The Female Athlete: Evaluation and Treatment of Sports-Related Problems

Carol C. Teitz, MD, Serena S. Hu, MD, and Elizabeth A. Arendt, MD

Abstract

Although many of the problems faced by the female athlete affect the male athlete as well, some occur exclusively or more commonly in women. These include spondylolisthesis, stress fractures in the pelvis and hip, and pelvic floor dysfunction. Female athletes are also more likely to have patellofemoral problems, noncontact anterior cruciate ligament tears, and bunions. For many of these conditions, the relative influences of osseous anatomy, ligamentous laxity, and the effect of sex hormones have not yet been established. There are also problems related specifically to the menstrual cycle and pregnancy. Amenorrhea is present in up to 20% of vigorously exercising women. The term "female athlete triad" has been coined to describe the complex interplay of menstrual irregularity, disordered eating, and premature osteoporosis seen in the female athlete. Many of the concerns related to exercise during pregnancy focus on the safety of the fetus rather than the athlete herself. Musculoskeletal problems in the physically active pregnant woman are related to weight gain, ligamentous relaxation, lordosis, and change in the center of gravity.

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The number of female athletes increased dramatically after the passage of Title IX in 1972. When women were first admitted to the US military academies in 1976, an increased incidence of overuse injuries was reported in female cadets. As greater attention was paid to the conditioning and training of girls in the preadolescent and high-school age groups, their injuries were found to be generally sport-specific rather than gender-specific. However, a study of the West Point class of 1992 found that women engaging in sports had more lower-extremity injuries than men, particularly stress fractures and patellofemoral pain. A higher incidence of noncontact anterior cruciate ligament (ACL) injuries has also been seen in women involved in a number of sports. The problems that occur exclusively or more commonly in the female athlete are the subject of this article.

Spondylolysis and Spondylolisthesis

Spondylolysis is found in 6% of the general population, but there is a higher prevalence in persons who participate in activities that place the lumbar spine in hyperlordosis, such as diving, gymnastics, and dance.[1] This association with hyperlordosis suggests that repetitive bending stresses in the pars interarticularis can cause a stress fracture. Progression of spondylolisthesis is more likely in females and is rare after adolescence.[2] Among young patients, the most common type of spondylolysis is isthmic and occurs at L5, with resultant slippage on the sacrum. Isthmic spondylolysis can be lytic, representing a fatigue fracture, or can be associated with an elongated but intact pars.

History and Physical Examination

The athlete may present with intermittent low back pain associated with particular activities or acute symptoms related to a specific event. Radicular symptoms are uncommon in young patients unless a high-grade slip is present.

On physical examination, some patients demonstrate the classic

Dr. Teitz is Associate Professor, Department of Orthopaedic Surgery, University of Washington, Seattle. Dr. Hu is Assistant Professor, Department of Orthopaedic Surgery, University of California, San Francisco. Dr. Arendt is Associate Professor, Department of Orthopaedic Surgery, University of Minnesota, Minneapolis.

Reprint requests: Dr. Teitz, Department of Orthopaedic Surgery, Box 354060, University of Washington, Seattle, WA 98195-4060.

Phalen-Dickson sign: tight hamstrings and a bent-knee, flexed-hip gait.[3] It is unclear whether this stance is secondary to the vertical position assumed by the sacrum, with resultant flexion of the pelvis, or whether nerve-root entrapment leads to the hamstring tightness. If slippage has occurred, careful palpation of the spine may reveal a stepoff, with prominence of the L5 spinous process.

Radiologic Evaluation

Lateral plain radiographs may not show spondylolysis but should reveal spondylolisthesis when it is present. The radiographs should be taken with the patient standing. Spondylolisthesis is graded with the Meyerding method according to the percentage of forward slip relative to the top of the sacrum. The slip angle is a measure of lumbosacral kyphosis and is an important prognostic indicator of slip progression (Fig. 1).[3] The slip angle is normally 0 degrees. Spondylolisthesis is more likely to progress in patients with slip angles greater than 50 degrees.

In the case of patients who present with typical spondylolytic complaints but whose radiographs are normal, a bone scan may identify an early stress fracture of the pars interarticularis. Scans can also help determine whether a positive radiographic finding represents a recent fracture or the lytic defect is long-standing.[4] Computed tomography can occasionally help establish whether the pars fracture is complete.

Treatment

Rest can help decrease symptoms. Bracing is successful in reducing or eliminating symptoms in as many as 80% of patients with a less than 25% slip. The brace must decrease lumbar lordosis.[5] In cases of acute lytic defects, prompt treatment with bracing and rest also can permit healing of the pars fracture. Physical therapy to stretch the lumbodorsal fascia and strengthen the abdominal musculature may help decrease hyperextension stress.

Patients with less than 25% slippage can return to physical activity after successful conservative treatment. Activities that do not hyperextend the spine are permitted for those whose slippage is between 25% and 50%. Patients whose symptoms are refractory to bracing and skeletally mature patients with a slip greater than 50% can be considered for surgical stabilization. The standard treatment for slips measuring as much as 50% at the L5-S1 level is bilateral lateral fusion of L5 to the sacrum with the use of autologous bone grafts. When the slippage is greater than 50%, inclusion of L4 is advocated so that the fusion will be placed under compression.[6] Fusion has been reported to be successful in 83% to 95% of patients; the clinical results have been reported as good to excellent in 75% to 100% of cases.[7] Although it may take as long as 18 months, hamstring tightness generally resolves after fusion in situ and does not require decompression. Most patients who undergo successful fusion for spondylolisthesis can return to sports as desired. They may lose a few degrees of motion in the lumbar spine, which may be a problem for athletes whose sport requires extreme flexibility.

A young patient with a pars defect at a level other than L5 and little slippage may be considered for a pars repair. This can be accomplished by wiring the transverse processes to the spinous process or, if the transverse processes are small, by placing a screw in the pedicle and then wiring the screw to the spinous process. The pars defect must be cleaned of soft tissue and bone grafted. After this procedure, healing can be expected in as many as 90% of patients under the age of 25 with normal disks and facets and less than 1 or 2 mm of slippage.[8]

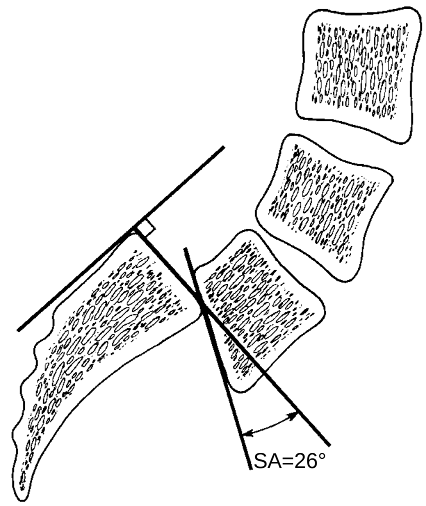

Fig. 1 The slip angle (SA) is the angle between the line perpendicular to a line drawn along the posterior border of the sacrum and a line along the inferior border of L5.

Pubic Ramus Stress Fractures

Etiologic factors commonly seen in association with pubic ramus stress fractures are tight adductors, leg-length discrepancy (fracture in the shorter leg), a crossover running style, and overstriding, either to gain speed or to keep up with a taller running partner. All of these factors have in common chronic pull by the adductor musculature attached to the pubic ramus.

History and Physical Examination

Stress fractures of the pubic ramus present with pain in the groin. The site of fracture is tender to palpation. Pain may be elicited by compressing the pubic symphysis.

Occasionally, stretching of the adductor muscles or adduction of the thigh against resistance will produce pain, making a stress fracture difficult to distinguish clinically from an adductor strain.

Radiologic Evaluation

Radiographs usually show a vertical fracture in the pubic ramus, with or without callus (Fig. 2, A). When the radiographic appearance is normal, a bone scan will reveal increased uptake in the area of fracture (Fig. 2, B).

Treatment

Treatment involves cessation of participation in impact sports until pubic tenderness is gone, which usually takes 6 to 12 weeks. Any contributing factors should be identified and resolved through physical therapy and training or use of a shoe lift if leg-length discrepancy is present. Subsequently, a progressive exercise program should include stretching and strengthening of the adductor muscles and running in the shallow end of a swimming pool. When these activities are well tolerated, the patient can begin sport-specific training.

Femoral Neck Stress Fractures

Femoral neck fractures are typically due to overuse, particularly in an amenorrheic athlete.

History and Physical Examination

These fractures present with groin pain or anterior thigh pain in the distribution of the obturator nerve. Pain may be present during weight-bearing activities as well as during swimming, bicycling, and even activities of daily living. On physical examination, point tenderness may be absent, except in the extremely thin individual. However, the Trendelenburg test is often positive, and an abductor lurch during gait is often present. Passive range of motion of the hip and abduction against gravity, with and without resistance, may be painful.

Radiologic Evaluation

To avoid mistakenly treating a stress fracture as a muscle injury, thereby risking complete fracture, the patient should be instructed to use crutches, and imaging studies should be obtained immediately when a femoral neck stress fracture is suspected. The initial plain radiographs may not reveal the fracture. However, after 2 or 3 weeks, callus may be found at the fracture site. A bone scan will reveal the fracture in the first 48 hours after occurrence. If the diagnosis is questionable, magnetic resonance (MR) imaging may be useful in differentiating a stress fracture from other lesions that produce increased uptake on a bone scan.[9]

Treatment

Extreme caution should be exercised when a stress fracture of the femoral neck is suspected. Because a frank femoral neck fracture can have a poor outcome, such as avascular necrosis of the femoral head, stress fractures in this area in young patients must be treated aggressively. Not all of these injuries need internal fixation. It is generally accepted that fractures on the tension (lateral) side of the neck are more likely to progress to complete fracture and should be internally fixed in situ with either multiple

A B

Fig. 2 **A,** Radiograph shows a stress fracture in the inferior pubic ramus. **B,** Bone scan reveals the stress fracture seen on the radiograph as well as an additional fracture in the superior pubic ramus.

compression screws or a sliding screw and side plate.[10] Fractures on the compression (medial) side of the neck may heal without any internal fixation. However, they must be watched closely, and the patient must be reliable. If the patient cannot walk without a lurch, she should use crutches for 3 to 4 weeks or until she can walk normally and without pain. The risk of frank fracture should be discussed with the patient at the outset. Stress fractures may take 3 months to heal.

Pelvic Floor Dysfunction

The muscles of the pelvic floor, or pelvic diaphragm, include the levator ani group (pubococcygeus, puborectalis, pubovaginalis, and iliococcygeus) and the coccygeus. The piriformis and obturator internus muscles are also continuous with the pelvic diaphragm. The endopelvic fascial floor and the smooth-muscle diaphragm in the base of the broad ligament also contribute to support of the pelvic floor.

There are four types of pelvic floor dysfunction: disuse, supportive, hypertonic, and incoordination.[11] Disuse dysfunction implies lack of awareness of the pelvic floor muscles due to lack of training, modesty, or muscle imbalance. This presents as stress incontinence or urge incontinence.

Supportive dysfunction is secondary to loss of nerve (pudendal), muscle, ligament, or fascial integrity. This can be congenital, hormonal, or secondary to connective tissue disease or, most commonly, can be due to trauma from childbirth or surgery. It presents as back pain and a sensation of suprapubic pressure.

Hypertonic dysfunction is characterized by excessive tone in the pelvic floor muscles. This can be psychogenic, iatrogenic, or musculoskeletal in origin. The primary symptom is pain, which is poorly localized in the perivaginal, perirectal, or suprapubic regions. Because the pain can radiate down the posterior aspect of the thigh, hypertonic dysfunction is easily confused with sciatica. Symptoms may be reproduced by a vaginal or rectal examination. Associated sexual dysfunction and dyspareunia are common.

Incoordination dysfunction is difficulty in contracting or relaxing the pelvic floor muscles. Imbalance of the gluteal, adductor, and abdominal muscles can mask weak contraction of the pelvic floor muscles. Myofascial or scar-tissue formation can restrict the contractility of the pelvic floor muscles. This can also be caused by neural damage and motor dysynergia.[11]

History and Physical Examination

Pelvic floor dysfunction usually presents as urinary incontinence but can also produce pain that mimics sciatica.[11] Patients present with pain localized to the upper outer quadrant of the buttock or pain in the posterior aspect of the thigh that originates from the area of the ischial tuberosity. The pain is not exacerbated by activities or the Valsalva maneuver. A history of urinary incontinence is common, and dyspareunia may be present. The patient is likely to be parous and to have had one or more traumatic vaginal deliveries.

The physical examination is more remarkable for pertinent negative findings than for positive findings. Patients with sciatica secondary to pelvic floor dysfunction have no restriction of back motion and no neurologic findings. Their hamstrings are not particularly tight, and a straight-leg-raising test does not reproduce the sciatic pain. Occasionally, piriformis muscle tightness will be noted, as manifested by decreased internal rotation on the involved side. Both hips normally have a similar total arc of motion, although one hip may have more or less internal rotation than the other. In patients with a unilaterally tight piriformis muscle, the total arc of motion of the involved hip will be less than that of the normal hip, and the loss will be in internal rotation. A vaginal or rectal digital examination may reveal hypertonic or flaccid muscles. When muscles are hypertonic, it will be difficult to perform the examination. When muscles are flaccid, the patient will not be able to squeeze the examining digit.

Additional Studies

The tone of the pelvic floor muscles can be determined with use of perineometers or surface electromyography. These can also reveal whether the patient can voluntarily contract her perineal muscles in a coordinated fashion or whether they are constantly flaccid or tonic.

Treatment

The initial treatment for these problems is pelvic floor exercises.[12] Many women do not perform these exercises correctly. Improper exercise technique causes bearing down instead of lifting up of the pelvic floor. The principles of training are the same as for any other muscle: specificity, overload, and progression. Biofeedback is very useful in educating women about the use of their pelvic floor muscles. This can be done with pressure-sensing perineometers that can be inserted vaginally (generally by a physical therapist) to obtain numerical values and to provide visual feedback to the patient during pelvic floor muscle contractions. Surface electromyography can also be used for biofeedback in the training mode.

A home program utilizing weighted vaginal cones can be instituted. Vaginal cones encourage proper lifting of the pelvic floor during contractions. These exercises are begun in positions that eliminate gravity and are advanced to upright and functional positions. They can be done concentrically, eccentrically, and isometrically and should include work on coordination as well as strengthening.[12]

Anterior Cruciate Ligament Injury

A high incidence of ACL injuries has been reported in women's gymnastics, team handball, volleyball, and alpine skiing. A recent review in which the injury surveillance system of the National Collegiate Athletic Association (NCAA) was used showed that female basketball players experienced four times as many ACL injuries as their male counterparts and that female soccer players had twice the injury rate of their male counterparts.[13] No conclusive evidence exists to explain the gender differences in this injury. Intercondylar notch anatomy has been implicated as an etiologic factor,[14] as have skill and experience level, muscle strength and coordination, limb alignment, joint laxity, and shoe-surface friction.

History and Physical Examination

The proportion of ACL tears that are due to a noncontact mechanism is higher in the female athlete. The physical examination in the acute setting reveals a hemarthrosis. Anterior knee laxity may or may not be demonstrable, depending on the status of the secondary static restraints, the degree of swelling, guarding by the patient, and the experience of the examiner.

Additional Studies

Radiographs occasionally demonstrate a small fracture off the posterolateral tibial plateau or a tibial eminence fracture. If the diagnosis of additional intra-articular injuries would change the immediate treatment plan, MR imaging is recommended to look for associated torn menisci and osteochondral injuries.

Treatment

Treatment is the same for male and female athletes. However, there are certain features of the female knee that may need special consideration when contemplating ACL reconstruction. In a small knee, a large graft carries with it the potential complication of patellar donor-site fracture, graft impingement, and diminished integrity of the remaining patellar tendon. When patellofemoral pain predates injury to the ACL, one should consider the use of hamstring autograft or patellar tendon allograft. The extensor mechanism disruption that occurs from harvesting a patellar tendon autograft may produce deficits in quadriceps strength and increased patellofemoral dysfunction,[15] although these problems are usually reversible and of short duration with adequate postoperative rehabilitation. Finally, avoiding postoperative stretching of the graft in a knee with a preexisting recurvatum deformity greater than 15 degrees is important for a successful outcome.

Patellofemoral Pain

Patellofemoral pain syndrome is often associated with variations in limb alignment, including increased anteversion of the femoral neck, external tibial torsion, and pronation of the foot. This limb alignment is also associated with an increased Q angle, patella alta, and generalized ligamentous laxity. Although these anatomic variations are not limited to women, they are seen more commonly in the female population.

History and Physical Examination

Patients generally complain of anterior peripatellar knee pain that is aggravated by squatting. Sitting for long periods of time with the knees flexed may be uncomfortable (theatre sign). In addition to looking for the variations in limb alignment noted above, one should try to differentiate the pain caused by periretinacular tightness from that caused by a mobile patella that may have an irregular articular surface. Patients with retinacular tightness demonstrate less than one quadrant of medial mobility or less than 15 degrees of lateral patellar tilt on passive testing (raising the lateral border of the patella to the horizontal plane or slightly beyond). Excessive lateral patellar compression can lead to overload of the lateral bone, cartilage, or soft tissues. Patients with this syndrome often present with lateral knee discomfort near the lateral femoral condyle and the distal insertion of the iliotibial band. This syndrome is frequently associated with radiographically demonstrated patellar tilt.[16]

Additional Studies

Axial views of the patellofemoral joint may reveal normal alignment, lateral patellar tilt, or lateral patellar subluxation. The diagnosis of patellar malalignment requires documentation of the changing relationships of the patella to the trochlear groove in all planes of knee motion.[17] Kinematic MR imaging studies can now reveal patellar tracking patterns in real time.[18] However, we still do not have good correlation between physical examination features, images, and patient pain and function.

Treatment

Quadriceps strengthening is the cornerstone of treatment for patellofemoral disorders and should emphasize closed-kinetic-chain exercises. These approximate the tibial rotation and subtalar motion associated with functional activities. Eccentric quadriceps activity is important in the decelerator function of the extensor mechanism and is important to emphasize during rehabilitation. However, it may increase symptoms in patients with patellar articular-surface abnormalities. In a young woman, muscle strength and coordination may need to "catch up" to bone maturation.

Because patellofemoral function is an integral component of limb function, any important anatomic variations in the joints proximal and distal to the knee should be addressed with the use of flexibility and strengthening exercises and possibly orthotic devices. Although orthoses are commonly used to control the overpronated foot in patients with patellofemoral pain, few controlled studies on their effectiveness have been performed with the use of standardized outcome measures.

McConnell taping alters glide, tilt, and rotation of the patella when augmented with muscle strengthening.[19] Although McConnell's success rate of 96% has not been duplicated, taping can help relieve pain during strengthening exercises. Use of knee sleeves is controversial, but may be an adjunct to quadriceps-strengthening exercises when subluxation is present.

Electrical muscle stimulation is useful as an early adjunct to muscle-strengthening exercises when these produce patellar pain. The electricity produces muscle contractions with a resultant load across the patellofemoral joint that is lower than that produced by quadriceps exercises.[20]

Educating the patient is critical. Important recommendations are to frequently alter positions of the flexed knee while sitting, to take breaks to straighten the knee when driving, and to avoid full squats.

The indications for surgical intervention for patellofemoral pain are narrow. Surgical realignment techniques are most likely to benefit patients with patellofemoral pain due to lateral subluxation and/or lateral tilt. Patellar shaving is appropriate when combined with surgical intervention to unload stressed areas of patellar articular cartilage. Lateral retinacular release is helpful in relieving tilt but inconsistent in controlling subluxation. Surgical correction of subluxation requires a medial procedure, such as imbrication of the medial retinaculum to realign the patella.

Medial advancement of the tibial tubercle is most appropriate in the patient with recurrent patellar instability when the Q angle is increased, whether or not malalignment is demonstrated radiographically.[16] Reduction of the Q angle to 10 degrees is advocated. The tubercle sulcus angle (sitting Q angle) should approach 0 degrees.

The role of tibial or femoral osteotomy in the treatment of patellofemoral pain is less clear. It is recognized that genu valgum and increased femoral anteversion contribute to patellar tracking abnormalities and instability. When the relationship between the patella and the trochlear groove is normal and the patella is stable but limb malalignment is present, an extra-articular long-bone osteotomy may decrease patellofemoral pain. When malalignment and instability are both present, a patella-stabilizing operation and an osteotomy should be considered. These can be done simultaneously or as separate procedures.

Bunions

Bunions are nine times more common in women than in men, due to a combination of hereditary predisposition, poorly fitting shoes, ligamentous laxity, and overpronation. The last can be the result of ligamentous laxity or compensation for increased femoral anteversion. Overpronation causes increased valgus stress on the great toe during the push-off phase of gait.

History and Physical Examination

The pain from a bunion is initially limited to the prominent tissue at the medial side of the first metatarsal head. Subsequently, as the great toe drifts into more valgus deviation and bears less weight, pain can shift to the heads of the second and third metatarsals. Dorsal subluxation of the second toe can cause corns and deformities of the interphalangeal joint as well.

Additional Studies

Standing anteroposterior and lateral radiographs of both feet should be taken. One should note the first and second intermetatarsal angle as well as the relative lengths of these metatarsals. The degree of hallux valgus should also be noted. Any metatarsophalangeal arthritis or subluxation of the sesamoids should be recorded.

Treatment

In the dancer or the athlete, particularly the running athlete or gymnast, the treatment of bunions requires attention to certain principles. The goal of treatment is to produce a stable correction while maintaining adequate range of motion of the first metatarsophalangeal joint. It is particularly important in athletes not to interfere with the sesamoids and to avoid dorsal or plantar displacement of the first metatarsal head, so that the first metatarsal continues to bear weight appropriately. A chevron osteotomy and bunionectomy have been reported to be successful in elite female runners.[21] However, bunionectomies should not be performed during the active career of dancers or athletes who require extreme dorsiflexion of the first metatarsophalangeal joint, such as sprinters and gymnasts. They should be treated symptomatically until their performing or sports careers are over.

The importance of properly fitting shoes cannot be overemphasized. Many women have a wide forefoot and a narrow hindfoot and as a result have problems with fit. Women tend to buy shoes so as to avoid slipping at the heel and may end up with a shoe that is too narrow in the forefoot. Instead, a shoe with a combination last or a shoe with a variable eyelet pattern that allows adjustable lacing for the forefoot and hindfoot will provide the necessary width in the forefoot and a snug fit in the hindfoot.[22]

The forefoot should be well padded. Orthoses including medial support to decrease the valgus stress and a metatarsal pad to decrease the weight borne by the second and third metatarsal heads may be helpful. A deep toe box may alleviate symptoms due to subluxation of the second toe on top of the first. A shoe with a straighter last will also help to control pronation.

Problems Associated With the Menstrual Cycle

Relative Iron Deficiency

There are no known negative effects of the menstrual cycle on the female athlete. Medals have been won and records broken by women in every phase of the menstrual cycle. However, primarily because of menstrual blood loss, many female athletes with normal hematocrits are relatively iron-deficient, as manifested by low ferritin levels. Restoring iron stores to normal has been associated with improved performance.

Athletic Amenorrhea

Excluding pregnant women, amenorrhea is present in up to 20% of vigorously exercising women. Its prevalence may reach as high as 50% in elite runners and professional ballet dancers.[23] Amenorrheic athletes are more likely to have begun training at an earlier age than normally menstruating athletes. Although "athletic amenorrhea" was first thought to be due to an insufficient amount of body fat, athletes who have normal body fat but who consume less than the number of calories needed for intensive sports training also become amenorrheic. Women participating in endurance sports in particular find it difficult to consume sufficient calories. Some athletes try to control weight by excessive vigorous exercising; others starve themselves purposefully. Attempting to impose a universal body shape stereotypic for a specific sport encourages eating disorders, ranging from a preoccupation with food and body image to more severe problems, such as anorexia nervosa and bulimia.

Amenorrhea can be classified as either primary or secondary. Primary amenorrhea is defined as no menstrual bleeding by the age of 16. Secondary amenorrhea is defined as no menstrual cycles in a 6-month period in a woman who has had at least one episode of menstrual bleeding. The most common cause of amenorrhea is pregnancy. Amenorrhea also can be due to structural abnormalities of the reproductive tract or hormonal abnormalities.[24] Athletic amenorrhea is thought to be a form of hypothalamic amenorrhea in which pulsatile gonadotropin-releasing hormone (GnRH) is deficient, absent, or inappropriately secreted. The neurohormones that modulate GnRH can be affected by psychological or physical stress, tumors, and congenital anomalies. Participation in endurance sports results in increases in serum levels of endogenous opioids, cortisol, melatonin, and dopamine, which in turn suppress the frequency and amplitude of GnRH pulses.[25,26] Resumption of normal menstrual cycles may take months or years after the psychological or physical stress is relieved. Prolonged amenorrhea can result in osteoporosis.

The bone mineral loss seen in athletes who have had amenorrhea for more than 6 months resembles that seen after menopause. Although high-intensity exercise may increase bone mineral density at maximally stressed skeletal sites even in amenorrheic and oligomenorrheic athletes,[27] whole-body bone mineral density is significantly lower in amenorrheic athletes than in control subjects ($P<0.05$).[28]

Sixty percent to 70% of peak bone mass in women is acquired before the age of 20. If a young female athlete is amenorrheic and does not lay down a normal amount of bone during adolescence, she may always have decreased bone mass. Restoration of normal menses may retard the rate of further bone loss, but the bone already lost cannot be replaced.[29]

The term "female athlete triad" was coined in 1991 to describe the complex interplay of menstrual irregularity, disordered eating, and premature osteoporosis seen in the female athlete. The factors in this triad are interdependent and can occur as a result of intense athletic participation.

History and Physical Examination

It is critical when evaluating the young female athlete with a stress fracture to consider the possibility of early osteoporosis related to amenorrhea. This is particularly so when a history of overuse is not forthcoming or when this is not the first stress fracture for the patient.

Questions about menstrual history, nutritional history, and body-weight history are important for screening. The menstrual history should include the age at menarche, the frequency and duration of menstrual periods, the date of the last menstrual period, and the use of hormonal therapy. The nutritional history should include a 24-hour recall of food intake, the usual daily number of meals and snacks, and a list of forbidden foods (e.g., meat or sweets). The body-weight history should include the highest and lowest weights since menarche and the athlete's satisfaction with her present weight. What does she feel her ideal weight should be? Has she ever tried to control her weight by using vomiting, laxatives, or diuretics?

Additional Studies

In amenorrheic women, it is important to rule out pregnancy and medical problems, such as thyroid or pituitary disorders, before ascribing amenorrhea solely to a woman's exercise program. Further workup is usually not in the purview of the orthopaedic surgeon, but may include pregnancy testing, determination of thyroid hormone and prolactin levels, and a progesterone challenge.

Bone mineral density is most precisely measured by dual-energy x-ray absorptiometry. This study subjects the patient to less than 5 mrem of radiation per scan, compared with 20 to 60 mrem for a chest radiograph and 300 mrem for dental x-ray films.

Treatment

The team physician is in the ideal position to screen for eating disorders and abnormal menses during the preparticipation physical examination. Treatment of the female athlete triad requires a multidisciplinary approach involving physicians, a nutrition specialist, and often a psychologist or psychiatrist. In the case of a high school or intercollegiate athlete, one should also involve the athletic trainer, the coach, and the patient's parents. An adequate diet must include not only the appropriate caloric intake but also at least 1,500 mg of calcium per day. Treatment of more seriously disordered eating may require contracts between the physician and the patient, specifying that the level of sports participation is decreased or competition is prohibited until certain goals, such as a specific weight gain, are reached. Treatment with replacement hormones may be necessary to prevent further bone loss. Typically, oral contraceptives are used initially. Additional educational materials about these problems can be obtained from the American College of Sports Medicine and the NCAA.

Exercise During Pregnancy

The recommendations of the American College of Obstetrics and Gynecology[30] regarding exercise during pregnancy are shown in Table 1. In summary, the pregnant athlete should try to maintain a core body temperature less than 38°C. Diabetes, hypertension, multiple gestation, cervical defects, and a history of miscarriage are contraindications to exercise during pregnancy. The pregnant athlete may need to omit contact sports and diving from her exercise choices. Vigorous exercise programs should not be undertaken during pregnancy by women who are not fit, especially during the first trimester. The types of exercises recommended should minimize the risk of injury while acknowledging the patient's preferences, and should be coordinated with the physician managing the patient's pregnancy.

Researching the effects of exercise in pregnancy is difficult because of the great variety of types of exercise, exercise intensities, and durations, which may have very different maternal and fetal effects. There is contradictory evidence concerning the influence of exercise on the onset of labor, the course of labor, and fetal growth. Nevertheless, most fit women with normal pregnancies may continue their regular program of exercise without having an adverse effect on most aspects of labor and fetal growth.

Many of the concerns related to exercise during pregnancy focus on the safety of the fetus rather than problems affecting the athlete herself. The primary concerns are fetal hyperthermia and the risk of neural-tube defects, insufficient placental blood flow, and inadequate glucose availability for the fetus.[31]

Temperature elevation is proportional to exercise intensity. A well-conditioned athlete can dissipate heat through sweating, but a poorly trained athlete is more likely to become hyperthermic. Dehydration and hot, humid environmental conditions will increase the likelihood of elevated body temperature during exercise. Intense training can raise rectal temperature above the level found to be teratogenic in sheep (39.2°C). However, no pro-

Table 1
Abridged ACOG Recommendations for Exercise During Pregnancy[30]

- Regular exercise (at least three times per week) is preferable to intermittent activity.
- Women should avoid exercise in the supine position after the first trimester.
- Pregnant women should stop exercising when fatigued and should not exercise to exhaustion.
- Exercise in which loss of balance could be detrimental to maternal or fetal well-being is contraindicated. Any type of exercise involving the potential for even mild abdominal trauma should be avoided.
- Pregnancy requires an additional 300 kcal / d to maintain metabolic homeostasis. Women who exercise during pregnancy should be particularly careful to ensure an adequate diet.
- Pregnant women who exercise in the first trimester should allow for heat dissipation by ensuring adequate hydration, wearing appropriate clothing, and maintaining optimal environmental surroundings during exercise.
- Many of the physiologic and morphologic changes of pregnancy persist 4 to 6 weeks post partum. Prepregnancy exercise routines should be resumed gradually.

spective studies have demonstrated temperature elevation to be a teratogen in humans.

Although plasma volume expansion occurs as a result of both exercise and pregnancy and may help maintain uterine blood flow, prolonged exercise also decreases splanchnic blood flow to 40% to 50% of resting levels. Since the uterine circulation is part of the splanchnic bed, there are concerns, again based on observations in sheep, about decreased blood flow to the placenta during exercise.

Glucose is a major fetal fuel, and its availability is a function of glucose levels in maternal blood. Glucose utilization by the muscles during exercise will decrease levels of circulating glucose and may limit fetal glucose availability.

Musculoskeletal problems in the physically active pregnant woman are related to weight gain, ligamentous relaxation, lordosis, and change in the center of gravity. Near term, running sports become more difficult as the weight and bulk of the abdomen increase. In the third trimester, exercise in water is advocated because the buoyant effect reduces the stress of weight bearing. There is concern that impact sports and sports requiring a lot of torque may cause membrane rupture, placental separation, umbilical cord entanglement, or direct fetal injury. The absolute intensity of weight-bearing exercise also should decrease as pregnancy progresses because the oxygen demands during such exercise increase during pregnancy. It is difficult to judge the intensity of maternal exercise with the usual criterion of heart rate because pregnancy increases maternal blood volume, heart rate, and cardiac output.

History and Physical Examination

One of the most common complaints of pregnant women, particularly in the second or third trimester, is back pain. It may or may not have a radicular component and is normally aggravated by activities in the standing position. Changes in sensory, motor, and deep tendon reflexes are rarely present. Most commonly, a Patrick (flexion, abduction, external rotation, and extension, or “fabere”) test will produce pain consistent with strain in the sacroiliac ligaments.

Treatment

Back pain can be decreased by switching from standing activities, such as running and dancing, to sitting activities, such as rowing and bicycling. Abdominal support straps may provide symptomatic relief, as will pelvic tilts and “angry cat” exercises (performed while facing down on hands and knees, producing lumbar kyphosis).

Summary

Female athletes are now highly visible and very successful. More girls and women are becoming and staying active than ever before. Appropriate conditioning programs are important, particularly in decreasing the incidence of overuse injuries. These programs are best accepted if they are part of a sport-specific training program. A good conditioning program should include both anaerobic and aerobic exercise and both strengthening and stretching exercises. Special emphasis should be placed on adequate nutritional intake. Also important is abdominal strengthening, with particular attention to decreasing excessive lumbar lordosis. An aspect of conditioning that should be modified for the female athlete is quadriceps strength training. Because patellofemoral problems are so prevalent in women, female athletes should avoid squats and full-arc isotonic knee-extension exercises in which the tibia is loaded.

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