REHABILITATION OF THE INJURED KNEE

EDITOR

Letha Y. Griffin

Staff, Peachtree Orthopaedic Clinic
Team Physician, Georgia State University
and Agnes Scott College
Atlanta, Georgia

SECOND EDITION

with *374* illustrations

Mosby

St. Louis Baltimore Berlin Boston Carlsbad Chicago London Madrid
Naples New York Philadelphia Sydney Tokyo Toronto

Mosby
Dedicated to Publishing Excellence

Editor: Robert Hurley
Developmental Editor: Leslie Neistadt
Associate Developmental Editor: Christine Pluta
Project Manager: Linda Clarke
Project Supervisor: Allan S. Kleinberg
Designer: Sheilah Barrett
Manufacturing Supervisor: John Babrick
Cover Artist: Diane Kay Davis

SECOND EDITION

Printed in the United States of America
Composition by Graphic World
Printing/binding by Maple-Vail York

Mosby–Year Book, Inc.
11830 Westline Industrial Drive
St. Louis, Missouri 63146

Library of Congress Cataloging in Publication Data

Rehabilitation of the injured knee/editor, Letha Y. Griffin.—2nd ed.
p. cm.
Rev. ed. of: Rehabilitation of the injured knee/editors, Letha Y. Hunter, F. James Funk, Jr. 1984.
Includes bibliographical references and index.
ISBN 0-8016-7556-1
1. Knee—Wounds and injuries. 2. Knee—Wounds and injuries—Patients—Rehabilitation. I. Griffin, Letha Y.
[DNLM: 1. Knee Injuries—rehabilitation. 2. Knee Joint—physiology. WE 870 R345 1994]
RD561.R43 1994
617.5'82—dc20
DNLM/DLC
for Library of Congress
94-26852
CIP

95 96 97 98 99/9 8 7 6 5 4 3 2 1

Chapter 26

WOMEN

Mary Lloyd Ireland
Mark R. Hutchinson

Medical research has traditionally focused on males more than females. Reasons cited included the easy accessibility of male subjects in the medical schools of the past and the increased risks and added variables associated with studying females of childbearing age. Similarly, because men participated in athletics in greater numbers than women and because they dominated the high-visibility sports, the focus of sports medicine research has been on the male athlete.

However, in the last decade as women have become increasingly active in both competitive and recreational sports, more research attention is being directed at female athletes, for whom anatomic, physiologic, and psychological gender differences create unique situations and concerns in the diagnosis and treatment of illnesses and injuries. In order to provide optimal care for female athletes, members of the sports medicine team must not only appreciate these gender differences but also understand how they affect injury patterns involving the knee as seen in various sports.

HISTORICAL PERSPECTIVE OF WOMEN IN SPORTS

Although women have participated in sports for more than 1000 years, only recently has the number of females participating in structured, competitive, and recreational athletics skyrocketed. There were no female participants in the first modern Olympic Games in 1896, and in 1932 only 4% of all participating athletes were female.[44] By 1968, however, the number of female participants had risen to 14%. Helen Wills Moody, "Babe" Didrikson Zaharias, and Althea Gibson were among the first well-known female athletes.

In the United States, the enactment and enforcement of the Title IX Educational Assistance Act of 1972 was a major impetus for the expansion of women's opportunities in athletics. Title IX mandated that all institutions receiving federal funds provide equal opportunities to women for all programs, including athletics.

With this added accessibility and encouragement, as well as the greater focus on fitness during the past two decades, the participation of women in sport has increased dramatically. Along with this increase in sports participation has come an associated increase in the incidence of sport-related injuries in women,[44,85,100] particularly those about the knee.

ANATOMY

The sports medicine professional must have a fundamental knowledge of knee anatomy in order to understand and implement a rehabilitation program that will permit the athlete to return to sport safely and effectively. The complex and intricate anatomy of the knee is discussed in Chapter 2. When compared with males, female athletes have certain anatomic differences that place them at greater risk for particular types of knee injuries.

Women: not just smaller men

Just as children are not adults in little packages, women are not just men in different packages. Most females have a lower center of gravity, wider pelvis, shorter legs, and greater genu valgum than males.[8,53] Women have less muscle mass and a greater percentage of body fat per body weight than men.[7,63]

However, during gait and normal running movements, muscle activity is the same for men and women by electromyographic (EMG) analysis.[77] There is no difference in EMG activity of the quadriceps muscle in women runners with and without patellofemoral pain,[77] but increased isokinetic and isometric torque production in men compared with women has been reported.[57] When corrected for weight, lower extremity strength in women is almost equal to that in men, but shoulder and upper extremity strength is less.[95]

With regard to injuries, the probability of injury increases with the weight of the participants.[39] Because women are smaller,[15,18,39] the likelihood of serious injury on the basis of total body weight is less than in men. However, in contact sports with participants of mismatched size, the smaller or less skilled participant is more likely to be injured, putting the female athlete at risk.

Role of the anterior cruciate ligament in knee stability

When compared with the male, the female may be more dependent on ligaments than muscles for knee stability. Because women are less muscular, they cannot as easily use strength to compensate for patellofemoral problems or rotatory instability. Where men rely on their strong quadriceps mechanism, strong hamstrings, and ability to maintain a relatively flexed position of the knee to prevent functional instability, women have less muscular power, often greater knee hyperextension, and increased laxity and are more dependence on the anterior cruciate ligament (ACL) for knee stability.

According to the NCAA surveillance survey,[91] females are at increased risk of ACL injury in a variety of sports, including gymnastics, soccer, and basketball. Contributing to this increased incidence may be the reduced femoral notch width and variable shape seen in some female knees when compared with male knees (Fig. 26-5).[95,130] Various authors have noted the relatively increased risk of ACL injury with reduced notch size.[68,115]

CONDITIONING

The baseline level of conditioning in most females is significantly lower than that of their male counterparts,[18,20,34,127,130] and this lower level of conditioning is thought to be related to the higher incidence of knee injuries in the female athlete.[8,53] This is not to imply that all women are in poor condition or that women athletes cannot benefit from conditioning; in fact, the opposite is true. Perhaps as a result of their lower level of fitness initially, women demonstrate more improvement with training, resulting in significant increases in strength, power, and muscular endurance.[9] Adequate conditioning is important in enhancing performance and reducing risk of injury.[42] Excellent comparative studies have been done in the military setting. Compared to men, women naval midshipmen improve their fitness more rapidly in aerobic and resistive training.[20] Athletic women in the Navy were found to have more success than their nonathletic female counterparts in the areas of stamina, strength, and self-discipline.[40] Women were capable of efficiency and aerobic metabolism on a par with men.[101]

Stress-related injuries, including those involving the knee, have long been known to be associated with poor conditioning.[6] A random review of 74 female and 74 male cadets demonstrated an increased incidence of stress fractures in the women.[95] In other studies at the Naval Academy, stress-related injuries were seen more frequently in women; however, as the women became acclimated to the rigors of training, their levels of serious injuries decreased to the level of the men's serious injuries.[67,101]

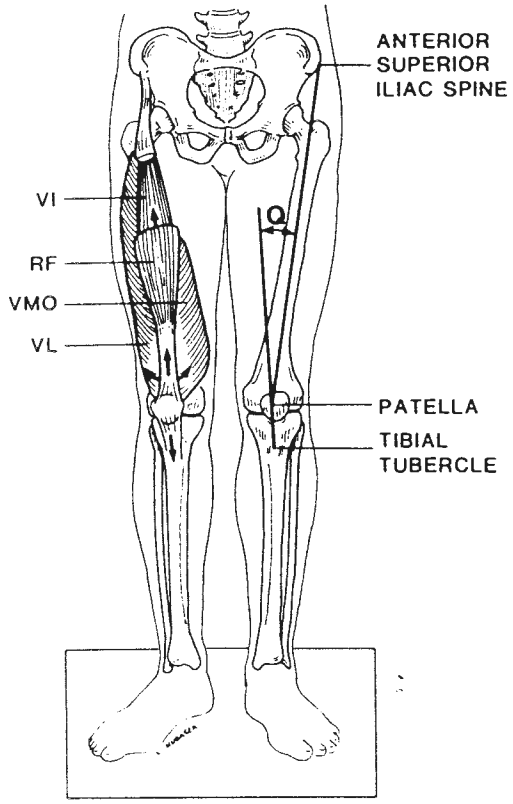

Fig. 26–2. Measurement of Q-angle is done with line drawn from ASIS to patella and patella to tibial tubercle. Normal Q-angle is less than 12 degrees.

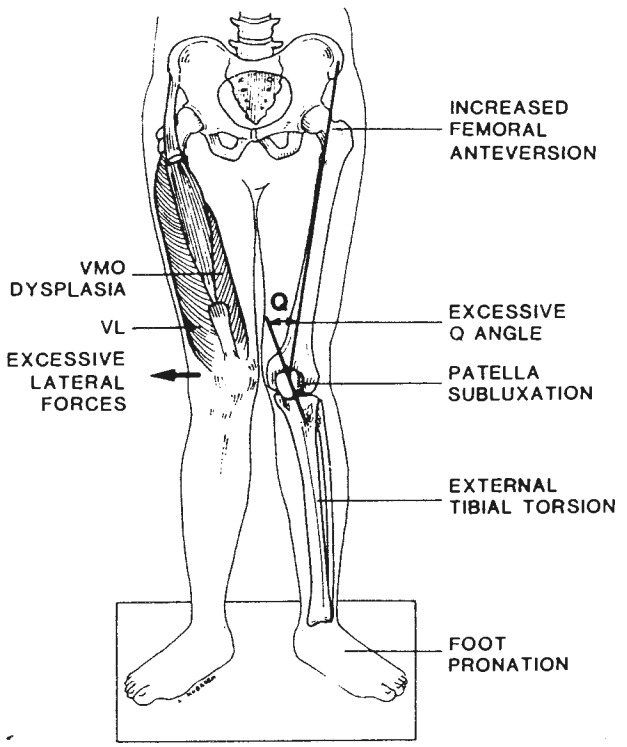

Fig. 26–3. *Miserable malalignment syndrome* is a term coined to describe patients who have increased femoral anteversion, genu valgum, vastus medialis obliquus dysplasia, external tibial torsion, and forefoot pronation. These factors create excessive lateral forces and contribute to patellofemoral dysfunction.

Alignment

Bony alignment contributes directly to the forces and strain on the knee compartments, ligaments, and musculotendinous structures. Therefore, anatomic gender differences are especially significant about the knee. In addition to the previously mentioned greater genu valgum, females often have increased femoral anteversion, less development of the vastus medialis obliquus (VMO), greater flexibility, and differences in femoral notch shape and width compared to males (Fig. 26-1). The genu valgum, VMO hypoplasia, and femoral anteversion enhance the laterally directed forces on the patellofemoral joint and intensify stresses on the medial compartment and the medial collateral ligament.[51]

The normal valgus alignment of the lower extremity creates a natural tendency for the mobile structures crossing the knee joint to be displaced laterally during gait.[6,29,32,51] The usual Q-angle, a measurement of the angle created by the intersection of the line from the anterior superior iliac spine to the center of the patella and the line from the center of the patella to the center of the tibial tubercle, is 12 degrees or less (Fig. 26-2). Increased Q-angles magnify the lateral vector and create asymmetry in the quadriceps force. These excessive lateral forces on the quadriceps mechanism, along with patella alta and rotatory limb malalignment, contribute to the destabilization of the patellofemoral joint and enhanced lateral patellar tracking (Fig. 26-3). Retropatellar pain or "miserable malalignment syndrome" is often seen in women who have femoral anteversion, genu valgum, vastus medialis hypoplasia, external tibial torsion, and/or foot pronation (Fig. 26-4).

Ligamentous laxity

Multiple factors contribute to an increased incidence of patellar subluxations and ligament sprains in the female athlete, including ligamentous laxity, flexibility, and strength.[37,98] Cyclic hormonal changes and pregnancy have been shown to increase connective tissue laxity in females, but studies have failed to demonstrate a relationship between knee laxity and injury.[30,62]

Although females tend to have more laxity than their male counterparts, athletic females have less laxity than their nonathletic counterparts.[62] Thus, laxity may be a function of conditioning rather than genetics.[6] Others argue that because patellofemoral conditions are often unilateral, anatomy alone cannot account for the increased incidence of knee injuries in the female athlete.[6] Further research and comparative studies will help to shed light on this complex issue.

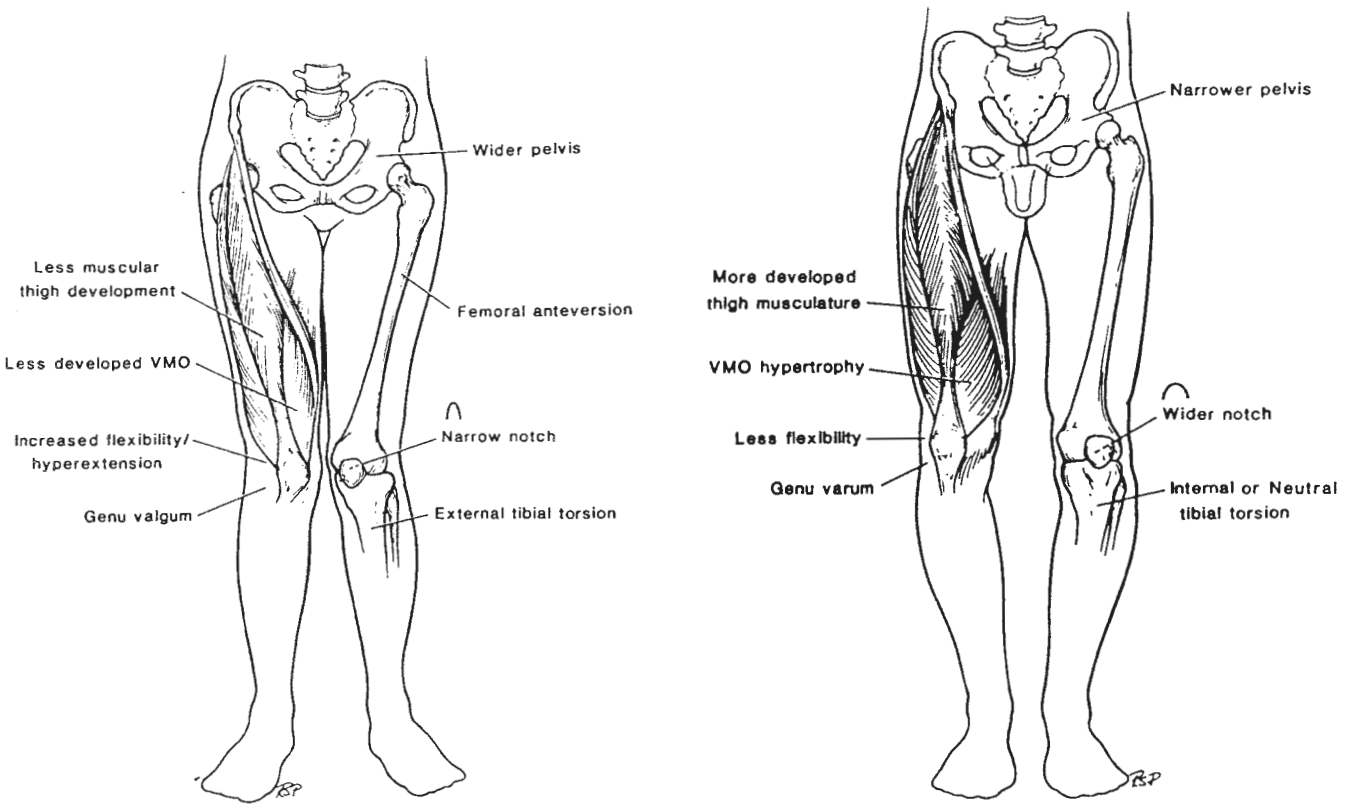

Fig. 26–1. Female alignment *(left)* is diagrammatically shown with wider pelvis, femoral anteversion, genu valgum, hyperflexibility, external tibial torsion, and narrow notch. Male alignment *(right)* demonstrates a narrower pelvis, more developed thigh musculature, genu varum, internal or neutral tibial torsion, and wider notch.

Fig. 26–4. Clinical view from the front and side of miserable malalignment syndrome alignment demonstrating knee hyperextension, VMO dysplasia, genu valgum, and pes planus.

Rehabilitation expectations and performance goals should be based on the athlete's preinjury level of conditioning. Often it is the poorly conditioned athlete who can make the greatest early strides in improving performance compared with the preinjury status of conditioning.[6,49,69,85,126] By increasing levels of conditioning in all athletic females, it may be possible to reduce the incidence and severity of injuries and associated time away from sport.

Injury-specific concerns for women

Certain specific injuries and injury patterns are seen more frequently in the female knee. Most injuries, however, are sport-specific, not gender-specific. Males sustain more injury by direct contact, whereas females are vulnerable to overuse syndromes and noncontact ligament sprains of the knee.[6] The increased incidence of contact-related injuries in males is directly correlated with the male predominance in certain sports, especially football and ice hockey.

Females are more likely to sustain noncontact injuries because of differences in anatomy, conditioning, and sport participation. Their injury rate is also influenced by the fact that they may not acquire the fundamental motor skills necessary for sports during the developmental years.[6]

STRESS FRACTURES

As previously mentioned, women, and especially unconditioned women, are at increased risk of sustaining overuse injuries, including stress fractures.[95] The major factor contributing to the incidence of stress fractures in female military recruits is the rapid onset of training, which fails to allow for progressive exposure to stress and the development of tolerance.[67] Many stress fractures can be avoided with a progressive training regimen; in fact, as female recruits became more acclimated to the rigors of training, the incidence of injuries declined.[101]

Women with relatively low bone density, amenorrhea, and poor diets—for example, female runners with menstrual irregularities and ballerinas with poor diets and menstrual irregularities—are more susceptible to stress fractures.* A detailed nutritional history should be obtained

*References 31, 48, 72, 81, 89, 120.

Fig. 26–5. Radiographs of notch views showing a narrow **A** shape of a female *(left)* and wide **C** shape of a male *(right)*. Smaller notch to femoral width ratios are contributing factors to ACL injury.

from these individuals so that nutritional deficiencies or eating disorders may be identified and treatment instituted. Obtaining a gynecologic history is also important; it may be possible to reduce the risk of stress fractures in some amenorrheic athletes by placing them on cyclic estrogens.

PATELLOFEMORAL STRESS SYNDROME

Patellofemoral joint problems are more common in female athletes than in male athletes.[6,24,53,62,127] Patellofemoral stress syndrome, or anterior knee pain, describes a vast array of disorders that may be categorized as inflammatory, mechanical, or miscellaneous (Table 26-1).[33] Patellofemoral stress syndrome is a clinical diagnosis that may be present with such concurrent pathologic processes as chondromalacia patella, symptomatic plica, lateral subluxation of the patella, and early degenerative disease. In addition, Ficat and Hungerford have described the "excessive lateral pressure syndrome," present in both males and females,[28] that has subtle abnormalities and symptoms unrelated to instability or significant malalignment.

Symptomatic plicas appear to be more common in women. The increased valgus alignment of the female knee increases the likelihood that the plica (a redundant flap of synovium[50,94]) will come in contact with the medial femoral condyle and become irritated and inflamed, causing anterior knee pain.

Most athletes with patellofemoral stress syndrome improve on a regimen of oral nonsteroidal anti-inflammatory medications, hamstring stretching, and quadriceps strengthening with particular emphasis on the vastus medialis obliquus (VMO). The VMO, the primary compensating factor for lateral patellar instability,[6,24,29,96] is the chief structure that provides an active medial vector to counterbalance the valgus force. VMO activity is not significantly different in symptomatic and asymptomatic individuals,[104] but patients with patellar subluxation exhibit decreased VMO activity.[79] The VMO is the first muscle to demonstrate atrophy in the injured knee,[29] and it is the most difficult part of the quadriceps to rehabilitate following injury.[6,29,111,128] VMO hypoplasia is more common in females and may be genetically

Table 26-1. Differential diagnosis of anterior knee pain

Inflammatory	Mechanical	Miscellaneous
Bursitis	Hypermobility	Reflex sympathetic dystrophy
Prepatellar	Subluxation	Osteochondritis dissecans
Retropatellar	Dislocation	Fat-pad syndrome
Pes anserinus	Patellofemoral stress syndrome	Systemic arthritides
Tendonitis	Pathologic plica syndrome	Muscle strain
Pes anserinus	Osteochondral	Stress fracture
Semimembranosus	Arthrosis	Meniscal tear
Patellar		Iliotibial band syndrome
Synovitis		

linked, making rehabilitation of the entire quadriceps, but particularly the VMO, especially important in these individuals.

OSGOOD-SCHLATTER'S DISEASE AND JUMPER'S KNEE

Osgood-Schlatter's disease, or tibial tubercle apophysitis, occurs more rarely in women than in men, which is probably related to sports played, intensity of participation, growth phases, and earlier maturation and physeal closure in females. Jumper's knee, or patellar tendonitis, is another condition seen less frequently in women, which may be a function of the reduced knee torque produced by females compared with males.

REHABILITATION CONSIDERATIONS IN WOMEN

In comparison with male athletes, the average female athlete has less experience in sports and less access to good coaching, athletic trainers, and facilities.* She may be subject to knee injury due to errors in the performance of sport-specific and rehabilitative skills.[6] Female athletes may not have access to or previous experience with the weight room. The coach, physical therapist, athletic trainer, or physician should provide thorough instruction in exercise and rehabilitation techniques, as well as monitor the athlete's progress.

For example, certain exercises are contraindicated in the athlete with patellofemoral pain. They include high-resistance exercises of the quadriceps in an arc of motion between 90 degrees and full extension.[52] The reason for this is the increase in patellofemoral contact area as knee flexion increases (Fig. 26-6),[2] which elevates the forces directed posteriorly, exacerbating pain and reducing the effectiveness of the exercise.

Another potential problem for these athletes is the extension machine (Fig. 26-7),[43,70,103] the use of which loads the anterior tibia, and as knee flexion increases, excessive patellofemoral joint pressures are created. Research has shown that loading the patellofemoral joint from above, as in squats, and from the foot, as in leg presses, produces fewer patellofemoral joint forces than loading the anterior tibia.[28,50,103] However, squats or leg presses at 90 degrees or down to parallel should be avoided because they generate maximal patellofemoral joint reaction forces.[103]

A more focused approach of quadriceps rehabilitation for an athlete with patellofemoral stress syndrome might include terminal extension exercises and straight leg raising. Closed kinetic chain exercises, such as squats performed with the feet apart to shoulder width and involving low loads, multiple repetitions, and limited flexion, minimize patellofemoral forces and improve quadriceps strength and relieve pain.[8] Squats are performed with feet neutral and externally rotated, which accelerates VMO strengthening (Fig. 26-8). Leg presses executed in a pain-free range of motion also help to restore quadriceps function (Fig. 26-9). Stationary bicycling (with low to moderate resistance and an elevated seat) and swimming are usually well tolerated.[58] In all of these activities, maintaining proper body mechanics is essential.

Selective VMO strengthening improves patellar tracking, but simple straight leg raising or terminal extension exercises are not the optimal way to rehabilitate the VMO.[84] Instead, the femur should be externally rotated to reduce the lateral pull of the tensor fascia lata and to stretch the VMO. Hip adduction should be performed with the knee in extension to optimize the firing of the VMO, which originates in part from the adductor magnus. Electrical stimulation of the VMO, modalities, and biofeedback may also be beneficial.

PSYCHOLOGICAL CONSIDERATIONS IN THE REHABILITATION OF THE FEMALE ATHLETE

In the past, competitive or aggressive females were felt to be unladylike; those who participated in sports were likely to have their womanhood or femininity questioned.[10] Some girls feared being called tomboys or becoming muscle-bound if they exercised, and so they were forced by social pressures into more sedentary roles.

With the advent of Title IX of the Educational Assistance Act of 1972, the participation of females in sports as administrators, coaches, and athletes has increased dramatically. More women are learning about the benefits of sports and are using participation and success in athletics as a springboard to deal with the stress, competition, and challenges of professional life.[92] Young females participating in athletics have demonstrated improvements in self-confidence and overall performance.[19,95,117]

Positive reinforcement by a respected coach or athletic trainer can further enhance the self-confidence of female athletes.[19] Negative feedback, however, erodes the self-confidence of women more quickly than men. Three factors may affect female athletes' susceptibility to situational vulnerability and reduced self-confidence.[19] First, they tend to

*References 6, 24, 30, 36, 49, 62, 85.

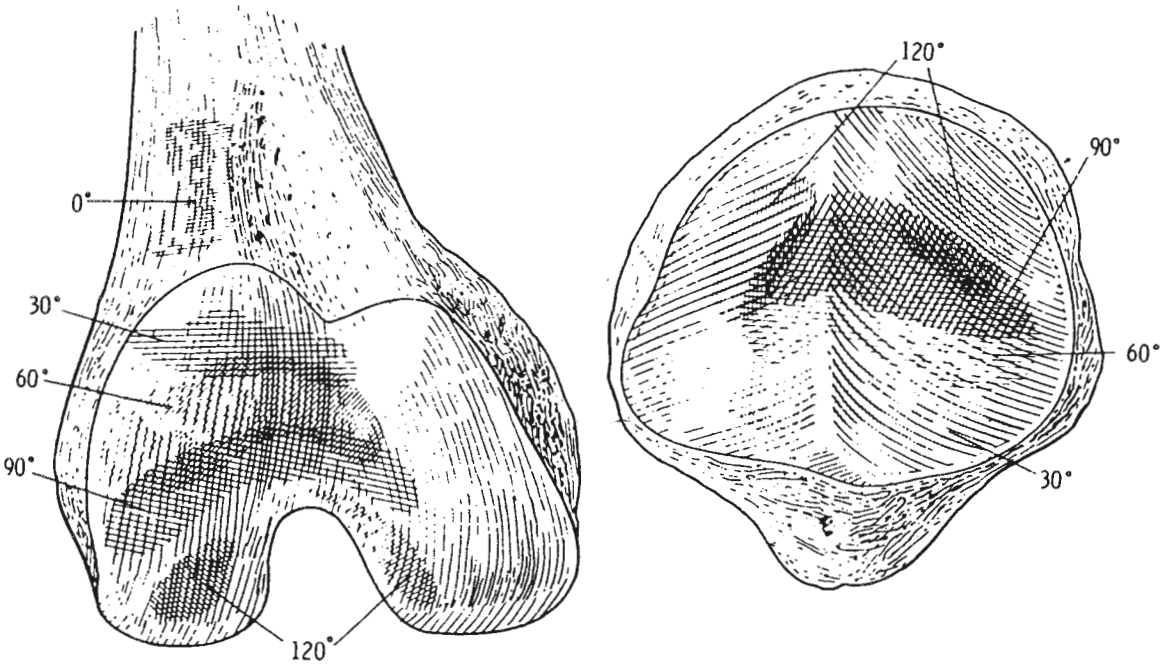

Fig. 26–6. Patellofemoral contact surface area increases with increasing degrees of flexion. The shaded areas match the respective angles of flexion at 0 degrees, 30 degrees, 60 degrees, maximal at 90 degrees, and 120 degrees. On femur, lateral is left; on patella, lateral is right. (From Aglietti P, Insall JN, Walker PS: A new patellar prosthesis, *Clin Orthop* 107:175, 1975.)

do poorly in sex-typed tasks considered to be masculine or sex-role inappropriate. Athletic trainers and physical therapists can counter this trend by emphasizing the appropriateness of the task—be it weight training or another rehabilitative technique—regardless of gender. Second, females are more sensitive to social evaluation than males. Women do not react as well as men when they are compared to other athletes or when they perceive themselves to be battling social pressures. Therefore, when rehabilitating a female athlete, it may be more effective to emphasize the individual's personal gains rather than comparing her progress with that of other athletes. Finally, women appear to be more effective in improving their performance when they receive objective, immediate, and accurate feedback. Without meaningful feedback, females tend to disparage their own performance, establishing a downward performance-confidence spiral.[19] Women may benefit from more frequent supervised rehabilitation sessions and more frequent objective evaluations (such as isokinetic studies) that can provide additional documentation and feedback regarding progress. Rehabilitation should be designed with a series of incremental realistic and attainable goals so the female athlete can see improvement.

Hormonal balance may also affect behavior. For example, menstruation may have a major impact on mood,[82] as demonstrated in one study, which showed that 60% of the athletes investigated noted mood changes with the menstrual cycle. However, only 25% detected a negative effect on their performance, and a small percentage perceived a positive change.[82]

Various authors have performed psychological assessments comparing female and male athletes.[56,90,117] Using the Bem Sex Role Inventory, which assesses feminine, masculine, and androgynous traits, female athletes tend to be more androgynous and male athletes tend to be more masculine than their nonathletic, same-sex counterparts.[90]

Women are inclined to view athletics as a social outlet, whereas men are intensely focused on winning.[44] As it becomes more socially acceptable for women to strive for success and desire victory, this difference may disappear. At the elite level, it is highly unlikely that there is any difference in the wish to succeed based solely on gender. Similarly, it is doubtful that the female athlete has any less interest in rehabilitation than the male athlete.

REHABILITATION OF THE PREGNANT FEMALE

When working with athletic females in training and rehabilitation, the clinician will undoubtedly be confronted with the issue of pregnancy. Various authors have outlined special considerations for exercise in the pregnant female.* Physically fit women with normal pregnancies who exercise regularly may have larger babies, shorter labor, and decreased incidence of complications compared with those without planned exercise programs.[129] Older studies from

*References 41, 45, 61, 75, 87, 108.

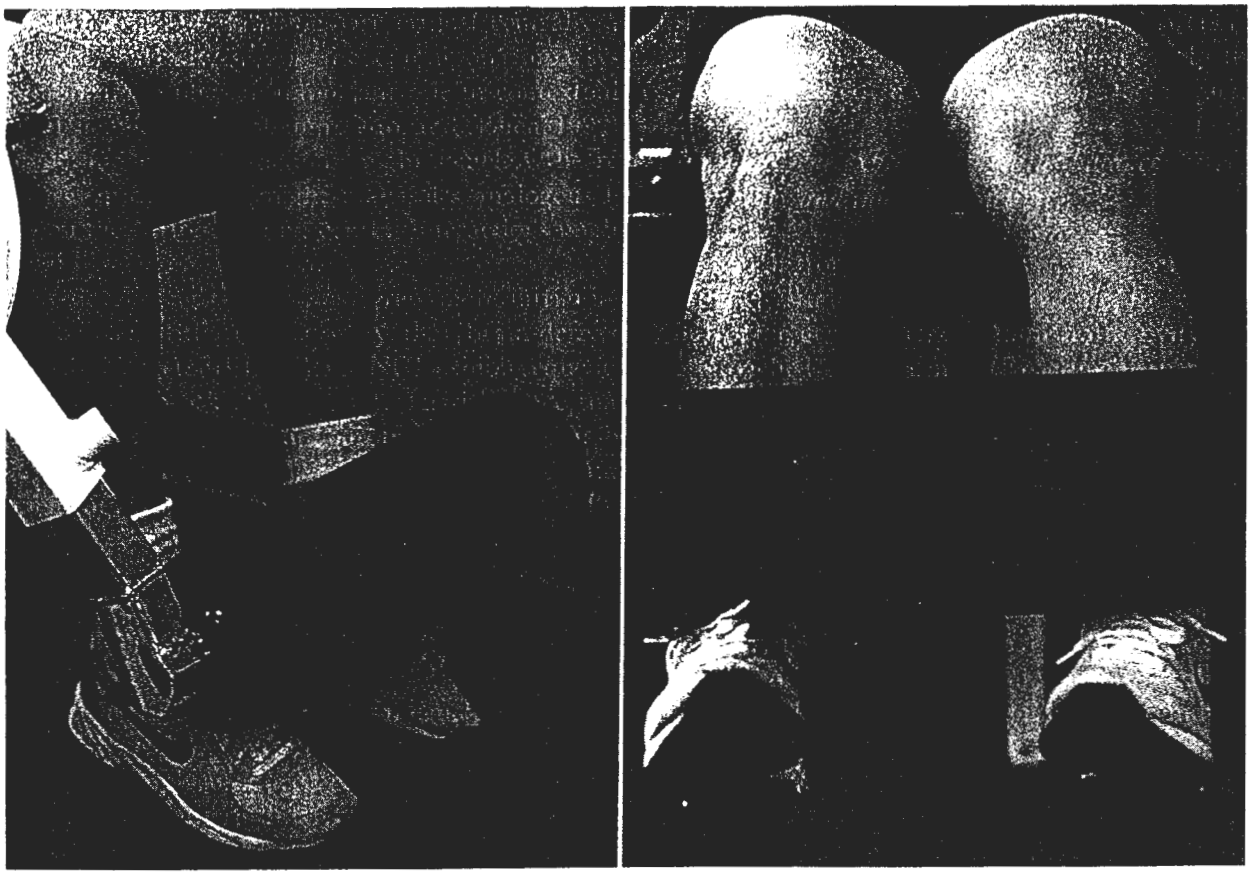

Fig. 26–7. Patient performing quadriceps strengthening exercises with knee extension machine generating excessive patellofemoral pressures with free distal movement and resistive forces on the anterior tibia.

Eastern Europe appear to confirm this.[26,27] Jogging during pregnancy may also improve the overall outcome.[60]

High-intensity exercise or change in the baseline level of exercise may, however, not always be in the best interests of the mother or the fetus. With strenuous exercise, maternal heart rates can rise as high as 200 beats per minute with an associated increase in blood pressure by 30 to 40 torr without apparent benefit to the fetus.[41] In fact, even in uncomplicated pregnancies, uterine blood flow is decreased during strenuous exercise and even more severely compromised in complicated pregnancies. There is concern that sustained exercise in pregnant women may elevate core body temperature, with possible teratogenic effects.[93,113]

Mild to moderate exercise, however, in the low-risk pregnant female is not deleterious to the fetus and may be beneficial in maintaining fitness and easing labor. A general rule of thumb is that if the athlete can carry on a conversation during her workout, then she has not exceeded her maximal physical effort.[41] The American College of Obstetricians and Gynecologists has created a set of guidelines for exercise during pregnancy and the postpartum period:[1,125]

1. Regular exercise (at least three times per week) is preferable to intermittent activities. (Competitive activities should be discouraged.)
2. Vigorous activities should not be performed in hot or humid weather or during a period of febrile illness.
3. Ballistic movements should be avoided. Deep flexion and extension of joints should be avoided because of connective tissue laxity. Activities that require jumping, jarring motions, or quick changes in direction should be avoided because of relatively increased joint instability.
4. Vigorous exercise should be preceded by a period of muscle warm-up and followed by a gradual decline in activity and cool-down.
5. Care should be taken when rising from the floor to avoid orthostatic hypotension.
6. During pregnancy, the maternal heart rate should not exceed 140 beats per minute.
7. During pregnancy, strenuous exercise should not exceed 15 minutes in length.

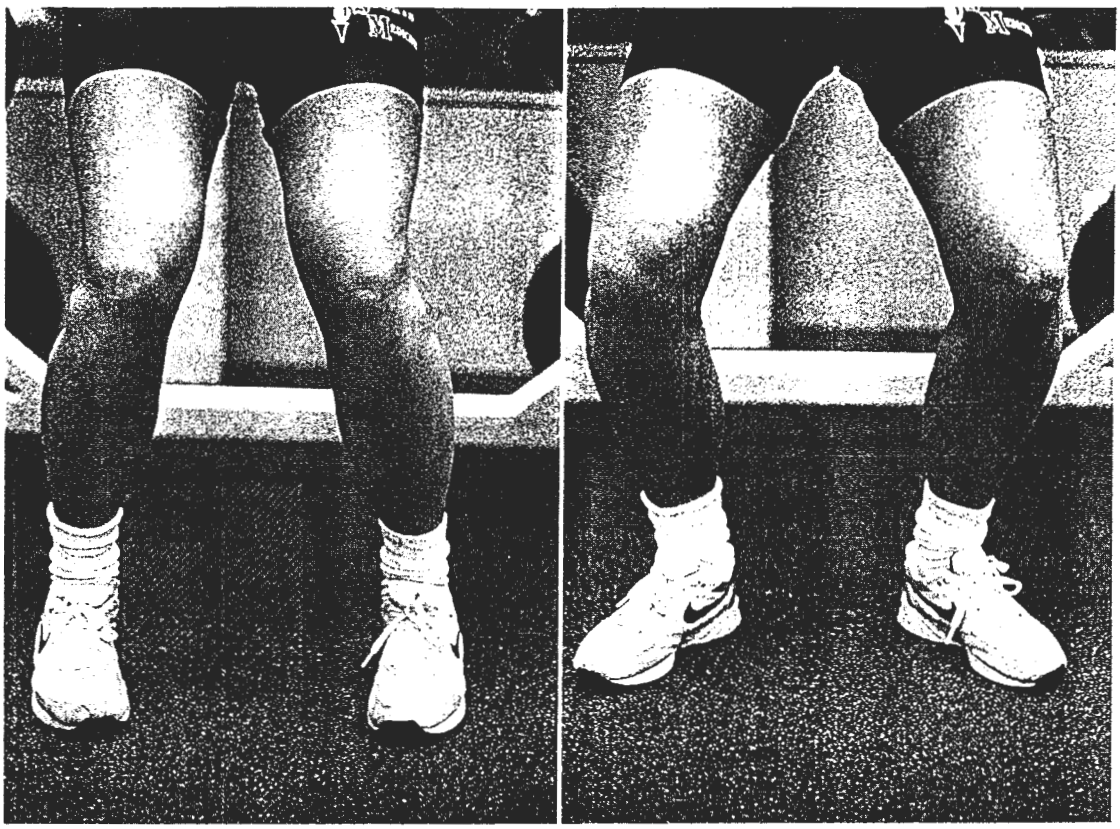

Fig. 26–8. Proper squat technique with feet apart at shoulder width *(left)* and with feet externally rotated *(right);* VMO stimulation is accentuated.

8. No exercises should be performed in the supine position after 4 months of gestation.
9. Liquid should be taken liberally and caloric intake should be adequate for the pregnancy and the exercise undertaken.
10. Maternal core temperature should not exceed 38°C.

High-intensity or prolonged endurance activities may be deleterious to the fetus, and the athlete and fetus may best be served if she refocuses her energies on shorter-duration aerobic activities. For moderate- to high-risk pregnancies, additional rest and reduced levels of exercise are indicated. Fortunately, the majority of pregnant athletic females can undergo rehabilitation for most knee injuries without added risk or difficulty.

EPIDEMIOLOGY OF KNEE INJURIES IN SPECIFIC SPORTS

The National Collegiate Athletic Association (NCAA) and Olympic competition include sports that are male and female combined, male only, and female only. In NCAA competition, female-only sports are field hockey and softball. Male-only NCAA sports include water polo, baseball, football, ice hockey, and wrestling. Olympic sports limited to females are rhythmic gymnastics and synchronized swimming. Male-only Olympic sports include baseball, bobsled, boxing, ice hockey, modern pentathlon, ski jumping, Nordic combined skiing, soccer, water polo, weight lifting, and wrestling (see box on p. 307). The first women's Olympic marathon was run in 1984 at the Los Angeles games.

About the knee, sprains and strains are the most common type of injury for both males and females. However, females tend to have a higher concentration of injuries about the knee than their male counterparts.[23] This conclusion is confirmed by the findings of the NCAA Injury Surveillance System, which has collected data on injuries in collegiate sports since 1982.[91] Knee injuries were rated as involving the patella, menisci, anterior cruciate ligament (ACL), or collateral ligaments in 1000 athletic exposures in 16 sports. In all women's sports, female gymnasts, soccer players, and basketball players had not only the highest incidence of injury but the most ACL injuries as well (Table 26-2).

Four sports—gymnastics, soccer, basketball, and lacrosse—can be compared for gender differences in rates of ACL injuries. With the exception of lacrosse, women ath-

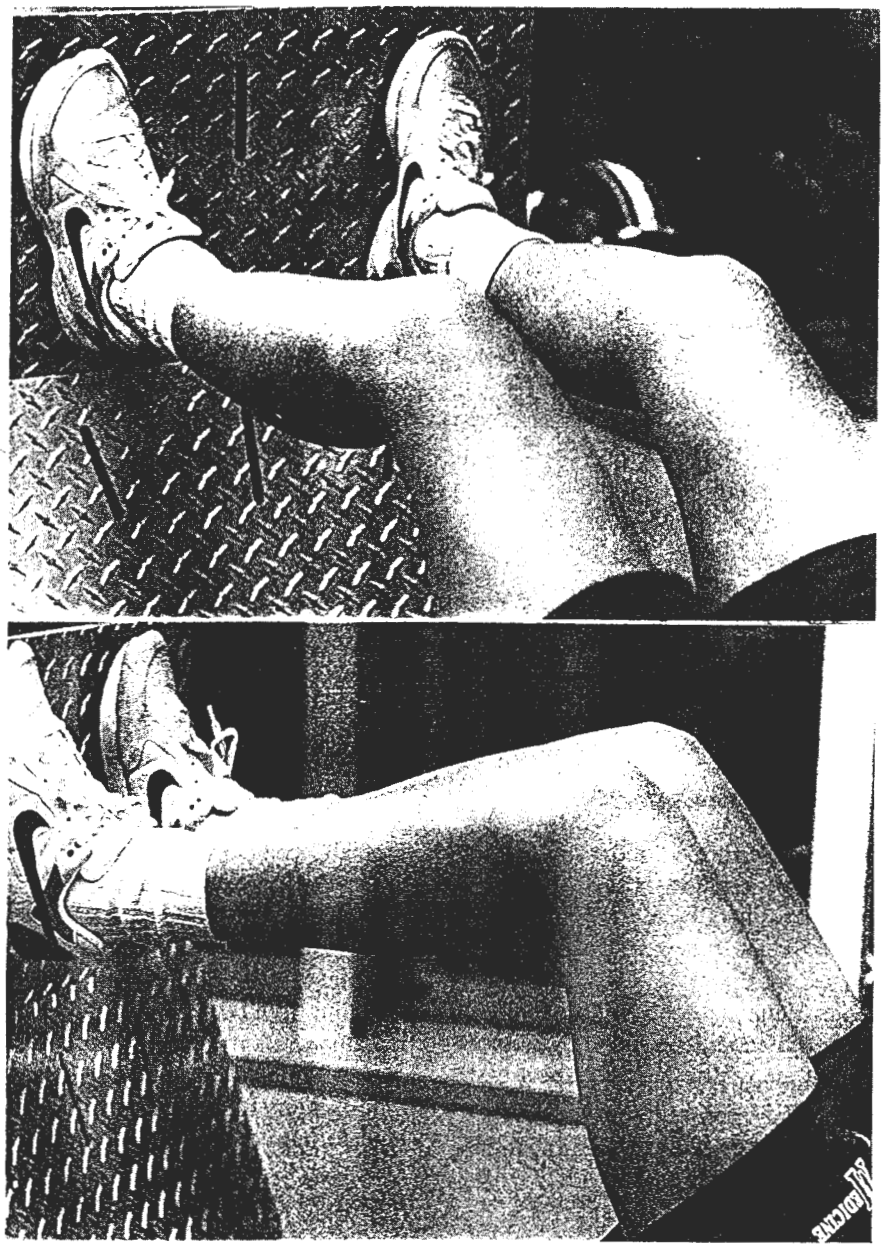

Fig. 26–9. Leg press is very effective for quadriceps strengthening with forces distal on plantar surface of feet through painless arc of knee motion.

Olympic and NCAA sports that are male or female, male only, female only, and combined

Olympic Sports

MALE AND FEMALE

Archery	Equestrian	Rowing	Table tennis
Athletics	Fencing	Shooting	Tennis
Basketball	Artistic gymnastics	Figure skating	Volleyball
Biathlon	Team handball	Speed skating	Yachting
Canoe/kayak	Field hockey	Alpine skiing	
Cycling	Judo	Nordic skiing	
Diving	Luge	Swimming	

MALE ONLY

Baseball	Nordic combined skiing
Bobsled	Soccer
Boxing	Water polo
Ice hockey	Weightlifting
Modern pentathlon	Wrestling
Ski jumping	

FEMALE ONLY

Rhythmic gymnastics
Synchronized swimming

NCAA Sports

COMBINED

Fencing
Rifle
Skiing

MALE AND FEMALE

Gymnastics	Lacrosse
Volleyball	Soccer
Basketball	Swimming/diving
Cross-country	Tennis
	Indoor/outdoor track
	Golf

MALE ONLY

Water polo	Ice hockey
Baseball	Wrestling
Football	

FEMALE ONLY

Field hockey
Softball

Table 26-2. Knee injury rates from the NCAA surveillance survey, 1991–1992

Sport	Athletic exposures	Total injuries	Rate per 1000 athletic exposures				
			Knee	ACL	Collateral	Meniscus	Patella
Women's							
Gymnastics	36,570	340	9.3	0.44	0.41	0.36	0.16
Soccer	75,064	595	7.93	0.27	0.39	0.29	0.17
Basketball	150,617	764	5.07	0.25	0.32	0.29	0.19
Field hockey	50,921	237	4.65	0.08	0.08	0.06	0.14
Lacrosse	33,315	156	4.68	0.12	0.15	0.09	0.18
Volleyball	120,258	492	4.09	0.11	0.12	0.14	0.2
Softball	71,179	255	3.58	0.13	0.11	0.08	0.11
Men's							
Spring football	39,894	378	9.48	0.18	1.03	0.18	0.28
Wrestling	108,990	977	8.96	0.11	0.86	0.29	0.19
Soccer	148,959	1221	8.2	0.13	0.53	0.19	0.23
Football	744,698	4853	6.52	0.21	0.69	0.25	0.14
Basketball	175,023	1055	6.03	0.07	0.21	0.14	0.24
Lacrosse	71,032	411	5.79	0.21	0.32	0.13	0.11
Gymnastics	10,046	54	5.37	0	0.1	0	0
Ice hockey	99,863	502	5.03	0.08	0.69	0.06	0.03
Baseball	176,702	602	3.41	0.02	0.08	0.06	0.07

letes sustained ACL injuries several times more frequently than men in the same sports.

The NCAA surveillance system has also documented injury rates in practices and games (Table 26-3). Men's spring football had the highest injury rate, followed by men's wrestling and women's gymnastics practices.[91] In women's athletics, gymnastics practice had the highest rate of injury, followed by soccer, basketball, volleyball, lacrosse, and softball practices.

Basketball

In the sport of basketball, females are at increased risk of knee injuries compared with their male counterparts.[130] Women have more patellofemoral disorders and noncontact ligament sprains, whereas men have more meniscal tears and direct contact ligament sprains.[6] An epidemiologic survey of athletes invited to the 1988 U.S. Olympic basketball trials showed that knee injuries occurred more frequently in females than males, and that females were more likely to require surgery.[57] As noted previously, the female basketball player is at increased risk for ACL injury not only over her male counterpart in basketball but also over female athletes in volleyball, lacrosse, and softball.[91]

Soccer

Female youth soccer athletes sustained injuries twice as frequently as their male counterparts, which may be attributed to less skill, conditioning, and training in the female athlete.[92,121] However, even elite female soccer athletes experienced a higher rate of injury (12 per 1000 hours of exposure) than a comparable group of male soccer players (5 per 1000 hours of exposure).[25] In soccer, knee injuries consistently represented 12% to 20% of all injuries,[64] and approximately one in six injuries to female soccer athletes involved a tear of a meniscus or major knee ligament.[25] In addition, the rate of ACL injuries in female soccer and female basketball athletes was similar.[91]

Field hockey

In field hockey, the knee injury rate was similar regardless of gender (32% for females, 27% for males).[16] For both male and female field hockey athletes, the most common type of knee injury was ligament sprain, followed by muscle strain.[16]

Softball

The incidence of lower extremity injuries in women increases with the need for cutting activities in that sport. Hence, there is a lower incidence of serious knee injuries in softball than in soccer or basketball. In fact, 82% of the injuries associated with significant time lost from sport involved the upper extremity.[22,74] Another study revealed that 19% of all injuries sustained by female softball athletes, but only 7% of those experienced by their male counterparts, affected the knee.[16]

American-style, noncontact football

Because of differences in size and weight, as well as social pressures, only a few women have participated in men's American-style, contact football at the high school and college level. Instead, women are more often involved in intramural, noncontact touch or flag football. As might be expected, different injury patterns are seen in tackle football and flag football.[18] In tackle football, the most com-

Table 26-3. All sports summary injury rates and percentage in practice versus game from NCAA surveillance system, 1992-1993

Sport	Injury rate*	Percentage practice	Percentage game
Spring football	9.59	94	6
Wrestling	9.41	66	34
Women's gymnastics	8.59	78	22
Women's soccer	7.90	51	49
Men's soccer	7.87	47	53
Football	6.57	58	42
Men's lacrosse	6.05	54	46
Men's ice hockey	5.70	32	68
Men's basketball	5.61	65	35
Women's basketball	5.13	61	39
Men's gymnastics	5.06	81	19
Field hockey	5.00	59	41
Women's volleyball	4.76	65	35
Women's lacrosse	4.25	68	32
Women's softball	3.90	52	48
Baseball	3.37	44	56

*Per 1000 athletic exposures including practices and games. From National Collegiate Athletic Association: *NCAA Injury Surveillance System*, Overland Park, Kansas, 1992-1993 NCAA.

monly injured part of the body is the knee.[14,21,67] In women's intramural flag football, the fingers are most commonly injured (39%), followed by the knee (16%).[18]

Track and field

At the collegiate level, there appears to be no difference in the knee injury rates of male and female track athletes.[16] At the elite level, however, female runners have been found to be more susceptible than males to stress fractures.[12] In addition, menstrual irregularity and stress fractures in collegiate female distance runners have been shown to be related.[5]

Volleyball

Knee injuries in volleyball constitute anywhere from 7% to 60 percent of all injuries; there is no significant gender difference.[112] Data from the NCAA surveillance system indicates that in female volleyball players the knee is the second most commonly injured body part (8% to 19%) behind the ankle (26% to 33%).[91] The risk of knee injury in female volleyball players is similar to that of male basketball players and female track and field athletes, which is significantly less than that of female basketball or gymnastics participants.[16,19]

Gymnastics

Both men and women take part in gymnastics as a sport, but they participate in different events. Women participate in balance beam, uneven parallel bars, vault, and floor exercise. Men participate in pommel horse, horizontal bar, still rings, parallel bars, vault, and floor exercise.

Women's gymnastics has the second-highest injury rate of all sports, including contact sports.[59] The greatest number of injuries are associated with the floor exercise, followed by the balance beam, uneven parallel bars, and vault, respectively.[35,36,47,83] Most injuries that occur during competition involve the upper extremity;[16,97,110] the usual mechanism for knee injuries is twisting or a difficult dismount.[53]

Knee pain is reported to affect 14% to 24% of all women gymnasts. Most such knee pain is overuse in nature, associated with intrinsic or extrinsic factors such as patellar malposition, limb deformity, muscular imbalance, malalignment, symptomatic plica, and muscle tightness.[124]

According to NCAA data, in 1991–1992 female gymnasts had the highest incidence of ACL injuries (0.44 per 1000 athletic exposures) of all sports. No male gymnast sustained an ACL injury that year. In addition, female gymnasts experienced significantly more sprains and lower extremity injuries, particularly of the knee, than male gymnasts.[16]

Cheerleading

Although male athletes do participate in cheerleading at the collegiate level, at the high school level cheerleading is primarily a female sport. Because competitive cheerleading involves the routine and precision of dance and the athleticism of gymnastics, one would expect that the numbers and types of injuries seen in cheerleading would be similar to those seen in dance and gymnastics. To date, however, few articles on cheerleaders' injuries have been published.[3,114,122,126] It has been noted that cheerleading injuries in females tended to be more severe, with an average of 7.8 days lost from sport, compared to 6.6 days for males.[3] In a separate study of 23 sports, high school cheerleading had the highest average number of days lost per injury (28.8 days).[3]

A 2-year retrospective chart review in an active orthopedic sports medicine practice revealed more than 70 injuries to cheerleaders.[55] Sprains were the most common types of injuries (30%), and the knee was the most frequently injured body part (nearly 50%). Knee injuries consisted of ligament sprains (34%), inflammation or plica irritation (31%), and patella subluxation or dislocation (26%).[55]

Ballet and dance

Ballet and dance athletes require both flexibility and finesse to perform well in their sport. A primary goal of the ballet dancer is to obtain external rotation of the hips, or turnout.[86] If external rotation of the hips is not achieved, the dancer is at increased risk for knee injuries.[86] Sammarco felt that dancers attempt to make up for poor turnout by flexing the hips and the knee, "screwing the knee,"[109] and increasing the likelihood of meniscal tears, as well as of patellofemoral strain and subluxation, particularly in the inexperienced dancer.[86,109]

Hip and knee injuries constitute 40% of the injuries to classical ballet dancers.[102] Ballet dancers also tend to have a high incidence of tibial fatigue (stress) fractures.[86] Proper technique, adequate flexibility, and sufficient strength can reduce or prevent many of these injuries. However, a dancer with multiple fatigue fractures also deserves an evaluation of her gynecologic and nutritional status.

In aerobic dance, 60% of the injuries were to the lower extremity, and 9.2% involved the knee. Shin splints were the most common injury (24.5%).[106] There were no significant gender differences in frequency, incidence, or severity of injury.[106]

Swimming

Knee injuries in swimming are closely related to the biomechanics of the stroke and the kick. For example, breaststroker's knee may be secondary to collateral ligament sprain or patellofemoral stress syndrome.[65,80,119,123] Reports indicate no significant differences in the incidence of injury between male and female swimmers.[123] However, breaststroker's knee in the female typically involves the medial patellar facet, whereas the same condition in the male often affects the tibial collateral ligament.[119]

CONCLUSIONS

General recommendations for rehabilitation of the injured knee in the male and female athlete are similar, consisting of initial treatment with rest, ice, compression, and elevation, followed by injury-specific rehabilitation. Women experience the same physiologic response to injury that men do and they respond to comparable rehabilitation techniques and modalities.

It is important, however, to identify and appreciate factors such as anatomic and physiologic differences and the baseline level of conditioning, all of which should be considered when setting goals and expectations in the rehabilitation of the female athlete. In addition, the female athlete should be educated regarding the common mechanisms and types of injuries in her chosen sport so that she may optimally condition and train to prevent future injury.

The informed clinician, therefore, is not only able to accurately diagnose and treat the female athlete's injured knee but is also cognizant of psychosocial gender differences and associated medical issues (e.g., eating disorders, menstrual irregularities, pregnancy) that may influence the rehabilitation process.

REFERENCES

1. ACOG Home Exercise Programs: *Exercise during pregnancy and the postnatal period*, Washington, DC, 1985, American College of Obstetricians and Gynecologists.
2. Aglietti P, Insall JN, Walker PS: A new patellar prosthesis, *Clin Orthop* 179:175–187, 1975.
3. Axe MJ, Newcomb WA, Warner D: Sports injuries and adolescent athletes, *Del Med J* 63:359–363, 1991.
4. Baechle TR: Women in resistance training, *Clin Sports Med* 3:791–880, 1984.
5. Barrow GW, Saha S: Menstrual irregularity and stress fractures in collegiate female distance runners, *Am J Sports Med* 16:209–215, 1988.
6. Beck JL, Wildermuth BP: The female athlete's knee, *Clin Sports Med* 4:345–366, 1985.
7. Behnke AR, Royce J: Body size, shape, and comparison of several types of athletes, *J Sports Med Phys Fitness* 6:75–88, 1966.
8. Benas D: *Special considerations in women's rehabilitation programs*. In Hunter LY, Funk FJ, editors: *Rehabilitation of the injured knee*, St Louis, 1985, Mosby–Year Book.
9. Berg K: Aerobic function in female athletes, *Clin Sports Med* 3:779–789, 1984.
10. Berlin P: The woman athlete. In Gerber EW, et al, editors: *The American woman in sport*, Reading, Mass, 1974, Addison-Wesley.
11. Borges O: Isometric and isokinetic knee extension and flexion torque in men and women aged 20–70, *Scand J Rehabil Med* 21:45–53, 1989.
12. Brunet ME, et al: A survey of running injuries in 1505 competitive and recreational runners, *J Sports Med Phys Fitness* 30:307–315, 1990.
13. Butts NK, Gushiken TT, Zarins B, editors: *The elite athlete*, New York, 1985, Spectrum.
14. Canale ST, et al: A chronicle of injuries of an American intercollegiate football team, *Am J Sports Med* 9:384–389, 1981.
15. Carter JEL, et al: Anthropometry of Montreal olympic athletes. In Carter JEL, editor: *Medicine and sport*, vol 16, Basel, 1982, S Karger.
16. Clarke KS, Buckley WE: Women's injuries in collegiate sports, *Am J Sports Med* 8:187–191, 1980.
17. Colisimo AJ, Ireland ML: Isokinetic peak torque and knee laxity comparison in female basketball and volleyball college athletes, *Med Sci Sports Exerc* 23(suppl 4):135, 1991 (abstract).
18. Collins RK: Injury patterns in women's flag football, *Am J Sports Med* 15:238–242, 1987.
19. Corbin CB: Self confidence of females in sport and physical activity, *Clin Sports Med* 3:895–908, 1984.
20. Cox JS, Lenz HW: Women midshipmen in sports, *Am J Sports Med* 12:241–243, 1984.
21. Culpepper MI, Niemann KMW: High school football injuries in Birmingham, Alabama, *South Med J* 76:873–878, 1983.
22. DeGroot H, Mass DP: Hand injury patterns in softball players using a sixteen inch ball, *Am J Sports Med* 16:260–265, 1988.
23. DeHaven KE, Lintner DM: Athletic injuries: comparison by age, sport, and gender, *Am J Sports Med* 14:218–224, 1986.
24. Eisenberg I, Allen WC: Injuries in a women's varsity athletic program, *Phys Sportsmed* 5:112–120, 1978.
25. Engstrom B, Johansson C, Tornkvist H: Soccer injuries among elite female players, *Am J Sports Med* 19:372–375, 1991.
26. Erdelyi GJ: Gynecological survey of female athletes, *J Sports Med Phys Fitness* 2:174, 1962.
27. Erkkola R: The influence of physical training during pregnancy on physical work capacity and circulatory parameters, *Scand J Clin Lab Invest* 36:747, 1976.
28. Ficat RP, Hungerford DS: *Disorders of the patellofemoral joint*, Baltimore, 1977, Williams & Wilkins.
29. Fox TA: Dysplasia of the quadriceps mechanism, *Surg Clin North Am* 55:199–226, 1975.
30. Franklin BA, Lussier L, Buskirk ER: Injury rates in women joggers, *Phys Sportsmed* 7:104–112, 1979.
31. Frusztajer N, et al: Nutrition and the incidence of stress fractures in the ballet dancers, *Am J Clin Nutr* 51:779–783, 1990.
32. Fulkerson JP, Hungerford DS: *Disorders of the patellofemoral joint*, ed 2, Baltimore, 1990, Williams & Wilkins.
33. Fulkerson JP, Shea KP: Current concepts review: disorders of patellofemoral alignment, *J Bone Joint Surg [Am]* 72:1424–1429, 1990.
34. Garrick JG, Requa RK: Girl's sports injuries in high school athletics, *JAMA* 239:2245–2248, 1978.

35. Garrick JG, Requa RK: Epidemiology of women's gymnastics injuries, *Am J Sports Med* 8:261–264, 1980.
36. Gillette J: When and where women are injured in sports, *Phys Sportsmed* 2:61–63, 1975.
37. Glick JM: The female knee in athletics, *Phys Sportsmed* 1:35–37, 1973.
38. Goldberg MJ: Gymnastic injuries, *Orthop Clin North Am* 11:717–726, 1980.
39. Goldberg B, Rosenthall PP, Nicholas JA: Injuries in youth football, *Phys Sportsmed* 12:112–120, 1978.
40. Good JE, Klein KM: Women in the military academies: US Navy, *Phys Sportsmed* 17:99–106, 1989.
41. Goodlin RC, Buckley KK: Maternal exercise, *Clin Sports Med* 3:881–893, 1984.
42. Griffin LY: The female as a sports participant, *J Med Assoc Ga* 81:285–287, 1992.
43. Grood ES, et al: Biomechanics of knee extension exercise, *J Bone Joint Surg [Am]* 66:725–734, 1984.
44. Hale RW, editor: *Caring for exercising women*, New York, 1991, Elsevier.
45. Hall DC, Kaufman DA: Effects of aerobic and strength conditioning on the pregnancy outcomes, *Am J Obstet Gynecol* 157:1199–1203, 1987.
46. Haycock CE: *Sports medicine for the athletic female*, Oradell, NJ, 1980, Medical Economics.
47. Haycock CE, Gillette JV: Susceptibility of women athletes to injury: myths versus reality, *JAMA* 236:163–165, 1976.
48. Hershman EB, Mailly T: Stress fractures, *Clin Sports Med* 9:183–214, 1990.
49. Highgenboten CL: Children's knee problems, *Orthop Rev* 10:37–48, 1981.
50. Hughston J, Andrews J: The suprapatellar plica and internal derangement, *J Bone Joint Surg [Am]* 55:1318, 1973.
51. Hungerford DS, Barry M: Biomechanics of the patellofemoral joint, *Clin Orthop* 144:9–15, 1979.
52. Hungerford DS, Lennox DW: Rehabilitation of the knee in disorders of the patellofemoral joint: relevant biomechanics, *Orthop Clin North Am* 14:397–402, 1983.
53. Hunter LY, et al: Common orthopaedic problems of female athletes. In Frankel VH, editor: *Instructional course lectures XXXI*, St Louis, 1982, Mosby–Year Book.
54. Hunter LY, Torgan C: Dismounts in gymnastics: should scoring be reevaluated? *Am J Sports Med* 11:208–210, 1983.
55. Hutchinson MR, Ireland ML, Jacobs DC: *Injuries in cheerleaders*, 1992 (unpublished).
56. Ikponmwosa O: Influence of sex role standards in sport competition anxiety, *Int J Sport Psychol* 12:289–292, 1957.
57. Ireland ML, Wall C: Epidemiology and comparison of knee injuries in elite male and female United States basketball athletes, *Med Sci Sports Exerc* 14, 1990 (abstract).
58. Ireland ML: Patellofemoral disease in runners and bicyclists, *Ann Sports Med* 3:77–84, 1987.
59. Jackson DS, Furman WK, Berson BL: Patterns of injuries in collegiate athletes: a retrospective study of injuries sustained in intercollegiate athletics in two colleges over a two year period, *Mt Sinai J Med* 47:423–426, 1980.
60. Jarrett R, Spellacy W: Jogging during pregnancy, *Obstet Gynecol* 61:705, 1983.
61. Jarski RW, Trippett DL: The risks and benefits of exercise during pregnancy, *J Fam Pract* 30:185–189, 1990.
62. Jones RE: Common athletic injuries in women, *Compr Ther* 6:47–49, 1980.
63. Katch VL, et al: Contribution of breast volume and weight to body fat distribution in the female, *Am J Phys Anthropol* 53:93–100, 1980.
64. Keller CS, Noyes FR, Buncher CR: The medical aspects of soccer epidemiology, *Am J Sports Med* 15:230–236, 1987.
65. Kennedy JC, Hawkins R, Krissoff WB: Orthopaedic manifestations of swimming, *Am J Sports Med* 6:309–322, 1978.
66. Kirby RL, et al: Flexibility and musculoskeletal symptomatology in female gymnasts and aged matched controls, *Am J Sports Med* 9:160–164, 1981.
67. Kowal DM: Nature and causes of injuries in women resulting from an endurance training program, *Am J Sports Med* 8:265–269, 1980.
68. LaPrade RF, Burnett QM: Femoral intercondylar notch stenosis and correlation to anterior cruciate ligament injuries: a prospective study, *Am J Sport Med*, 1993 (in press).
69. Levine J: Chondromalacia patellae, *Phys Sportsmed* 7:41–49, 1979.
70. Lieb FJ, Perry J: Quadriceps function: anatomical and mechanical study using amputated limbs, *J Bone Joint Surg [Am]* 50:1535–1548, 1968.
71. Lindner KJ, Caine DJ: Injury patterns of female competitive club gymnasts, *Can J Sport Sci* 15:254–261, 1990.
72. Lloyd T, et al: Interrelationship of diet, athletic activity, menstrual status, and bone density in collegiate women, *Am J Clin Nutr* 46:681–684, 1987.
73. Lockey MW: The sport of cheerleading, *J Miss State Med Assoc* 32:375, 1991 (letter).
74. Loosli AR, et al: Injuries to pitchers in women's collegiate softball, *Am J Sports Med* 20:35–37, 1992.
75. Lotgering FK, Gilbert RD, Longo LD: The interactions of exercise and pregnancy: a review, *Am J Obstet Gynecol* 149:560, 1984.
76. Lysens R, et al: The predictability of sports injuries, *Sports Med* 1:6–10, 1984.
77. MacIntyre DL, Robertson DG: Quadriceps muscle activity in women runners with and without patellofemoral pain syndrome, *Arch Phys Med Rehabil* 73:10–14, 1992.
78. Malone TR, et al: *Relationship of gender to anterior cruciate ligament injuries in intercollegiate basketball participants*, Durham, NC, 1991, Duke University, Dept of Physical Therapy and Occupational Therapy and Dept of Surgery, Division of Orthopaedics.
79. Mariani P, Caruso I: An electromyographic investigation of subluxation of the patella, *J Bone Joint Surg [Br]* 61:169–171, 1979.
80. Marino M: Profiling swimmers, *Clin Sports Med* 3:211–228, 1984.
81. Matheson GO, et al: Stress fractures in athletes: a study of 320 cases, *Am J Sports Med* 15:43–58, 1987.
82. May JR, et al: *A preliminary study of elite adolescent women athletes and their attitudes toward training and femininity*. In Butts NK, Gushiken TT, Zarins B, editors: *The elite athlete*, New York, 1985, Spectrum.
83. McAuley E, et al: Injuries in women's gymnastics: the state of the art, *Am J Sports Med* 15:558–565, 1987.
84. McConnell J: The management of chondromalacia patellae: a long term solution, *Aus J Phys Ther* 32:215–223, 1986.
85. Micheli L: *Female runners*. In D'Ambrosia R, Drez D, editors: *Prevention and treatment of running injuries*, Thorofare, NJ, 1982, Slack.
86. Micheli LJ, Gillespie WJ, Walaszek A: Physiologic profiles of female professional ballerinas, *Clin Sports Med* 3:199–209, 1984.
87. Mullinax KM, Dale E: Some considerations of exercise during pregnancy, *Clin Sports Med* 5:559–570, 1986.
88. Murphy RJ, et al: Five year football injury survey, *Phys Sportsmed* 6:95–102, 1978.
89. Myburgh KH, et al: Low bone density is an etiologic factor for stress fractures in athletes, *Ann Intern Med* 113:754–759, 1990.
90. Myers AM, Lips HM: Participation in competitive amateur sports as a function of psychological androgeny, *Sec Roles* 4:571–578, 1978.
91. National Collegiate Athletic Association: *NCAA injury surveillance system*, Overland Park, Kansas, 1991-1992, 1992-1993, NCAA.
92. Nilsson S, Roass AA: Soccer injuries in adolescents, *Am J Sports Med* 6:358–361, 1978.
93. Orseli RC: Possible teratogenic hyperthermia and marathon running, *JAMA* 243:332, 1980 (letter).

94. Patel D: Plica as a cause of anterior knee pain, *Orthop Clin North Am* 17:273, 1986.
95. Pearl A: *The Athletic Female*, Champaign, Ill, 1992, Human Kinetics.
96. Perry J: Function of the quadriceps, *J Can Physiother Assoc*, 1972.
97. Pettrone FA, Ricciardeli E: Gymnastic injuries: the Virginia experience, *Am J Sports Med* 15:59–62, 1987.
98. Powers JA: Characteristic features of injuries in the knee of women, *Clin Orthop* 143:120–124, 1979.
99. Protzman RR: Physiologic performance of women compared to men, *Am J Sports Med* 7:191–194, 1979.
100. Protzman RR, Bodnari LM: Women athletes, *Am J Sports Med* 8:53–55, 1980.
101. Protzman RR, Griffis C: Stress fractures in men and women undergoing military training, *J Bone Joint Surg [Am]* 59:825, 1977.
102. Reid DC, et al: Lower extremity flexibility patterns in classical ballet dancers and their correlation to lateral hip and knee injuries, *Am J Sports Med* 15:347–352, 1987.
103. Reilly DJ, Martens M: Experimental analysis of quadriceps muscle force and patellofemoral joint reaction force for various activities, *Acta Orthop Scand* 43:126–137, 1972.
104. Reynolds L, et al: EMG analysis of the vastus medialis obliquus and the vastus lateralis in their role in patellar alignment, *Am J Phys Med* 62:61–71, 1983.
105. Robinson SJ, Hoeltzel LE, editors: The injured athlete, Philadelphia, 1982, JB Lippincott.
106. Rothenberger LA, Chang JI, Cable TA: Prevalence and types of injuries in aerobic dancers, *Am J Sports Med* 16:403–407, 1988.
107. Ryan AJ, Allman JR, editors: *Sports medicine*, ed 2, New York, 1989, Harcourt Brace Jovanovich.
108. Sady SP, Carpenter MW: Aerobic exercise during pregnancy: special considerations, *Sports Med* 7:357–375, 1989.
109. Sammarco GJ: *Dance injuries*. In Nicholas JA, Hershman EB, editors: *The lower extremity and spine in sports medicine*, St Louis, 1986, Mosby–Year Book.
110. Sands W: Competition injury study: a preliminary report on female gymnasts, *USGF Technical Journal*, 1981, p 7.
111. Santavirta S: Integrated electromyography of the vastus medialis muscle after meniscectomy, *Am J Sports Med* 7:40–42, 1979.
112. Schafle MD, et al: Injuries in the 1987 national amateur volleyball tournament, *Am J Sports Med* 18:624–631, 1990.
113. Schaeffer CF: Possible teratogenic hyperthermia and marathon running, *JAMA* 241:1892, 1979 (letter).
114. Shields RW, Jacobs IB: Median palmar neuropathy in a cheerleader, *Arch Phys Med Rehabil* 67:824–826, 1986.
115. Souryal TO, Moore HA, Evans JP: Bilaterality in anterior cruciate ligament injuries: associated intercondylar notch stenosis, *Am J Sports Med* 16:449–454, 1988.
116. Snyder ED, Spreiter E: *Social aspects of sports*, Englewood Cliffs, N J, 1978, Prentice Hall.
117. Stark JA, Toulesse A: The young female athlete: psychological considerations, *Clin Sports Med* 3:909–920, 1984.
118. Strauss RH, editor: *Sports medicine*, Philadelphia, 1984, WB Saunders.
119. Stulberg SD, et al: Breaststroker's knee: pathology, etiology and treatment, *Am J Sports Med* 8:164–171, 1980.
120. Sullivan D, et al: Stress fractures in 51 runners, *Clin Orthop* 187:188–192, 1984.
121. Sullivan JA, et al: Evaluation of injuries in youth soccer, *Am J Sports Med* 8:325–327, 1980.
122. Tehranzadeh J, Labosky DA, Gabriele OF: Ganglion cysts and tears of triangular fibrocartilages of both wrists in a cheerleader, *Am J Sports Med* 11:357–359, 1983.
123. Vizsolyi P, et al: Breaststroker's knee: an analysis of epidemiological and biomechanical factors, *Am J Sports Med* 15:63–71, 1987.
124. Walsh WM, Hurman WW, Shelton GL: Overuse injuries of the knee and spine in girls' gymnastics, *Clin Sports Med* 3:829–850, 1984.
125. White J: Exercising for two: what's safe for the active pregnant woman, *Phys Sportsmed* 20:179–186, 1992.
126. Whiteside JA, Fleagle JA, Kalenak A: Fractures and refractures in intercollegiate athletes, *Am J Sports Med* 9:369–377, 1981.
127. Whiteside PA: Men's and women's injuries in comparable sports, *Phys Sportsmed* 8:130–140, 1980.
128. Wild JJ, Franklin TD, Woods GW: Patellar pain and quadriceps rehabilitation, *Am J Sports Med* 10:12–15, 1982.
129. Woodward SL: How does strenuous maternal exercise affect the fetus: a review, *Birth* 8:17, 1981.
130. Zelisko JA, Noble HB, Porter M: A comparison of men's and women's professional basketball injuries, *Am J Sports Med* 10:297–299, 1982.