CE 2.5 CONTACT HOURS

A review of knee pain in adolescent females

Abstract: Primary care practitioners are in a position to educate patients and parents about the risk factors that may increase the incidence of knee pain in adolescent females. This article highlights patellofemoral pain syndrome, Sinding-Larsen-Johansson syndrome, Osgood-Schlatter disease, and meniscal tears.

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Acute and chronic knee pain is a common complaint in the adolescent female population. Moderate-to-severe cases may even lead to disability. Studies show that up to 31% of adolescents suffer from knee pain, and there are a number of risk factors that predispose adolescent females to higher rates of injury.[1] Female athletes have a prevalence of injury one and a half to three times higher than their male counterparts.[1]

Athletics are a major cause of knee pain in females, but proper training programs may reduce the incidence of pain and knee damage.[2] Although some injuries are inevitable, the most effective method of reducing knee pain in females is to prevent injury altogether. This review will focus on the most common types of knee pain in the adolescent female as well as risk factors, prevention, and management.

Etiology

Both acute and chronic knee pain are commonly seen in adolescent females. Acute pain is typically caused by trauma during athletic participation, and chronic pain is commonly a result of overuse.[3] Cutting and twisting sports, such as soccer,

Keywords: adolescent females, knee pain, meniscus, Osgood-Schlatter disease, patellofemoral pain syndrome, Sinding-Larsen-Johansson syndrome

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basketball, volleyball, and football are often associated with ligament and meniscal injuries. Runners are more often diagnosed with overuse injuries, such as patellofemoral pain syndrome and Osgood-Schlatter disease (see *Sports and associated knee injuries*).

Patellofemoral pain syndrome. Patellofemoral pain syndrome (PFPS) is a frequent injury in adolescent females, and although its etiology is not completely clear, it is likely due to overload on the knee joint.[4,5] PFPS most commonly presents as anterior knee pain or nonspecific knee pain.[6] PFPS may be difficult to diagnose because it is a multidimensional injury that mainly stems from the interaction between a person's intrinsic anatomy and their training and exercise.[7] Adolescents experience PFPS at higher rates than the rest of the population.[1]

Osgood-Schlatter disease and Sinding-Larsen-Johansson syndrome. Osgood-Schlatter disease is a common overuse injury that leads to chronic pain in early adolescence prior to growth plate closure. It presents with pain and swelling over the tibial tuberosity where the patellar tendon attaches the quadriceps muscle to the tibia. Repetitive movement leads to inflammation of the insertion site.[8] Osgood-Schlatter disease coincides with periods of rapid growth; therefore, females between ages of 8 and 12 and males 12 and 15 years are most likely to develop symptoms. Furthermore, participating in running, volleyball, basketball, and soccer place teens at highest risk.[9]

Although it is more often seen in males, Osgood-Schlatter disease should also be considered in the early adolescent female population. Sinding-Larsen-Johansson (SLJ) syndrome is similar to Osgood-Schlatter disease and most commonly present in males ages 10 to 14; it often presents in adolescent female athletes.[10] SLJ syndrome is also described as an overuse injury and is due to repetitive pressure, tension, and traction by the patellar tendon on the still cartilaginous lower pole of the patella during quadriceps contraction.[10]

Meniscal lesions. Meniscal tears are a common injury in adolescent females.[11] Both the medial meniscus (MM) and lateral meniscus (LM) lie within the patellar joint and act primarily as shock absorbers for any outside force as well as a lubricant for the articular cartilage.[12] Twisting and cutting sports place adolescents at higher risk for a meniscal tear. Additionally, meniscal lesions may accompany more severe ligament injury and occur in greater than 80% of all anterior cruciate ligament (ACL) tears.[12]

Sports and associated knee injuries[25,36]

Basketball/volleyball
- Ligament injury
- Meniscal tear
- Osgood Schlatter disease
- SLJ syndrome

Running
- PFPS
- Osgood Schlatter disease
- SLJ syndrome

Skiing
- Contusion
- Ligament injury
- Meniscal tear
- Patellar dislocation

Soccer
- Ligament injury
- Meniscal tear
- PFPS
- Osgood Schlatter disease
- SLJ syndrome

Pathophysiology

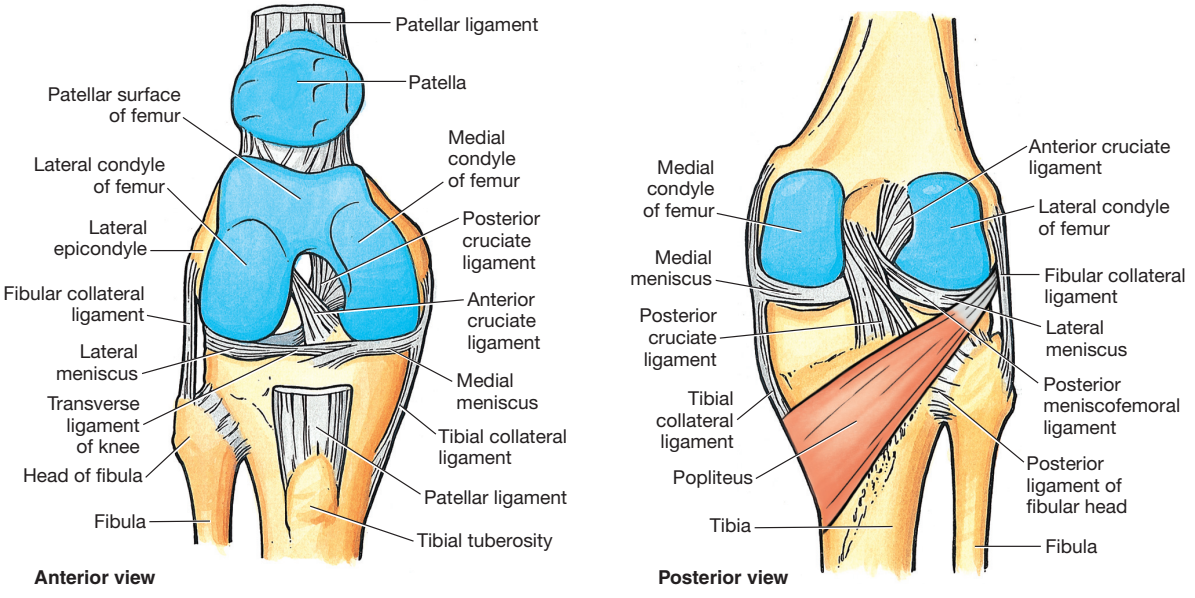
Anterior knee pain is a common chronic complaint for adolescent females. Chronic pain is multifactorial and can occur as a result of overtraining. Acute pain is more likely due to a traumatic injury. Knee injury and pain can have lifelong complications if not managed properly. (See *Knee joint anatomy*.)

Patellofemoral pain syndrome. Patellofemoral pain is thought to be due to anatomical and biomechanical factors.[13] This syndrome is characterized by inflammation of the synovial lining (soft tissue that lines the joint), inflammation of the fat pad, elevation of the intraosseous pressure, and an increase in the metabolic activity in the patellar joint.[4] The combination of inflammatory processes is best described as a loss of homeostasis of the knee joint.[4] PFPS is an exceedingly prevalent overuse injury in adolescent females. The best method of prevention is to highlight the importance of rest periods throughout the training process.[14]

Osgood-Schlatter disease and Sinding-Larsen-Johansson syndrome. Osgood-Schlatter disease is generally recognized as an overuse injury and is described as a traction apophysitis of the tibial tuberosity.[9] Apophysitis is defined as inflammation and microtrauma to the apophysis of a bone.[15] During periods of rapid growth, the apophysis is weakened and is therefore more susceptible to damage. Repetitive movements place stress on the tibial tuberosity and cause multiple micro avulsion fractures in the apophysis.[8] Fortunately, most patients will heal after a period of rest from athletic participation and physical therapy, and symptoms are not likely to be present following the fusion of the growth plates.[8]

SLJ syndrome occurs following periods of repetitive strain in adolescent athletes. Repetitive traction of the patellar tendon during quadriceps contraction causes

Knee joint anatomy



Source: Moore KL, Agur AM, Dalley AF. *Essential Clinical Anatomy.* 4th ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2011:387.

an increase in pressure and tension on the lower pole of the patella.[10] The increased forces on the patella in turn causes effusion, pain, cartilage damage, tendon thickening, fragmentation of the lower pole of the patella, and bursitis. Ultrasound is diagnostic and may reveal edema, fragmentation of the lower pole of the patella, patellar tendon thickening, and bursitis.[10]

Meniscal lesions. The patellofemoral joint includes both the MM and LM. Each meniscus is a vascularized extracellular matrix and acts primarily as a shock absorber between the tibia and femur.[11] LM tears are most likely to occur when the foot is planted and a valgus force is put on a bent knee. This torque causes the femur to rotate externally and tear the meniscus. MM tears occur when the foot is planted, a varus force is put on a bent knee, and the femur rotates internally.[11] When intact, the menisci have a smooth and shiny surface, but once a tear occurs, the once slippery surface becomes jagged and can cause symptoms, such as locking, buckling, catching, and pain.

Identifying risk factors

Multiple risk factors have been identified that increase risk of knee injuries in adolescent females. Extrinsic factors, such as level of performance, duration of training, protective equipment, environmental factors, and coaching may influence the type and severity of knee injury.[16] Additionally, playing sports on a hard surface may contribute to lower leg injuries.[17]

Intrinsic factors (those that are inherent to the individual) include age, gender, anatomy, flexibility, coordination, and proprioceptive skills, fitness level, nutrition status, and prior injuries.[16]

Although females have certain inherent risks, there are numerous modifiable factors that can be targeted by interventions to reduce knee injuries. Neuromuscular training programs that aim to increase coordination and proprioceptive skill while addressing muscle-tendon imbalance may reduce the incidence of ACL injuries in adolescent female athletes.[16,18] (See *Modifiable and nonmodifiable risk factors for knee pain and injury.*)

Obesity and fitness. Obesity in children and adolescents has increased dramatically over the past two decades. Increased weight causes a mechanical overload on the lower extremities and creates increased pressure on the knee joint.[19] Evidence shows that high body mass index (BMI) and greater body fat percentage are associated with a greater incidence of medial collateral ligament tears.[16,19] In 2012, Widhalm and colleagues conducted a study of 20 subjects (between 8 and 20 years of age) in Finland to assess the quality and structure of articular cartilage in obese adolescents with knee pain.[19] The average age of the participants in the study was 14.2 years, and the mean BMI of participants was 38.2.

This study showed articular cartilage lesions or meniscal damage in every patient. Cartilage lesions were identified in all 24 knees that were imaged, while asymptomatic meniscal tears were detected in 16 of 20 subjects.[19]

The fact that adolescents of normal weight did not have joint damage further supports the idea that obesity leads to damage of knee articular cartilage.[19] There is no definitive study that demonstrates if a greater than average BMI is directly associated with knee pain or injury in adolescent females, but it is likely that a high BMI greatly contributes to this common problem.

Athletic participation. Athletic participation can require a significant amount of commitment and training. Many female athletes practice their sports on a daily basis, which predisposes them to injury. In 2007, Rauh and colleagues found that knee reinjuries most commonly occur in females playing sports that require more lower extremity use.[17] Repetitive strain while training for sports such as soccer, basketball, and running makes adolescent females susceptible to acute and/or chronic PFPS, patellar tendonitis, and other knee injuries.[17]

Puberty. Various musculoskeletal injuries appear in female athletes, with the majority of injuries occurring throughout the adolescent growth spurt. Puberty in females causes a number of bodily changes, including skeletal growth, muscle mass increase, and fat deposition.[14] The myriad of physical changes that predispose adolescent female athletes to lower extremity injury, known as the miserable malalignment syndrome, are discussed below.[14]

Postpubertal females have a widened pelvis, increased internal tibial torsion (inward twisting of tibial bone), pes planus (flat feet), genu valgum (knock knees), and an increased quadriceps angle or Q angle. The Q angle is the angle at which the femur meets the tibia and is measured by creating one line from the center of the patella to the tibial tubercle and another line from the patella to the anterior-superior iliac spine of the pelvis. Much of this misalignment is due to the quadriceps neuromuscular dominance over all other lower extremity structures.[14]

Hormonal fluctuations throughout puberty and the menstrual cycle have been associated with ligament laxity and a higher incidence of knee injury in females. Progesterone and relaxin levels rise during days 15 to 28 of the menstrual cycle. Relaxin is a hormone that is synthesized by the ovaries during the menstrual cycle, and both decrease the rate of collagen synthesis and inhibit the repair of connective tissue.[18,20] Thus, the increase in relaxin may lead to a greater incidence of ligament and soft tissue injury. The relationship between hormone levels and ligament injuries needs to be further studied before a consensus can be reached. Pubertal changes lead to both ligament and joint laxity in adolescent females.

One study aimed to determine the effects of pubertal status on joint laxity in both male and female athletes.[21] The study had a cross-sectional cohort design and included 275 females and 143 males ranging from 11 to 18 years of age.[21] Results showed that prepubertal males and females experienced ligament sprains at equal rates. However, postpubertal females have increased joint laxity and may be at risk for decreased static and passive joint stability. Unfortunately, this hypermobility may predispose adolescent females to knee ligament injuries.[21]

Modifiable and nonmodifiable risk factors for knee pain and injury[2,34]

	Modifiable	Nonmodifiable
Intrinsic risk factors	BMI Fitness level Flexibility Proprioception Coordination Muscle strength	Age Anatomical alignment Gender Joint/ligament laxity Prior injury Sex hormones
Extrinsic risk factors	Equipment Duration of practice Level of contact	Level of competition Playing surface Position in sport Type of sport Weather/environmental factors

Clinical presentation

The clinical presentation of knee pain differs for acute pain due to trauma and chronic pain. A thorough clinical history, physical exam with manual testing, and imaging can be necessary in order to formulate a differential diagnosis for knee pain (see *Clinical presentation of knee pain and injury* and *Manual diagnostics*).

Patellofemoral pain. PFPS is typically described as either nonspecific anterior knee pain or diffuse peripatellar and retropatellar localized pain.[1] Patients with PFPS will present with pain while walking up and down stairs, sitting with their knees in the flexed position, squatting, and with pain both during and after physical activity. Additionally, patients with PFPS typically have limited knee extensor strength.[22]

Patients with PFPS will have pain in the medial and lateral parapatellar areas.[23] Anterior, posterior, and lateral radiographs may be helpful and at times reveal an asymmetrically shaped patella with a shorter medial portion and elongated lateral portion.[23] Diagnosis can be made through physical exam and history, but a radiograph is helpful to rule out bony pathology. Treatment for PFPS includes pain management and physical therapy for stretching of the iliotibial band and strengthening of the medial quadriceps

Clinical presentation of knee pain and injury[9,25,26]

Potential injury	Clinical presentation	Diagnostics
Instability Inability to bear weight	Fracture Patellar dislocation	MRI Radiograph
Instability Inability to bear weight Popping, clicking, catching Significant swelling	Ligament tear Meniscal tear	Clinical presentation and history Manual tests MRI
Anterior knee pain Aching Swelling Tenderness	PFPS syndrome	Clinical presentation and history Manual tests
Chronic pain over tibial tubercle or inferior pole of patella	Osgood-Schlatter disease, SLJ syndrome	Clinical presentation and history Manual tests Radiograph

Manual diagnostics[12,23,26]

Potential diagnosis	Manual diagnostic	Normal	Abnormal/positive test
Joint hypermobility	Knee hyperextension	<10 degrees past neutral	>10 degrees past neutral
ACL rupture	Lachman	<4 mm displacement	>4 mm displacement
Meniscal injury	McMurray	No thud or click	Thud or click that can be felt
	Apley Grind Test	No pain	Pain
Patellar dislocation	Patellar Apprehension Test	No apprehension	Apprehension, discomfort
Osgood Schlatter	Active resisted extension of knee, passive flexion of knee	No pain	Pain

muscle.[24,25] Knee braces and patellar taping can be helpful when returning to activity to decrease pain.

Osgood-Schlatter disease and Sinding-Larsen-Johansson syndrome. Adolescents with Osgood-Schlatter disease typically present with a steady increase of tenderness, pain, and swelling over the tibial tuberosity. There may be a small bump over the anterior tibial tuberosity. This disease is usually unilateral; however, up to 30% of patients will have symptoms bilaterally.[9] Diagnostic radiographs should be taken and will show changes and fragmentation in the apophysis.[8] Treatment of Osgood-Schlatter disease consists of rest. Symptoms should diminish with limitation of activity and when periods of rapid growth finish.

Patients with SLJ syndrome may present with increasing anterior knee pain and swelling at the inferior pole of the patella. Pain can worsen with prolonged knee flexion, loading, and movement. An ultrasound should be performed to diagnose SLJ syndrome and will show swelling and thickening of both the patellar tendon and cartilage. Treatment of SLJ syndrome consists of 1 to 2 months of decreased activity with no participation in sports that require repetitive pressure and strain on the knee joint.[10] Total recovery can take anywhere from 12 to 24 months after physiologic regeneration of both the cartilage and the tendon and complete ossification of the patella.[10]

Meniscal lesions. Most patients describe meniscal injuries as a sharp, sudden pain along the lateral or medial joint line along with catching, locking, or popping.[26] Tears are also associated with more severe ligament injuries, which present acutely with extreme joint instability, pain, and edema.[12] Adolescent females most frequently experience meniscal tears during athletics when too much torque is placed on a bent knee.[11] While the majority of patients with meniscal lesions present with the typical findings, many adolescents may be asymptomatic or continue to play athletics with the injury.

Meniscal tears should be on the differential diagnosis for any adolescent athlete who reports locking, swelling, and joint instability. The McMurray test may help to narrow the diagnosis and indicate the need for imaging. To perform the McMurray test, the patient must be supine, the ipsilateral

hip should be flexed at 90 degrees, and the knee in question should be slightly flexed. Next, the provider should extend the knee and apply a valgus force while externally rotating the tibia.[25]

Meniscal pathology should be suspected if this test causes the patient pain, and both a magnetic resonance imaging (MRI) and radiograph should be ordered. Fractures and bony lesions can likely be ruled out by radiograph, but an MRI is necessary to assess structure and meniscal integrity. Treatment is typically surgical, and any patient with a suspected meniscal tear must be referred to orthopedics due to the increased incidence of osteoarthritis following meniscal damage.

Management

Management of knee pain or injury includes pain control, minimizing soft tissue swelling, and maintenance of range of motion. An easy first step in managing knee pain is following the principles of PRICE: pain control, rest, ice, compression, and elevation.[14] Pain control can be accomplished through the use of nonsteroidal anti-inflammatory drugs, which will help to decrease swelling of the joint and thereby decrease pain. Resting the joint, performing passive range-of-motion exercises, icing the injury for 20 to 30 minutes every 2 to 3 hours, and using compression wraps while elevating the limb will also reduce swelling. Referral to an orthopedist or sports medicine practice should be made with severe effusion, neurovascular compromise, probable ligament injury, meniscal tears, fracture, persisting limp, and joint instability.[26] Although knee pain is often treated conservatively, more severe injuries such as ligament tears may be best treated surgically.[26]

Physical therapy is a primary treatment option for many patients with knee pain. Interventions typically focus on increasing quadriceps strength and realignment through taping, bracing, and stretching.[27] Studies show that physical therapy helps to reduce pain and improve function in patients with PFPS.[27] Additionally, taping may align the patella and reduce pain during rehabilitation and exercise.[28] Poor long-term outcomes with PFPS are associated with increased duration of symptoms as well as higher severity of pain at baseline.[1] Early referral to physical therapy and initiation of treatment may possibly prevent poor long-term prognosis in adolescent females with PFPS.[1]

Prevention

Numerous prevention programs are being studied that may reduce the incidence of pain and injury in adolescent females. Pediatric nurse practitioners should encourage sport-specific neuromuscular training programs and address modifiable risk factors prior to and during athletic participation. Additionally, behavior modification should focus on educating patients and families about healthy lifestyle choices as well as strength and fitness conditioning.

Behavior modification. An increasing number of adolescent females are participating in organized athletics in recent years, but fitness levels have decreased significantly compared to children of the previous generations.[16] Acute and chronic injuries have increased in the pediatric population due to children participating in high levels of activity without the proper training or strength.[16] Increasing physical activity and healthy nutrition should be emphasized as ways to prevent knee pain for all adolescents and not simply those with increased BMI.

It should be noted that all adolescents with low physical activity levels are at increased risk for knee pain and for developing sports-related injuries.[16,29] However, adolescents who are obese do have increased forces placed on joints of the lower extremities. The strain on these joints makes it difficult to perform physical activity, and therefore, it is increasingly challenging to lose weight.[19]

Neuromuscular training. Nonspecific physical activity may provide neuromuscular training, which improves the speed and efficiency of muscle firing pattern during movement. This training also promotes dynamic joint stability and helps with coordination and proprioceptive skills that are used throughout physical activity and activities of daily living.[30] Neuromuscular training has been shown to decrease the risk of knee pain and injury in adolescent females and decreases the incidence of ACL tears in adolescent female soccer players.[29-32] Specific neuromuscular training programs have been created to prevent knee pain and injury in adolescents. Multicomponent programs had higher rates of success than one-dimensional programs, and combining preseason training with in-season training may decrease ACL injuries in adolescent female soccer players.[32,33] Successful neuromuscular training programs consist of a combination of lower-extremity plyometrics, stretching, core strength and control, and dynamic balance.

Addressing modifiable risk factors. Addressing modifiable risk factors may reduce incidence of injury in adolescent females. Adolescent females have lower extremity misalignment, partly due to the overwhelming dominance of the quadriceps muscle. Modifying "the six Ss" (structure, shoe, surface type, stretching, strengthening, and speed) may help reduce the incidence of injury (see *Six Ss*).[14] Athletes and coaches should not increase their workouts too quickly at the start of the season. However, it is difficult to convince any athlete to slow down when they are eager to get back into shape and peak performance levels.

Role of nurse practitioner

The first step toward prevention is detecting the potential risk factors that predispose adolescent females to pain. The

primary care nurse practitioner (NP) should take a thorough history and physical to determine if an adolescent is at risk for developing an injury and to determine the source of the pain if there is a current complaint. Asking questions about levels of physical activity in prior months, nutrition, the types of sports being played, and duration of training will help practitioners formulate a patient-specific plan to prevent pain and injury.[34] The majority of athletic organizations currently require a preparticipation evaluation.

Preparticipation physical exam Completing a PPE in an office setting allows the NP time to address multiple factors that increase incidence of knee pain, such as BMI, fitness level, and specific sports. It also provides an environment to educate adolescents and parents about the risk of overuse injuries and the importance of rest periods throughout the year. The PPE musculoskeletal history includes questions about past and current injuries, missed days of practice or competition due to injury, and past orthopedic surgeries.[35] A knowledgeable provider will understand the risks and injuries associated with individual sports and will ask sport-specific questions. The PPE musculoskeletal physical in general pediatrics simply includes a basic assessment of strength and joint range of motion.[35] However, a more specific knee exam may be helpful in all athletes to identify predisposing risk of injury.

Addressing the importance of having an adequate level of fitness prior to joining an athletic team will also help to reduce the incidence of knee pain. Physical fitness should be measured prior to the start of an athletic season or training program, since low fitness levels are associated with increased incidence of knee injury.[29] Providers can educate coaches, athletes, and parents on the need for proper technique and equipment use as well as limiting the duration of training. Emphasizing the body's need for rest periods throughout the year and the danger of increasing activity too quickly may help to prevent chronic pain and injury, such as PFPS. Additionally, with a rise in childhood obesity, NPs should encourage participation in sports and fitness at each visit. Educating families from the start will hopefully lead to healthy participation in sports without pain and injury.

Stress prevention

Acute and chronic knee pain is a common disability in adolescent females and can be difficult to manage. The focus going forward should be to prevent pain and injury from occurring in the first place. Recognizing the modifiable factors such as lack of strength and fitness prior to athletic participation and obesity (which place these females at higher risk) will allow NPs to intervene and modify risks prior to injury.

Adolescent females should be encouraged to participate in safe and appropriate physical activity, as it is a way to engage in teamwork and build self-esteem. Providers should promote proper training programs, emphasize the need for rest periods, and educate coaches, parents, and adolescents on how to prevent and manage knee pain. Should injury occur, the NP has the tools to assess, diagnose, and manage patients in order to get them back into the game as swiftly and safely as possible. NP

Six Ss

Ss	Suggested change
Structure	Improve body mechanics to overcome structural deficits of greater Q angle and imbalanced muscle groups
Shoe type	Reduce irregular distribution of ground forces and provide cushioning to reduce joint stress
Surface type	Avoid irregular topography
Stretching	Increase flexibility
Strengthening	Balance muscle groups
Speed	Avoid increasing practice volume too quickly

Adapted from *The Active Female* (p.163), by M. Zumwalt, J. Robert-McComb, and R. Norman (Eds.), 2008, Totowa, NJ: Humana Press.

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