduction of pain with extension and single-leg extension of the back.

Important questions to be asked during the preparticipation physical examination include:

1. Have you ever had a sprain, a strain, or swelling after injury?
2. Have you had any other problems with pain or swelling in muscles, tendons, bones, or joints?

Unlike low back pain in the adult, which can often be attributed to a “muscle strain,” low back pain in the adolescent is more likely to involve significant pathology. Micheli and Wood compared the etiologies of back pain in adults and adolescents and demonstrated an increased risk of posterior element disease in adolescents.26 Forty-seven percent of the adolescents had spondylolysis (a stress fracture of the pars interarticularis). Additional diagnoses to be considered include spondylolisthesis, injury to posterior elements (eg, facet joints, transverse process, or spinous process), “kissing spines,” or mechanical low back pain. Sports placing athletes at increased risk for posterior element disease include tennis, diving, football, gymnastics,
wrestling, volleyball, and some track and field events.

Radiographs are warranted for athletes with the acute onset of low back pain following trauma. Radiographs would also be warranted for individuals with persistent low back pain (>1 month), neurologic abnormalities, or evidence of a systemic illness. Standard radiographs to assess for spondylolysis include anteroposterior, lateral, and bilateral oblique views of the lumbar spine. A positive result on a radiograph would be a radiolucent line through the pars interarticularis on the oblique view (Scottie dog sign of Lachapelle). If results of radiographs are negative but clinical suspicion remains high, a technetium bone scan or single photon emission computed tomography image can be obtained to increase sensitivity.

The treatment of individuals with acute spondylolysis requires modification of activity (avoidance of spine extension), bracing, and physical therapy. A referral to a sports medicine specialist, pediatric orthopedic surgeon, or spine surgeon is generally recommended. Restriction from activity varies depending on return-to-play criteria and can range from 6 weeks to 6 months. Return to play generally requires pain-free activity and a season of participation is generally lost.

CONCLUSION

Pediatricians are well qualified to handle most problems identified during the preparticipation physical examination. By emphasizing the medical history and using standard guidelines, pediatricians can appropriately guide young athletes through the medical challenges facing them.

REFERENCES