Common athletic injuries in adolescent girls

Keith J. Loud, MD, CM*; Lyle J. Micheli, MD†

Departments of *Pediatrics and †Orthopaedic Surgery, Harvard Medical School, and Divisions of *Adolescent Medicine and †Sports Medicine, Children's Hospital Boston, Boston, Massachusetts, USA.

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Teenaged girls constitute the fastest growing segment of children and adolescents participating in organized athletics. Adolescent girls appear to have similar injury rates as boys in comparable activities but different injury patterns. To properly diagnose and manage athletic injuries in adolescent girls, pediatric health care providers must be aware of these differences, especially as the literature and their knowledge base may be skewed to the traditional predominance of males in sport. This review identifies athletic injuries that are unique to or especially common in adolescent girls, including apophyseal injuries; breast and pelvic injuries; scoliosis and spondylolysis; multidirectional shoulder instability and "gymnast's wrist"; anterior cruciate ligament injuries and patellofemoral pain syndrome; chronic exertional lower-leg compartment syndrome, ankle sprains, and reflex sympathetic dystrophy; and stress fractures. It also briefly discusses possible risk factors for these injuries, emphasizing the female athlete triad.

Correspondence to Keith J. Loud, MD, CM, Children's Hospital Boston, 300 Longwood Avenue, Boston, MA 02115, USA; e-mail: keith.loud@tch.harvard.edu

The close of the last millennium saw women's team sports in the United States gain more attention than ever before. Among the most publicized examples of this trend were the establishment of the Women's National Basketball Association in 1997; national television broadcasts of the National Collegiate Athletic Association (NCAA) Division I Women's Basketball Championships; U.S. Olympic Team gold medals in softball (1996, 2000), women's basketball (1996, 2000), ice hockey (1998), and soccer (1996); and the World Cup of Women's Soccer, held in the United States in 2000 and won by the host squad. Media commentators were quick to anoint this the beginning of a new era in women's sports, but these events more accurately represent the culmination of nearly 30 years of progress toward gender equity in intercollegiate and interscholastic sports [1,2]. Since the enactment of Title IX of the Educational Amendments Act in 1972, which required women's intercollegiate athletic offerings to be proportional to the representation of women in the student body, the number of girls participating in high school sports has increased from 300,000 to 2.37 million [3], making high-school-aged girls the fastest growing segment of children and adolescents under the age of 18 participating in organized team sports [4].

Meanwhile, leading specialists in pediatric and adolescent sports medicine have begun to advocate that pediatric and adolescent primary care practitioners are ideally positioned and suited, if not prepared, to manage most injuries sustained by child and adolescent athletes [4,5]. Excellent literature reviews of these injuries and other conditions common to young athletes [6,7,8,9] as

well as texts such as Care of the Young Athlete, produced jointly by the American Academy of Orthopaedic Surgeons and the American Academy of Pediatrics [10••], have been published recently. The American Academy of Pediatrics has also paid special attention to the medical concerns of the female athlete [11••]. This article will highlight and briefly review the clinical presentation of athletic injuries unique to girls and those that are especially common in, though not exclusive to, girls. The reader is directed to the more comprehensive references just noted for discussions of diagnostic algorithms and management plans.

Epidemiology

Epidemiologic data on athletic injury in this population is considered ``limited'' [6••]. As in most areas of pediatrics, research involving children and adolescents is relatively sparse. The bulk of the recently published studies in this age group come from Europe and Asia [12–20] and may not represent the American experience. In addition, these reports are so hindered by lack of uniformity in the definitions of sport injury (the numerator) and population at risk (the denominator) [21] that a leading European author has questioned whether they have any value [22]. Finally, even the most recent studies may not yet reflect the increased participation of adolescent girls in team sports. Nonetheless, the best available evidence shows that boys and girls in high school sports have similar injury rates in comparable sports [23,24,25•], but data from adult women and the extensive experience of the senior author (LJM) and others suggest that girls have different injury types and patterns.

Issues of growth

Adolescent girls, like adolescent boys, experience significant growth during their early teenage years. Growth in height occurs at the ends of long bones in the growth plates (physes), articular surfaces (epiphyses), and tendon insertions (apophyses). These areas are cartilaginous rather than osseous (bony) and therefore vulnerable to injury in the adolescent athlete. Acute trauma to a joint can cause a Salter-Harris fracture of the physis; any tenderness over a growth plate warrants a high index of suspicion, prompt radiographic evaluation, and early orthopaedic referral for management, as adverse outcomes include partial or complete growth arrest and angular deformity [6••]. Common injuries to the epiphysis and articular cartilage include osteochondritis dissecans lesions, especially in the knee and elbow, Legg-Calvé-Perthes disease, and slipped capital femoral epiphysis. Apophyseal injuries are unique to the adolescent athlete and can include acute traumatic avulsions as well as the more common overuse syndromes, many of which are well known to the pediatric practitioner by their eponyms: posterior calcaneal apophysitis, or Sever disease; tibial tuberosity, or Osgood-Schlatter disease; inferior patella, or Sindig-Larsen-Johansson syndrome; and medial humeral epicondyle, or Little League elbow. Less famous, but equally important, apophysites involve the iliac crest and ischial tuberosity of the pelvis [26].

Gender differences

Aside from obvious gynecologic anatomic structures, why would girls sustain different injuries than boys? Differences in body size, shape, and composition; energy metabolism, circulation; cardiorespiratory capacity; endocrinology; and skeletal muscle strength have all been analyzed to determine their influences on athletic injury rates. The female pelvis is wider and more flat, in general, than the male pelvis, although there is great variability among women. This increased pelvic width contributes to a greater quadriceps femoris, or Q, angle in women than men (Fig. 1). The percentage of boys' muscle strength achieved by girls drops from 90% at age 11 to 75% by age 16.
The most likely cause of this difference is testosterone, which facilitates muscle hypertrophy. Estrogen, on the other hand, may cause increased joint laxity. A cross-sectional survey of adolescent athletes (mean age, 15.5 years) in northern New England showed a significantly higher proportion of females (22%) with joint hypermobility than males (9%) [28]. This hypermobility may increase the risk of certain injuries in girls, such as subluxations of the shoulder, patella, and peroneal tendons, but these effects, like those of increased Q angle and decreased muscular strength, have yet to be validated with epidemiologic studies.

![Figure 1. The static Q angle](image)

Figure 1. The static Q angle The static Q angle is determined by measuring the acute angle produced by the intersection of two lines. The first line is drawn through the anterior superior iliac spine and the midpoint of the patella. The second line is drawn through the midpoint of the patella and the tibial tubercle.

Gynecologic issues

Certain anatomic structures are exclusive to females, and injuries to these structures are therefore unique to girls. Breast discomfort during exercise is common among women but may be underreported, especially by adolescent girls. For some contact and collision sports, breast padding is appropriate to prevent trauma to the breast, such as abrasions, lacerations, and contusions that can lead to hematoma formation or Mondor disease (thrombophlebitis of the superficial breast veins). The nipple is the most prominent and most commonly injured part of the breast. Repetitive vigorous abrasion (jogger's nipple) or cold-induced thermal injury (bicyclist's nipple) may lead to bloody discharge and patient concern about breast cancer. The differential diagnosis does include intraductal neoplasms. Prophylactic measures include application of plastic bandages or petroleum jelly over the nipples before exercise [29].

A case report of partial detachment of the round ligament of the ovary, causing persistent pelvic and hip pain in a female adolescent athlete, should serve as a reminder of the complex gynecologic anatomy in the female pelvis [30]. The authors, suspecting endometriosis, made the surprising diagnosis at the time of laparoscopy. Similarly, practitioners caring for athletic girls must always keep gynecologic concerns such as endometriosis, ovarian cysts, and the more emergent pelvic inflammatory disease and ectopic pregnancy high on their differential diagnosis of pelvic and hip pain [31].

The spine

Idiopathic scoliosis (curvature of the spine) is more prevalent in girls than boys and may be even more common in female athletes. Elite ballet dancers may inherit a tendency toward scoliosis along
with their low upper-to-lower body ratio and long arm span, features that are desirable for the ideal image in classical ballet [32]. Idiopathic scoliosis should not be considered an injury, as it generally does not cause back pain. Any back pain in association with scoliosis warrants investigation for syrinx, disc herniation, tethered cord, tumor, or spondyloysis [32].

Spondylolysis is a stress fracture in the pars interarticularis of the posterior vertebral elements of the spine. Commonly found at the L4 or L5 vertebral level, it is believed to be caused by repetitive microtrauma, particularly flexion and extension of the lumbar spine. Activities that emphasize this motion include dance, gymnastics, and figure skating, all of which are predominantly undertaken by females in the adolescent age group; therefore, it is a common cause of back pain in young female athletes. The pain will be exacerbated by a provocative physical examination test in which the girl is asked to hyperextend her back while standing on alternate legs. If unilateral, discomfort will be greater on the weight-bearing side. Diagnosis can be made with anteroposterior, lateral, and oblique radiographs but often requires single photon emission computed tomographic bone scan [32,33].

Upper extremity

Conventional wisdom in orthopedics holds that female shoulders demonstrate greater laxity than male shoulders [34]. Along with decreased upper body strength and increased elbow carrying angle (cubitus valgus), this laxity was proposed to account for poorer throwing mechanics and potentially greater throwing injuries in women. An extensive review of the existing data reveals that there are insufficient data to confirm this belief [34]. Similarly, multidirectional shoulder instability cannot be described as a condition that differentially affects girls, but it is common in swimming and gymnastics, in which girls often participate. Symptoms include shoulder pain, subjective instability described as "looseness," "clicking," or "clunking," and easy fatigability. Provocative maneuvers on physical examination may elicit such a clunking sensation, but the diagnosis is often made on history alone, as imaging studies are rarely helpful [34].

Another condition that has increased incidence in girls, likely owing to increased participation, is "gymnast's wrist." This term encompasses many conditions that may lead to chronic wrist pain, the most worrisome of which is distal radial physis injury [6]. Risk factors include age between 12 and 14 years and gymnastic activity greater than 35 hours per week. The clinical presentation is often bilateral pain over the dorsal aspect of the wrists exacerbated by loaded dorsiflexion, which is the mechanism of injury. Examination findings include discomfort and prominence of the distal radius. Radiographs may reveal widening, beaking, or indistinct appearance of the distal radial physis [6].

As for the other physeal injuries discussed previously, early recognition and treatment are important to prevent premature fusion, growth arrest, and radial shortening.

The knee

Anterior cruciate ligament injuries have the strongest epidemiologic evidence for a female preponderance. Comparisons of National Collegiate Athletic Association intercollegiate athletes in soccer and basketball show a female-to-male ratio of anterior cruciate ligament injuries of 2:1 and 8:1, respectively [35]. A prospective study of the incidence of anterior cruciate ligament injury at the United States Naval Academy showed that female midshipmen had relative risks of 1.40 in mixed-sex intramural sports, 3.96 in intercollegiate sports, and 9.74 in military training, for an overall relative injury risk of 2.44 compared with male midshipmen [36].

This same trend has also been identified in adolescent girls. A Norwegian study of matched soccer
cohorts aged 15 to 18 years found a 5.4-fold increased risk of anterior cruciate ligament injury in girls compared with boys. Of great concern, these girls had a much lower rate of return to soccer after injury than the boys [37]. In Massachusetts, a study analyzing anterior cruciate ligament reconstructive surgery rates in high school basketball and soccer players found a female-to-male ratio of 1.8:1 [38]. Numerous on-going studies are identifying potential risk factors, which include Q angle, femoral intercondylar notch shape and size, anterior cruciate ligament thickness, joint laxity, hormonal influences, and training techniques [39].

Presentation of an anterior cruciate ligament injury in girls is usually history of hearing or feeling a "pop" in the knee with jumping, pivoting, or twisting, followed by significant joint swelling. Unlike in boys, these mechanisms of injury are largely non-contact [39]. After resolution of the acute effusion, the athlete may return to activities but may sense her knee to be unstable or "giving way." The most sensitive diagnostic test is the Lachman maneuver on physical examination [40]. Magnetic resonance imaging can confirm clinical suspicion.

Another cause of knee pain particularly common in young female athletes is patellofemoral pain syndrome. Unfortunately, a rational approach to this entity is hindered by the lack of a uniform definition as well as a lack of randomized controlled treatment trials [41]. In fact, patellofemoral pain syndrome is so often seen for anterior knee pain of multiple cause that some authors prefer the term "anterior knee pain syndrome" [42]. Common to all causes is repetitive overuse or overload of the knee extensor mechanism or surrounding soft tissue [40]. Contributing factors (Fig. 2) may include femoral anteversion, increased Q angle, external tibial torsion, tibia vara, and pronation of the midfoot—the so-called "miserable malalignment syndrome" [43,44]—as well as vastus medialis obliquus muscle dysfunction [44]. An interesting hypothesis to explain the perceived increased prevalence in women comes from Denmark, where a study showed that in an active population, patellofemoral pain syndrome affected an equal number of males and females, but the females were half as likely to be pain free at 5-year follow-up [45].

![Figure 2. Lower extremity anatomic alignment in females](Published with permission from Ireland ML: Anterior cruciate ligament injuries in young female athletes: high risks call for new approaches. Harmon KG, Ireland ML: Gender differences in noncontact anterior cruciate ligament injuries. Clin Sports Med 2000, 19:292.)

Lower extremity

Chronic exertional lower-leg compartment syndrome is reported by one group to affect young female athletes more than young males [46]. This condition is suggested by lower-leg muscular pain with running or other activity and is relieved, very rapidly, by stopping the activity; diagnosis is confirmed by elevated compartment pressures measured immediately after exercise. Differential diagnosis includes tibial stress fracture, anterior tibialis tendinitis, and the catch-all group of "shin splints." An epidemiologic study of 11,780 scholastic and collegiate basketball players showed that females had a 25% greater risk of ankle injury than males. Fortunately, this greater risk was entirely due to grade I ankle sprain; there were no differences in more severe sprains or fractures [47]. Unfortunately,
athletic girls are more prone to reflex sympathetic dystrophy than boys (6:1 ratio), even after relatively minor trauma [48]. Reflex sympathetic dystrophy is a regional pain cycle that usually affects the lower extremity and presents with pain out of proportion to the degree of injury, dysesthesia to light touch, edema, and skin color changes [48].

Stress fractures

Women engaged in military training are known to have increased risk for stress fracture [49]. Whether this risk translates to athletic women or girls is controversial and an area of much current research [50]. Girls in activities with traditionally high levels of female participation such as dance [51], gymnastics [52], and figure skating [53] have already been shown to have increased risk for spondylolysis [32,33•]. They also sustain stress fractures of other, less common, parts of the body, such as the femoral neck. It is not clear to what degree these are attributable to the high number of repetitions required of these girls to master the intricate maneuvers specific to these activities versus the lean physique emphasized by these activities, which predisposes them to the female athlete triad.

The female athlete triad

The female athlete triad is a term that describes the inter-relatedness of disordered eating, amenorrhea, and osteoporosis in certain female athletes [54]. True osteoporosis may not develop in all cases, but the lack of estrogen associated with amenorrhea and the decreased calcium and vitamin D intake with disordered eating can cause decreased bone mineral density, which, in turn, is believed to increase the risk of stress fracture in these athletes [55]. Of more concern is the impact on long-term bone density and risk for osteoporosis, with its attendant risk for pathologic fracture, in later adulthood. For this reason, the American Academy of Pediatrics Policy Statement, "Medical Concerns in the Female Athlete" [11••], which discusses this topic in detail, is essential reading for all who care for young female athletes.

Conclusions

Pediatric and adolescent primary care providers can, and should, play a significant role in the diagnosis and management of injuries in athletic girls. Numerous excellent references are available to assist clinicians in this process. A knowledge and understanding of the injury patterns common to girls is necessary to help navigate these resources, many of which reflect the traditional predominance of boys in sport.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:
* of special interest
** of outstanding interest

  * This issue of Clinical Orthopedics, subtitled "Women's Musculoskeletal Health: Update for the New Millenium," is entirely devoted to the topic but emphasizes the concerns of older adult women.

* This article presents a novel approach to repetitive extension injuries of the spine.

Bibliography Current World Literature
