5 Points on
Female Athletes: Unique Challenges Facing Women Warriors

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Since Title IX passed in 1972, women have become exponentially more involved in competitive sports, from high school to professional levels. With more women engaging in serious athletics, the specific challenges they face have come to the forefront of sports medicine. These problems include the female athlete triad, concussions, exercise safety in pregnancy, anterior cruciate ligament (ACL) injuries, and continued sex discrimination and social injustice. Orthopedists treating female athletes should be aware of these problems, each of which is discussed in this review.

1 Female athlete triad

In 1992, the term *female athlete triad* was coined to describe 3 problems that often coexist in high-intensity female athletes.[1] Since then, the definition has evolved, but the problem has remained essentially the same. The modern definition incorporates menstrual abnormalities, low energy availability with or without disordered eating, and decreased bone mineral density (BMD).[2]

With intense exercise and weight loss comes a variety of menstrual disturbances.[3] In affected athletes, the hypothalamus is underactivated, and changes in gonadotropin-releasing hormone and luteinizing hormone lead to decreased estrogen production. Research suggests abnormal menses result from having inadequate energy and insufficient caloric intake to support extensive exercise.[1] This phenomenon can occur in athletes in any sport but is most prevalent in lean-body sports, such as swimming, gymnastics, and ballet. The incidence of abnormal menses is as high as 79% in ballet dancers but only 5% in the general population.[3] Menstrual abnormalities indicate hormonal abnormalities that can interfere with growth and maturation in young athletes.

Although full-blown eating disorders are uncommon among female athletes, disordered eating patterns are often found among women in competitive sports. Disordered eating can involve a spectrum of inadequate caloric intake and purging behavior, such as vomiting or laxative abuse, and has been reported in up to 25% of collegiate female athletes.[4] Physicians must recognize these conditions and initiate counseling and treatment when appropriate. Women with disordered eating are at risk for developing electrolyte imbalances, malnutrition syndromes, and osteopenia.

Although careful evaluation and counseling are important, physicians must note that, in most cases, athletics participation may also *protect against* disordered eating and body image difficulties. A study of 146 college-age women found better body satisfaction among athletes than among nonathletes.[5] Lean-sport athletes (eg, swimmers, gymnasts) were at higher risk for disordered eating and body image problems than other athletes were. Similarly, other studies have found that a majority of athletes have healthy eating habits.[4]

For poorly nourished and hormonally imbalanced female athletes, decreased BMD poses substantial risk. One study found a significant difference in BMD between athletes with amenorrhea and athletes with normal menses.[6] In a cohort of female Navy recruits, those with amenorrhea were at 91% higher risk for stress fractures; calcium and vitamin D supplementation reduced risk by 20%.[7] Osteopenia may be a special problem for prepubescent athletes. Girls who engage in intense exercise and have delayed menarche may have a low estrogen state, predisposing them to low BMD.[3] Osteopenia and osteoporosis are difficult to reverse and can put these athletes at risk for stress fractures the rest of their lives. If unrecognized, stress fractures can end an athlete's career.

Recommendations for dual-energy X-ray absorptiometry (DXA) include testing female athletes who have a diagnosed eating disorder, body mass index under 17.5, history of de-

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layed menarche, oligomenorrhea, 2 prior stress fractures, or prior abnormal DXA scan. Complete testing recommendations appear in the 2014 consensus statement on the female athlete triad and return to sport.[2,8]

Orthopedists performing physical examinations for sports participation can screen for the female athlete triad through thoughtful questioning about menstrual history, nutrition habits, and stress fracture symptoms. Best treatment for a diagnosed case of the triad is multidisciplinary care with strong social support. When abnormal menses are an issue, referral to a gynecologist or endocrinologist and consideration of estrogen replacement should be discussed. Some cases require a psychiatrist's assistance in treating disordered eating. Athletic trainers, coaches, and parents should be involved over the treatment course.[1] Orthopedists must counsel women with osteopenia and osteoporosis about decreasing exercise to a safe level, improving nutritional intake, and supplementing with calcium (1200-1500 mg/d) and vitamin D (600-800 IU/d).[3,7]

2 Concussions

Increasing awareness of males' sport-related concussions, particularly of concussions that occur during National Football League practice and games, has made physicians and researchers more aware of the rate of concussion in female athletes. That rate has increased, and, according to some reports, the risk for sport-related injury is higher for female athletes.[9] A study of high school athletes found that the rate of concussion in girl's soccer was second only to that in football.[10]

Concussions are categorized as mild traumatic brain injuries, and manifestations of the diagnosis are divided into physical, emotional, cognitive, and observed symptoms. The spectrum of symptoms is wide, ranging from difficulty concentrating and thinking clearly to headaches and dizziness.[11] Compared with male athletes who sustain a concussion, female athletes report more of these concussive symptoms and have worse visual memory scores.[12]

Efforts to change sports at the player level have been resisted. Helmets have been proposed for field hockey and lacrosse but have not passed stringent concussion testing. In soccer, which has a high rate of concussion, a reform to eliminate heading the ball has been considered. Resistance to these suggestions stems from the thought that changes could alter the traditions of the games. Some individuals have indicated that helmets may give players a false sense of security and thereby cause them to play more aggressively.

Orthopedic surgeons must be aware of concussion symptoms. Multiple concussions may have a cumulative effect on functional ability and emotional well-being and may lead to chronic traumatic encephalopathy.[13] Concern about the long-term effects of concussion has led to the implementation of universal "return to play" laws. These laws vary by state but have 3 steps in common: Educate coaches, players, and athletes; remove athletes from play; and obtain health care professionals' permission to return to play.[14] These guidelines set up an action plan for treating an athlete who has sustained a concussion.

Encouraging results of educating coaches have been noted. Coaches who were given Centers for Disease Control and Prevention–sponsored material on preventing, recognizing, and responding to concussions were able to effectively address concussions; 6 months later, 63% were better able to appreciate the severity of concussions.[15] Continued education of athletic communities should help bring this injury to the attention of those treating female athletes.

3 Exercise safety in pregnancy

Women in sports can continue their athletic regimens during pregnancy. It is important to address challenges to the pregnant woman and to the fetus when assessing the risks of exercise.

The physiologic changes that occur during pregnancy may affect how a pregnant athlete responds to stress. Plasma volume, red blood cell volume, and cardiac function and output all increase during normal pregnancy.[3,16] Abnormal heart rate during pregnancy can adversely affect the fetus. During and after exercise, fetal bradycardia can occur. Therefore, recommendations should include not exceeding pre-pregnancy activity levels.[3] Careful monitoring of exercise intensity is recommended by the American College of Obstetrics and Gynecology; the guideline is to maintain less than 70% of maximal heart rate.[17,18]

The negative effects of exercise on the pregnant athlete are limited, but it is important to educate patients and to consider preventive strategies. One physiologic change that occurs during pregnancy is ligamentous laxity, which is caused by the hormone relaxin.[16] Ligamentous laxity has the potential to put pregnant athletes at risk for soft-tissue and bony injury during impact sports. However, the positive effects of exercise during pregnancy include improved appetite, sleep, and emotional health.[19] Aerobic exercise during pregnancy may reverse insulin resistance as demonstrated in animal studies; though this outcome has not been demonstrated in human studies,[20] women should be reassured that moderate exercise has overall beneficial effects.

Some research suggests that exercise may expose the fetus to hyperthermia, blood sugar changes, physical injury, and premature labor.[16] Typically, fetal heat is dissipated from the mother. After intense exercise, maternal body temperature rises and leads to some degree of fetal hyperthermia.[16] Animal model studies have suggested that hyperthermia may result in a slightly higher rate of congenital abnormalities. Pregnant women should keep their exercise routines to less than 60 minutes, should exercise in a thermally regulated environment, and should keep themselves hydrated to avoid fetal hyperthermia.[18]

Reduced blood flow, accompanied by a deficit of oxygen to the uterus and the developing fetus, is another concern for pregnant athletes. During exercise, when more blood is flowing to the muscles, less is flowing to the uterus.[16] Furthermore, during the third trimester, women should avoid supine exercise, as venous outflow is poor with the body in that position.[21]

Elite athletes who continue training during pregnancy should be carefully counseled about adjusting their training regimens. Because of increased cardiac output and blood volume, the heart rate will be lower than usual, demanding an adjustment in interpretation. Blood cell counts do not increase as much as plasma volume does—often leading to relative anemia. For elite athletes, this means iron supplementation is crucial.[22] Thermal regulation may be more difficult, as training regimens may demand prolonged exercise. Physicians should recommend adequate hydration for these athletes.[18]

Although continued exercise is generally safe for a pregnant athlete and her fetus, caution is required when there is increased risk for premature delivery, or other special conditions exist. Multiple gestation, placenta previa, history of early labor or premature births, and incompetent cervix all contraindicate aerobic exercise during pregnancy.[18] With these exceptions in mind, physicians can safely counsel pregnant women to do moderate exercise 30 minutes every day.[17,18] Other recommendations are listed at the American College of Obstetricians and Gynecologists website.[23]

4 Anterior cruciate ligament injuries

ACL injuries affect a staggering number of athletes. In the United States, approximately 100,000 people sustain these injuries annually.[24] As they occur up to 8 times more often in women than in men, ACL injuries are a top concern for physicians treating female athletes.

This disproportionate injury rate is influenced by differences between male and female anatomy. The width and shape of the femoral intercondylar notch have been studied as potential variables influencing the risk for ACL injury. Analysis of notch-view radiographs revealed a significant inverse relationship between notch width and ACL injury.[25] A-shaped notches, notches with a significantly larger base and a narrowed roof, were more prevalent in women but did not correlate with increased risk for ACL injury. Studies have shown that female athletes with a noncontact ACL injury have a higher lateral tibial plateau posterior slope; this slope is associated with increased peak anteromedial ACL strain, which may contribute to injury.[26] An analysis of magnetic resonance imaging scans in patients with and without ACL injury revealed that, for female patients, decreased femoral intercondylar notch width at the anterior outlet combined with increased lateral compartment posterior slope correlated best with risk for ACL injury.[27]

Although static anatomical factors contribute to ACL injuries in female athletes, dynamic neuromuscular influences are potential opportunities for intervention. Female athletes with high relative quadriceps strength and weak hamstring strength may be at increased risk for ACL injury.[28] This "quadriceps dominance" becomes important in sports involving high-risk activities, such as running, cutting, pivoting, and jumping. In addition, compared with male athletes, female athletes demonstrate increased lateral trunk motion and knee valgus torque while landing during noncontact ACL tears, making core stability a factor in ACL injury.[29]

The collaborative efforts of physicians, physical therapists, athletic trainers, and coaches have yielded multifactorial neuromuscular training programs for the prevention of noncontact ACL injuries. Ideal ACL prevention protocols involve sessions that last for at least 10 minutes and take place 3 times a week. At these sessions, exercises are focused on strengthening, balance, and proprioceptive training.[30] The programs last about 8 weeks, but sustained benefits require maintenance after the program has been completed and during the off-season. Program adherence must be encouraged and can be facilitated by varying workouts and raising risk awareness. The most effective programs have reduced the relative risk of noncontact ACL injuries by 75% to 100%.[31] These promising results have led to increased focus on program implementation in an effort to prevent ACL injury.

5 Continued sex discrimination and social injustice

In 1972, Title IX was passed as part of the Education Amendments Act. Title IX states, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any educational program or activity receiving Federal financial assistance." Passage of this law, which has implications outside of athletic participation, marked an important turning point in women's ability to participate equally in college sports.[32,33] The Civil Rights Restoration Act, passed in 1988, strengthened Title IX and made it applicable to all institutions receiving federal funding.[34] Before the 1970s, women typically were restricted to club sports, and funding and participation opportunities were weighted heavily toward men. Over the past 40 years, women's participation in high school, college, and professional sports has taken a huge leap forward.[32] For example, the number of women participating in high school sports increased from 294,000 (7.4% of all athletes) in 1972 to 3.4 million (>41% of all athletes) in 2014.

Despite advances in women's civil rights, examples of inequality in US schools remain, particularly in the distribution of funding, which still strongly favors men's football.[32] Men's sports receive 90% of media coverage.[33] In 2002, women represented 55% of college students but only 42% of varsity athletes.[34] The schools that have complied the least with Title IX are schools in the Midwest and the South and those with football teams.[34] Women are underrepresented as coaches, and funding continues to be disproportionately spent on men's sports.

For women, the benefits of participating in sports are far-reaching and significant. These benefits include improvements in academic success, mental health, and responsible behavior.[33] Women's gaining acceptance and respect throughout the athletic world seems to have carried over elsewhere. Although many institutions remain noncompliant with Title IX, efforts continue to have a strongly positive effect on gender equality in the United States.

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