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Special concerns of the female athlete

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Since the adoption of Title IX in the early 1970s women's sports participation has dramatically increased. The majority of the injuries sustained by female athletes are due to participation in the sport rather their sex, but there are anatomic, hormonal, and functional differences between the sexes which must be considered when caring for the female athlete. Differences between men's and women's versions of sports such as lacrosse and gymnastics and similarities between sports such as men's and women's basketball and soccer should also be understood.

The benefits of exercise are extensive. Females involved in sports are less likely to become pregnant during the teenage years, less likely to become involved in an abusive relationship, and more likely to finish high school and to go on to college. Women involved in sports have better self-esteem and self image. [1] Weightbearing exercise has a positive effect on bone mass in participants of all ages. There are also the cardiovascular and weight control benefits of exercise to be considered, especially in older athletes.

Sex differences

After age 10 to 12 years there are significant differences in all aspects of physical performance when comparing males with females. Females reach physiological and skeletal maturity and achieve peak height velocity before males. Women have more body fat and less lean body mass than males, a difference that can be attributed to increased estrogens in the female and increased androgens in the male. [2] Females have less upper body strength, which even with training remains 30% to 50% less than that of males. Lower extremity strength is much closer in parity. [3] Men also have higher red blood

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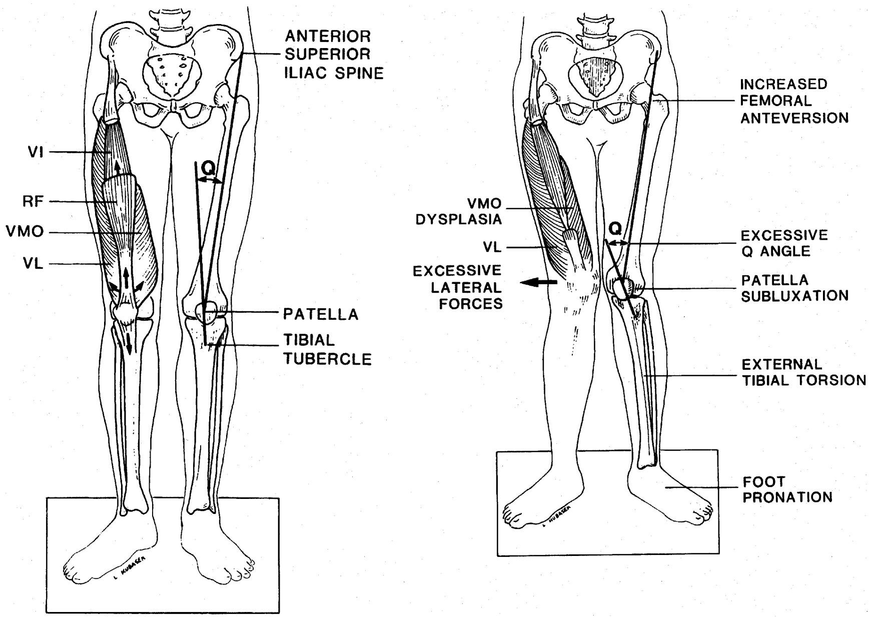

Fig. 1. Normal and miserable malalignment lower extremities. In well-developed quadriceps, low-er Q angle, and neutral tibial torsion, there is a superior patellofemoral biomechanical pattern. Miserable malalignment syndrome creates rotatory and laterally directed forces on the patella.

cell counts and hemoglobin levels than women. Work capacity studies show that there is only a slight difference between males and females in oxygen uptake when the data are expressed relative to body size and composition. [4] Despite these differences women show the same physiological training changes as males and experience significant increases in strength, power, and muscular endurance. [5]

Women have a wider pelvis, are more flexible, and have less developed musculature than men. Lower extremity alignment differs in the female and may predispose to injury. The so-called miserable malalignment syndrome of excessive forefoot pronation, pes planus, external tibial torsion, quadriceps angle of greater than 15 degrees, increased femoral anteversion, hypoplastic vastus medialis obliquus, and heel valgus angulation demonstrates the extreme of lower extremity differences between males and females (Fig. 1). Women have shorter limbs relative to body length. However, the center of gravity of men and women is only slightly different. This difference may account for differences in upper limb musculature with a shorter lever arm for movement and power. [6]

Injury rates

There have been many studies comparing injury rates between male and female athletes. [7–10] Studies comparing males and females have been done at the military academies. [11] The National Collegiate Athletic Association (NCAA) has collected data on injury rates for 16 sports since 1982 and for 21 sports since 1997. Soccer, lacrosse, gymnastics, and basketball are the four NCAA sports for which data were collected and in which both males and females compete. The data are reported as the number of injuries per 1000 athletic exposures. Due to differences in equipment and rules for competition in lacrosse and gymnastics, comparisons of injury rates between men and women in these two sports must be made carefully. Arendt and Dick [12] and Arendt et al [13] reported anterior cruciate ligament (ACL) injury rates for soccer and basketball over a total 10-year period (1989–1993, 1994–1998). The rates of injury in females compared with males were 2.6 times greater in soccer and 3.6 times greater in basketball.

Using the 1997–1998 data, for women the highest rate of injury in collegiate sports was in soccer followed by spring soccer, gymnastics, lacrosse, basketball, fall lacrosse, softball, field hockey, volleyball, and spring volleyball (Table 1). Men's spring football and lacrosse had the highest overall injury rates for men or women. There appears to be a trend in most sports toward more injuries occurring during practices than during games. However, more knee injuries, and ACL, collateral ligament, and meniscus tears occur in games. Compared with males, females sustained greater rates of knee injuries involving the ACL (4.9 times greater), collateral ligament (2.5 times), and meniscus (1.9 times) (Fig. 2). The NCAA classification combines patella and patellar tendon; therefore, no specific diagnosis is documented. The ankle is the most commonly injured body part for both males and females. [9]

Table 1
Injury rates per 1000 athletic exposures and percentage in practice and games 1997–1998

	Women				Men			
	Injury rate	Total injuries	Practice	Game	Injury rate	Total injuries	Practice	Game
Gymnastics	6.79	258	87%	13%	1.44	6	83%	17%
Fall lacrosse	5.04	11	100%	0%	4.97	44	95%	5%
Lacrosse	5.56	234	68%	32%	5.63	505	57%	43%
Basketball	5.37	721	68%	32%	4.42	648	66%	34%
Spring soccer	8.11	82	54%	46%	10.9	94	74%	26%
Soccer	8.17	919	50%	50%	6.95	1098	49%	51%
Spring volleyball	2.98	42	88%	12%	—	—	—	—
Volleyball	3.84	327	62%	38%	—	—	—	—
Field hockey	3.99	209	62%	28%	—	—	—	—
Softball	4.27	308	54%	46%	—	—	—	—
Wrestling	—	—	—	—	9.42	972	68%	32%
Spring football	—	—	—	—	11.2	1274	100%	0%
Football	—	—	—	—	6.1	4210	57%	43%
Baseball	—	—	—	—	3.34	605	52%	48%
Ice hockey	—	—	—	—	5.79	514	30%	70%

Data from NCAA Injury Surveillance System. Overland Park, KS, National Collegiate Athletic Association, 1991–1998.

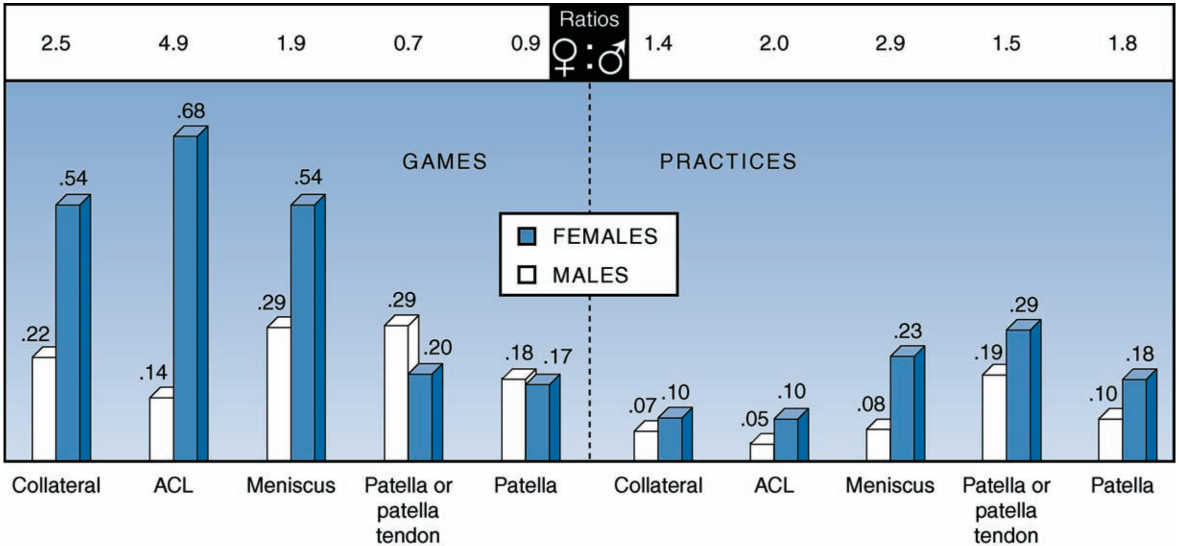

Fig. 2. Knee structure injury rates in basketball. Data are from the NCAA Injury Surveillance System, 1997–1998. [9] Injury rates are expressed as injuries per 1000 athletic exposures.

Certain injuries are more common in females, although most sports medicine research has been done on males. More research with female athletes needs to be done to prevent injury in the future and to answer the question of why certain injuries are more common in females. Only one long-term study has been done to date on female athletes. The majority of these athletes had continuing problems related to injuries sustained during their collegiate athletic careers. This is of concern. This indicates that we do not know the long-term effects of athletic injuries on women and more research in this area need to be done. [14]

Lower extremity

Ankle injuries

The ankle remains the most frequently injured joint in both male and female athletes. Osteochondritis dissecans of the talus, tibiotalar impingement syndrome, high ankle sprain, chronically subluxating peroneal tendons, and posterior impingement should be included in the differential diagnosis of ankle sprains failing to respond to conservative care. Stress fractures of the tarsal navicular should be ruled out in athletes at risk with foot pain. Medial tibial stress syndrome or shin splints are a common complaint among athletes and should be differentiated from exertional compartment syndrome and stress fracture. [15]

Knee injuries

Compared with males, females have an increased rate of anterior knee pain, patellofemoral disorders, and ACL injuries. [16–18] Dynamic movement patterns, core stability, and hip strength are different in males and females (Fig. 3). In our experience, anterior knee pain is more common in women and has an extensive differential diagnosis, which is summarized in Table 2. A specific diagnosis should be made in patients with anterior knee pain.

It has been well established that females have a higher rate of ACL injury than males. The reason is most likely multifactorial. Differences in training, neuromuscular responses, laxity, hormonal influences, and anatomic differences all play a role. Hip weakness, anterior hip tightness, and quality of pattern of movement are other contributing factors. The elastin and collagen tissue in females may contribute to the completeness of ACL tears and scar formation. Due to their lesser muscular development and lower extremity alignment differences, females rely more on the ACL and less on hamstring control. Ligamentous reconstruction should be considered in the ACL-dominant female as she is at high risk for significant meniscal and articular surface injury. [3,10]

Review of video footage reveals that compared with males, females tend to be in a more upright position, with less hip and knee flexion and their knees in more valgus angulation when landing from jumps as demonstrated in (Fig. 4). This “point of no return” with the athlete more upright with an externally rotated

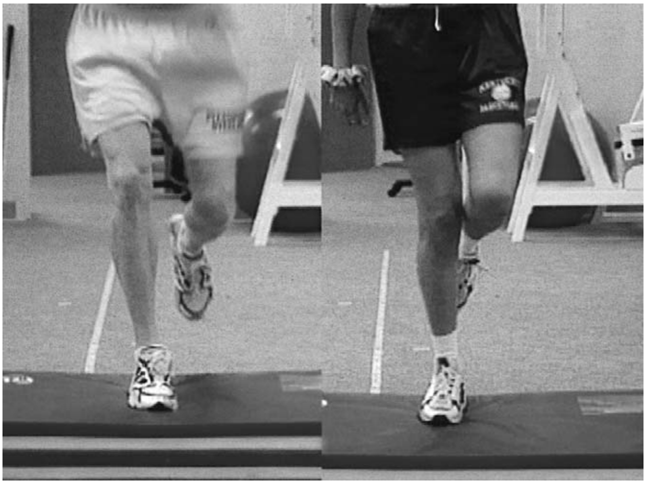

Fig. 3. Dynamics of landing. This photograph demonstrates some of the dynamic differences between males and females. The male (*yellow shorts*) has more flexion at the knee and hip with his body weight back and his knee in less valgus angulation. The female (*blue shorts*) has less knee and hip flexion with her body weight more forward and her knee in more valgus angulation. (Copyright 1999 by Mary Lloyd Ireland, MD).

pronated lower extremity may predispose to injury. Isokinetic strength testing has revealed a higher hamstring-to-quadriceps peak torque ratio in the trail leg at 60 degrees per second in volleyball players, which is the one statistically significant difference that has been found between males and females. A plyometric jump training program was done in female volleyball players. After training, females showed increased jump heights, increased hamstring strength, decreased peak landing forces, and decreased knee abduction and adduction moments. The females also showed peak torque ratios similar to males athletes after training. [19] This is significant inasmuch as the hamstring strength is increased, there is less strain on the ACL, and this strengthening program could affect the number of ACL injuries in female athletes.

There have been studies showing that there are estrogen receptors within ligamentous structures, including the ACL. Estrogen inhibits type I procollagen synthesis and proliferation fibroblasts in vitro at physiological estradiol concentrations, but the in vivo function of these receptors has yet to be elucidated. [20] There have been further studies linking phase of menstrual cycle to the risk of injury to the ACL. In one study there appeared to be more ACL tears during the ovulatory phase of the menstrual cycle. [21] More work in this area needs to be done with a larger series of athletes.

The majority of ACL injuries sustained by females are of a noncontact mechanism. The American Orthopedic Society for Sports Medicine, the National Athletic Trainers Association, the NCAA, and the Orthopedic Research and Education Foundation sponsored a consensus conference to address the issue of

Table 2
Anterior knee pain: differential diagnosis

Mechanical	Inflammatory	Other
Repetitive Microtraumatic	Bursitis	Referred pain
Patella	Prepatellar	Lumbar disk herniation
Stability	Retropatellar	Others
Subluxation	Semimembranosus	Reflex sympathetic dystrophy
Dislocation	Pes anserinus	(regional pain syndrome)
Tilt	Tendinitis	Tumors
Rotation	Quadriceps patella	Benign
Malalignment	Pes anserinus	Malignant
Stress fracture	Semimembranosus	
Bipartite	Patella tendinitis	
Fibrous union	Pigmented villonodular synovitis	
Acute fracture	Neuromas/retinacular pain	
Pathological medial plica	Arthritis	
Patellofemoral stress syndrome	Osteoarthritis	
Osteochondral fracture	Rheumatoid arthritis	
Trochlear groove	Psoriatic arthritis	
Patella	Others	
Loose bodies	Reiter's syndrome	
Cartilaginous		
Osteochondral		
Osteochondritis dissecans		
Patella		
Trochlear groove		
Skeletally immature		
Osgood-Schlatter's disease		
Sinding-Larsen-Johansson syndrome		
Acute Macrotraumatic Injury		
Extensor mechanism disruption		
Quadriceps rupture		
Patellar tendon rupture		
Inferior avulsion fracture		
Interstitial		
Skeletally immature		
Tibial tubercle fracture		
Patellar fracture		
Transverse		
Displaced/nondisplaced		
Comminuted		
Status post–anterior cruciate ligament reconstruction with central third patellar tendon bone		

noncontact ACL injuries and define risk factors and directions for future research. [22] The members of the symposium concluded that at-risk situations for noncontact ACL injury include deceleration, cutting or changing directions, and landing. The shoe surface coefficient of friction may increase the risk of ACL injury. There is no evidence that knee braces prevent ACL injury. There is

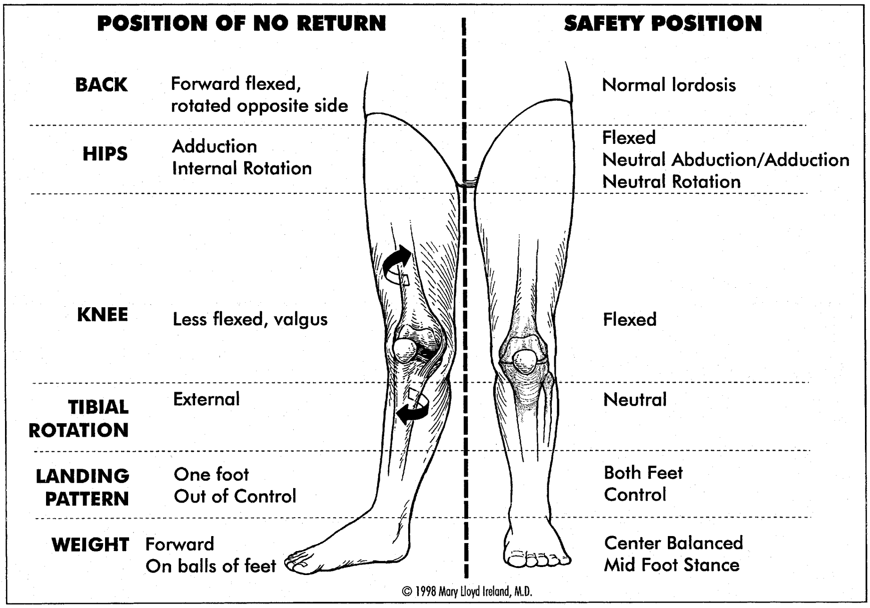

Fig. 4. This diagram shows the "position of no return." The position, which places the anterior cruciate ligament at risk, is an awkward out-of-control landing with the leg pronated in valgus angulation, the body more upright and the leg in pronation and rotation, and the knee in valgus angulation. The safety position is more flexed, body over legs, and more balanced. (Copyright 1998 by Mary Lloyd Ireland, MD).

no consensus regarding the role of the notch in ACL injury owing to difficulties in obtaining reliable and reproducible measurements. There are insufficient data on ACL size as measured by notch size to support ligament size related to risk of injury. There is no consensus regarding hormonal influences on the ACL and risk of ACL injury. There is no basis for modification of participation during various phases of the menstrual cycle or manipulation of sex-specific hormones to prevent ACL injuries. [22]

Upper extremity

Shoulder injuries

In younger females, joint laxity and decreased strength can cause shoulder problems. With generalized laxity, sport-dependent problems involving the shoulder can occur. The vicious cycle of physiological instability, rotator cuff weakness, pain, posterior tightness, and further imbalance results in persistent pain and dysfunction in overhead activities. Care should be taken to address scapular dysfunction. A specific diagnosis of the cause of the pain should be

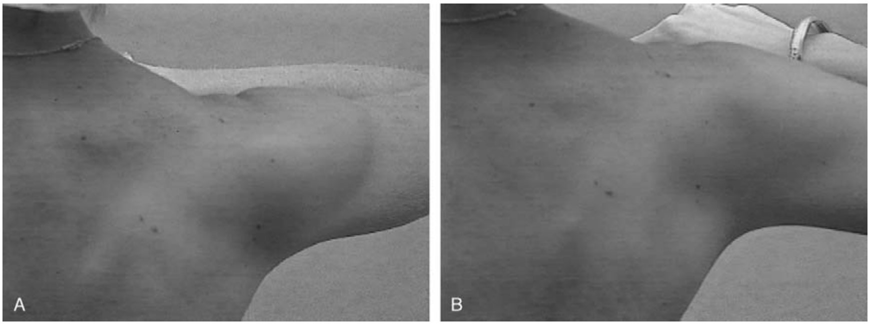

Fig. 5. Voluntary shoulder dislocation. The cheerleader is able to dislocate her glenohumeral joint posteriorly as she moves into horizontal adduction (*A*) and reduce as she externally rotates and abducts (*B*). (Copyright 1999 by Mary Lloyd Ireland, MD).

made. Restoration of normal range of motion and strength with proper sport biomechanics should be the goal. [23] The cheerleader shown in Fig. 5 has bilateral multidirectional shoulder laxity. She can voluntarily posteriorly subluxate her glenohumeral joint (Fig. 5A) as she moves into horizontal adduction and reduce moving into external rotation (Fig. 5B).

Elbow injuries

Females have shorter upper extremities, an increased valgus-carrying angle, decreased upper extremity strength, and increased ligamentous laxity compared with males. Osteochondritis dissecans of the elbow with possible loose body formation should be considered as a diagnosis in axially loading sports such as gymnastics, diving, cheerleading, and tumbling. Elbow dislocations are not infrequent in sports requiring aerial maneuvers. [3] A cheerleader sustained an elbow dislocation when she fell attempting a double back stunt (Fig. 6). Repeated attempts at reduction by bystanders were unsuccessful. An arterial injury occurred as well. Despite counseling, she returned to cheerleading 6 months after the injury with a range of motion of 10 to 140 degrees and full pronation and supination.

Hand and wrist injuries

Contact injuries in sports such as ice or field hockey or lacrosse can result in fractures to the hand or wrist. Overuse injuries to the wrist are common in gymnastics, golf, weightlifting, racquet sports, and bicycling. In gymnastics the upper extremity becomes a weightbearing limb and studies indicate the incidence of wrist pain in gymnasts to be as high of 73%. [24] The differential diagnosis in chronic wrist pain in any athlete should include triangular fibrocartilage tears, injury to the distal radial physis, ulnar impaction syndrome, dorsal wrist ganglion, dorsal wrist capsulitis, and carpal instability. Other possible sources

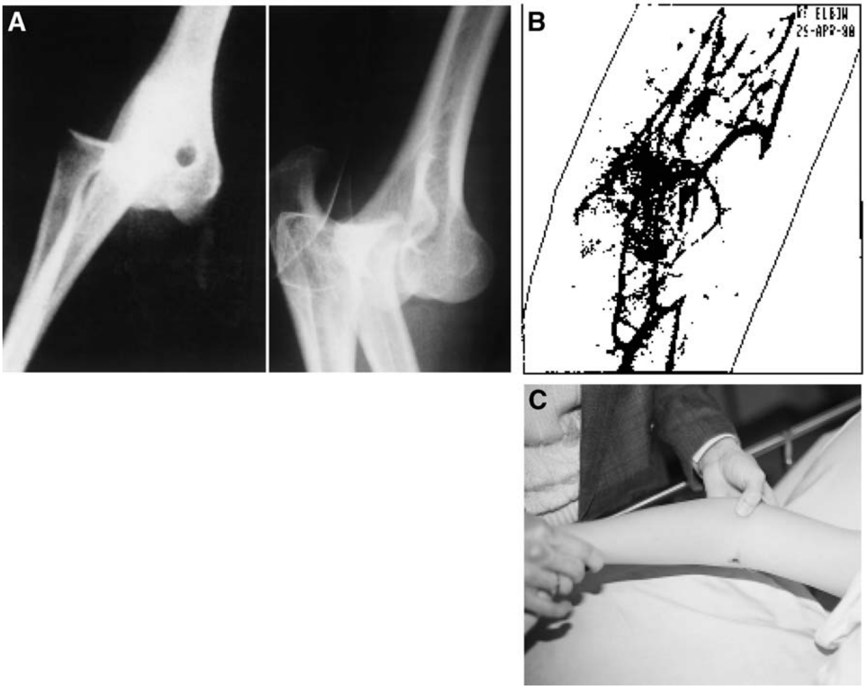

Fig. 6. Elbow dislocation. (*A*) Anteroposterior and lateral radiographs show a posterolateral elbow dislocation. Examination revealed a pulseless upper extremity and an ecchymotic area anteromedially. (*B*) Arteriogram shows no filling of the brachial artery. (*C*) Cephalic vein patch was done to restore normal vascularity to the upper extremity.

of wrist pain are hamate fracture, carpal tunnel syndrome, tendinitis, and ulnar nerve compression.

Stress fractures

There are several populations of female athletes at increased risk for stress fracture. There is a high association between menstrual irregularities and stress fracture which is discussed below. [25–27] Distance runners, ballet dancers, gymnasts, and those with poor nutrition and menstrual irregularities are at increased risk. [3] A detailed nutritional and gynecological history should be obtained in female athletes presenting with stress fracture.

The spine in the female athlete

Scoliosis is more common in females than males. Early screening with appropriate intervention should be done as part of the preparticipation physical examination. Spondylolisthesis and spondylolysis should be considered in

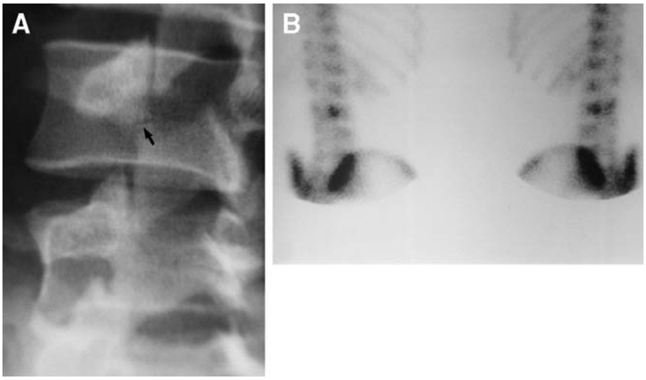

Fig. 7. Spondylolysis. (*A*) In this athlete with pain on hyperextension, an acute pars interarticularis defect is seen on oblique views. (*B*) The acuteness of the injury is demonstrated on bone scan with increased activity in the L-4 area. (*From* Fu FH, Stone DA. Sports Injuries: Mechanisms, Prevention, and Treatment. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2001.)

athletes who perform repetitive flexion and extension activities. The radiographic examination should include oblique and standing lateral views. Back pain with a negative radiographic examination should be evaluated with a single-photon emission computed tomography (SPECT) bone scan to rule out fracture. Sciatica can occur with or without spondylolisthesis or lysis and should be evaluated accordingly. Vertebral body fractures, pedicle stress fractures, and multiple compression fractures have also been reported in female athletes and should be in the differential diagnosis of an athlete complaining of back pain. [3] Fig. 7 demonstrates a case of spondylolysis.

The female athlete triad

The female athlete triad is defined as amenorrhea, disordered eating, and osteoporosis. The triad is a multifactorial problem. The earlier the diagnosis, the better the chance for establishment of normality. Activities such as dancing, cheerleading, gymnastics, figure skating, and distance running, which emphasize a prepubertal body type, perfectionism, thinness, have revealing clothing, and are subjectively judged place women at increased risk for developing this disorder. [28] Other risk factors include a drive to excel at any cost, pressure from coaches or parents, lack of knowledge regarding nutrition, a family history of eating disorders, and a history of abuse. Young athletes who are approaching puberty appear to be at increased risk as well. When evaluating an athlete suspected of having the triad it is of utmost importance to take a detailed nutritional and menstrual history. [29] The true prevalence of the female athlete triad is unknown. The best treatment for the female athlete triad is prevention through preparticipation physical examination, education, nutritional counseling, and screening. If the triad is already established, the treatment is multidisciplinary

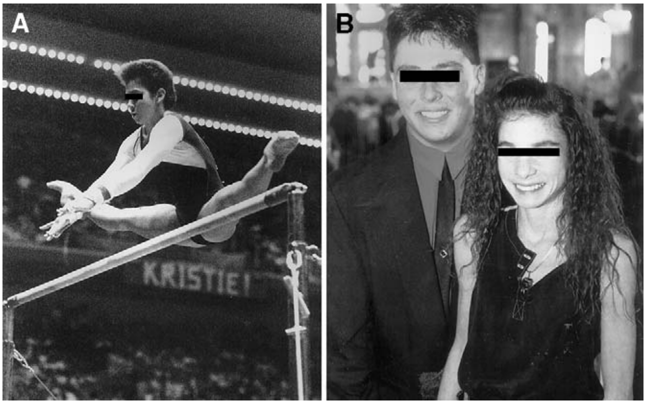

Fig. 8. (*A*) Christy Henrich is shown when she was competing at the elite level in gymnastics. (*B*) She did not make the Olympic Team. She died of anorexia nervosa. Her picture several months before her death is shown. (Reprinted with permission from API Wide World Photos, 50 Rockefeller Plaza, New York, NY 10,020.)

with a physician, psychiatrist or psychologist, and nutritionist involved in the care of the athlete. [30] Cure is rare. Educational programs are available. [31] This 22-year-old gymnast died of starvation or nutritional deficiencies (Fig. 8). [31a]

Disordered eating

There is a wide spectrum of eating disorders among athletes, ranging from anorexia nervosa and bulimia, to restrictive eating behaviors, to poor nutritional habits. The risk factors for disordered eating are the same as those listed earlier under The Female Athlete Triad. Those athletes with anorexia nervosa or bulimia are of obvious concern but athletes with less extreme disordered eating patterns are at risk for certain endocrine, skeletal, and psychiatric problems. [32] Eating disorders are 10 times more prevalent in women than in men. The exact prevalence in athletes is unknown but ranges from 15% to 62% of athletes depending on the sport. The prevalence of eating disorders in the nonathlete is estimated at between 1% and 3%. The prognosis for eating disorders is poor. Among nonathletes, 50% do well, 30% struggle and relapse, and there is a 10% to 20% mortality rate. There have been no published studies to date regarding the prognosis of eating disorders in female athletes and it is unknown how often disordered eating patterns resolve after college or competitive athletics. Many continue to struggle with weight concerns and body image after their athletic careers are over. [33]

Anorexia nervosa is defined by the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV) as refusal to maintain minimal body weight for height (less than 85% of expected weight), intense fear of weight gain, disturbed body image, and three consecutive months of amenorrhea in post-menarchal females or failure to begin menstruating by age 16. Signs and symptoms of anorexia include amenorrhea, fat loss, muscle loss, dry hair, dry skin, cold and discolored extremities, decreased body temperature, lanugo, lightheadedness, decreased ability to concentrate, and bradycardia. [34]

Bulimia nervosa is defined by the DSM-IV as recurrent binge eating within any 2-hour period; overeating; a sense of lack of control over eating during any 2-hour period; recurring behavior compensation for overeating by vomiting, abuse of laxatives, or other drugs; fasting or excessive exercise; binge eating and purging at least twice weekly for 3 months; and negative self–body image and self-image. Disturbed behavior does not occur exclusively during times of anorexia nervosa. Signs and symptoms include swollen parotid glands, chest pain, sore throat, abdominal pain, erosion of tooth enamel, face edema, extremity edema, diarrhea, constipation, menstrual irregularities, knuckle scars, nail changes, and bloodshot eyes. [34]

Menstrual irregularities

Primary amenorrhea is defined as absence of menstruation by age 16 in a girl with secondary sex characteristics. Secondary amenorrhea is absence of three of more consecutive menstrual cycles after menarche. Oligomenorrhea is a menstrual cycle greater than 36 days. The prevalence of amenorrhea in the general population is 2% to 6% and in athletic populations, between 3.4% and 66%. All three of these disorders can result in decreased bone mineral density (BMD) and put the patient at risk for early osteoporosis and stress fracture. The exact cause of amenorrhea in athletes is unknown, but it most likely has a hypothalamic origin and results in decreased ovarian hormone production and hypoestrogenemia similar to menopause.[35,35a–c]

The significance of athletic amenorrhea is the observed skeletal demineralization seen in nonmenstruating athletes which predisposes them to injury, especially stress fracture and early osteoporosis. [36] The long-term effects to bone health caused by athletic amenorrhea are unknown. The danger is that these women are losing bone at a time in their lives when they should be laying it down and they may never achieve peak bone mass. [35] There is also a theoretical risk of increased incidence of cardiovascular disease, infertility, reproductive system cancer, and osteoporosis. Athletic amenorrhea is a symptom of an underlying problem and should be treated in the first 3 months. After ruling out other causes of amenorrhea, treatment of athletic amenorrhea in a woman who has been menstruating for less than 3 years is to decrease exercise intensity and improve nutrition. [37] For an athlete who is more than 3 years post-menarche, treatment is low-dose oral contraceptives. [35]

Osteoporosis

Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enhanced skeletal fragility and increased risk of fracture. Women are four times more likely to develop osteoporosis than men. [38] Osteoporosis is defined in terms of BMD. Bone densitometry by dual photon radiographic absorptiometery is the modality of choice to evaluate BMD. Weightbearing exercise has a positive effect on bone mass and may reduce the rate of bone loss in adult women but it will not produce a large increase. [39] In the face of athletic amenorrhea, the positive effects of weightbearing exercise are negated. This method is quicker, less expensive, and can image specific body sites more easily than previous scanning methods. [35] Athletes suspected of early osteoporosis, the female athlete triad, and those with oligomenorrhea or amenorrhea should undergo bone densitometry. Educational programs are available. [40,41]

Iron deficiency anemia

Women are at greater risk than men for anemia. Forty percent to 50% of adolescent female athletes demonstrate some degree of iron depletion or decreased iron stores without overt anemia. [42] Twenty percent to 30% of female adolescents and young adults (athletes and nonathletes) demonstrate iron deficiency. [32] Runners appear to be at increased risk for iron deficiency anemia during their training season. Black adolescent female runners have twice the incidence of iron deficiency anemia of white adolescent female runners. True iron deficiency anemia should be differentiated from pseudoanemia or sports anemia which results from expanded plasma volume with a normal red blood cell count. [1] Only those athletes at high risk for anemia or those with a previous history of iron deficiency anemia should be screened.

The aging female athlete

As our society becomes more fitness-oriented it has become more acceptable for older women to pursue exercise. Women are continuing to be active in sports which they enjoy and some of those who have never before exercised are beginning fitness programs. Most information on the aging female athlete has been extrapolated from male data, but there have been a few studies suggesting the following positive aspects of exercise in the aging female athlete. As we age we lose muscle mass, flexibility, and bone mass, and aerobic capacity declines. [43] Body weight decreases due to loss of muscle mass while the percentage of body fat increases. Despite these changes, exercise training can still increase the size and strength of conditioned muscle. Exercise programs should take into account prior fitness levels, bone demineralization, and type of exercise. In addition to increased muscle strength, cardiovascular benefits, increase in lean body mass, and increased bone mineralization are other positive outcomes of exercise. Treatment of injuries in older females should be based on activity level and physiological age rather than chronological age.

The pregnant athlete

As women's sports participation increases, so too will the number of women who wish to continue their exercise programs throughout their pregnancy. Of importance is the physical fitness level of the patient before conception. In most cases women can safely continue an exercise program during their pregnancy. This should be done in coordination with the athlete's obstetrician. The major concerns for pregnant athletes are the effects of elevated maternal temperature on the fetus, the effect of exercise on blood flow to the fetus, and the effects of exercise on the weight of the fetus. [38] The American College of Obstetricians and Gynecologists guidelines for exercise during pregnancy and contraindications to exercise during pregnancy are summarized in Table 3. [44,45] The

Table 3
Summary of the American College of Obstetricians and Gynecologists contraindications to and recommendations for exercise during pregnancy

Contraindications
Pregnancy-induced hypertension.
Preterm rupture of membranes.
Preterm labor during the prior or current pregnancy or both.
Incompetent cervix/cerclage.
Persistent second- or third-trimester bleeding.
Intrauterine growth retardation.
1. During pregnancy, women can continue to exercise and derive health benefits even from mild-to-moderate exercise routines. Regular exercise (at least 3 times per week) is preferable to intermittent activity.
2. Women should avoid exercise in the supine position after the first trimester. Such a position is associated with decreased cardiac output in most pregnant women; because the remaining cardiac output will be preferentially distributed away from splanchnic beds (including the uterus) during vigorous exercise, such regimens are best avoided during pregnancy. Prolonged periods of motionless standing should also be avoided.
3. Women should be aware of the decreased oxygen available for aerobic exercise during pregnancy. They should be encouraged to modify the intensity of their exercise according to maternal symptoms. Pregnant women should stop exercising when fatigued and not exercise to exhaustion. Weightbearing exercises may under some circumstances be continued at intensities similar to those prior to pregnancy throughout pregnancy. Nonweightbearing exercises such as cycling or swimming will minimize the risk of injury and facilitate the continuation of exercise during pregnancy.
4. Morphologic changes in pregnancy should serve as a relative contraindication to types of exercise in which loss of balance could be detrimental to maternal or fetal well-being, especially in the third trimester. Further, any type of exercise involving the potential for even mild abdominal trauma should be avoided.
5. Pregnancy requires an additional 300 kcal/d to maintain metabolic homeostasis. Thus, women who exercise during pregnancy should be particularly careful to ensure an adequate diet.
6. Pregnant women who exercise in the first trimester should augment heat dissipation by ensuring adequate hydration, appropriate clothing, and optimal environmental surroundings during exercise.
7. Many of the physiological and morphological changes of pregnancy persist 4–6 wks postpartum. Thus, prepregnancy exercise routines should be resumed gradually based on a woman's physical capability.

Modified from Exercise During Pregnancy and the Postpartum Period. ACOG Technical Bulletin, 89. Washington, DC. American College of Obstetricians and Gynecologists; 1994. p. 3–4.

benefits of exercise during pregnancy include weight control, improved muscle tone, improved self-esteem, decreased incidence of varicosities, decreased incidence of back pain, and decreased incidence of sleep disturbance. [46]

Conclusion

Appreciation of the unique situations that exist for female athletes will improve their care and treatment. Medical personnel who have added these insights to their armamentarium can make diagnoses more efficiently and institute treatment earlier. The epidemic of knee injuries in females is of concern and requires further research. Very important factors in prevention are strengthening of the trunk and core, low back, and hip musculature and analysis of dynamic movement patterns. The high incidence of eating disorders and hormonal and nutritional imbalances increases the risk for stress fracture. Treatment of eating disorders and menstrual irregularities should be instituted quickly to avoid adverse sequelae to the bone. Exercise can be performed safely in most pregnant patients in conjunction with their obstetrician and in keeping with their prepregnancy level of fitness. Sports participation and physical fitness should be encouraged in women of all ages.

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