

An Overview of Hip Injuries in Running

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Contents

Abstract	992
1. Aetiology	993
2. General Approach	994
3. General Treatment Principles	995
4. Specific Conditions	996
4.1 Muscle Strains and Tendonitis	996
4.1.1 Aetiology	996
4.1.2 History, Physical Examination and Diagnostic Imaging	996
4.1.3 Prognosis and Treatment	996
4.2 Apophysitis and Avulsion Fractures	997
4.2.1 Aetiology	997
4.2.2 History, Physical Examination and Diagnostic Imaging	998
4.2.3 Prognosis and Treatment	999
4.3 Iliotibial Band Syndrome	999
4.3.1 Aetiology	999
4.3.2 History, Physical Examination and Diagnostic Imaging	999
4.3.3 Prognosis and Treatment	999
4.4 Bursitis	1000
4.4.1 Aetiology	1000
4.4.2 History, Physical Examination and Diagnostic Imaging	1000
4.4.3 Prognosis and Treatment	1001
4.5 Osteoarthritis	1001
4.5.1 Aetiology	1001
4.5.2 History, Physical Examination and Diagnostic Imaging	1002
4.5.3 Prognosis and Treatment	1002
4.6 Stress Fractures	1003
4.6.1 Aetiology	1003
4.6.2 History, Physical Examination and Diagnostic Imaging	1004
4.6.3 Prognosis and Treatment	1005
4.7 Snapping Hip Syndrome	1006
4.7.1 Aetiology	1006
4.7.2 History, Physical Examination and Diagnostic Imaging	1006
4.7.3 Prognosis and Treatment	1006
4.8 Acetabular Labral Tears	1006
4.8.1 Aetiology	1006

4.8.2	History, Physical Examination and Diagnostic Imaging	1007
4.8.3	Prognosis and Treatment	1007
4.9	Sports Hernia	1007
4.9.1	Aetiology	1007
4.9.2	History, Physical Examination and Diagnostic Imaging	1008
4.9.3	Prognosis and Treatment	1008
4.10	Additional Conditions	1008
5.	Injury Prevention	1009
6.	Conclusions	1010

Abstract

Running has steadily gained in worldwide popularity and is the primary exercise modality for many individuals of all ages. Its low cost, versatility, convenience and related health benefits appeal to men and women of broad cultural, ethnic and economic backgrounds. With more children and adults participating in recreational and competitive running, the incidence of injuries has steadily increased. Most running-related injuries affecting the lower extremities are due to preventable training errors, and some may necessitate medical evaluation or a significant reduction in training.

Hip injuries in runners are due to interactions of intrinsic and extrinsic factors that adversely affect the complex regional anatomy. Acute or chronic hip pain presents a diagnostic and therapeutic challenge because the vague, nonspecific symptoms and signs may originate from local, regional or distant foci. Muscle strains and tendonitis are the most common aetiologies of hip pain and typically result from sudden acceleration/deceleration manoeuvres, direction changes or eccentric contractions. Apophysitis and avulsion fractures may affect younger runners and produce localised pain at muscle attachment sites. Iliotibial band syndrome is a common cause of lateral hip and knee symptoms characterised by sharp or burning pain that is exacerbated by activity. Bursitis, due to repetitive activity or acute trauma, may affect the trochanteric, ischial or iliopectineal bursae. Hip osteoarthritis may also produce persistent pain that worsens with running. Stress fractures are potentially serious conditions that affect women more frequently than men. Snapping hip syndrome is a benign condition that results from tight connective tissues' passing repeatedly over the greater trochanter, anterior hip capsule, lesser trochanter, femoral head or iliopectineal eminence. Acetabular labral tears, sports hernias and nerve entrapment syndromes are also potential causes of persistent hip pain in runners.

Treatment of hip pain in running should focus not only on addressing the symptoms but also identifying the underlying conditions that precipitated the injury. Injury prevention and comprehensive rehabilitation are essential, since prior hip injuries increase the risk of subsequent ones. Coaches, trainers and medical personal who care for runners should advocate running regimens, sur-

faces, shoes, technique and individualised conditioning programmes that minimise the risk of initial or recurrent hip injuries.

Recreational and competitive running have steadily gained in popularity worldwide over the last three decades, and running is currently the primary means of exercise for many adults. A recent survey of sports participation found that 36 million Americans ran at least once in 2003, 10.5 million ran ≥ 100 days and 12 million have been in the sport for ≥ 10 years. The average age of frequent runners (>100 days/year) is 30.6 years, and $>40\%$ of these are female.^[1] The low cost, versatility, convenience and minimal required equipment of running have contributed to its appeal to men and women of broad cultural, ethnic and economic backgrounds. Running or brisk walking has also been promoted for preventing or treating cardiovascular disease, obesity, hypertension, diabetes mellitus, hypercholesterolaemia, osteoporosis and other medical conditions.^[2-12] Moreover, research has shown that running on a treadmill is the optimal indoor exercise for enhancing energy expenditure compared with other exercise modalities such as stair stepping, stationary cycling and ergometer rowing.^[13]

At some point in their running careers, $>25\%$ of runners experience musculoskeletal injuries that necessitate evaluation.^[14] Running is a relatively atraumatic sport, and running injuries, usually affecting the lower extremities, are 2 to 2.5 times less common than injuries from other sports.^[15] The incidence of hip injuries from running depends on many factors, but the average recreational runner, who trains steadily and races occasionally, has a yearly injury incidence rate between 37% and 70%.^[16,17]

Although hip injuries are not as common as injuries affecting the lower leg or foot, the overall prevalence of hip pain among adults has increased, especially among women and Mexican-Americans.^[18] Approximately 14% of adults >60 years of

age report significant hip pain on many days of the week, and most of these painful symptoms are not due to osteoarthritis (OA).^[19] People who do not regularly engage in leisure-time physical activity are also more likely to report hip pain.^[19] Approximately 10% of the athletes who seek care at sports medicine clinics report chronic hip pain.^[20-22] Some of these injuries may lead to a significant reduction in training and may ultimately require medical evaluation.^[17,22,23]

1. Aetiology

Acute or chronic hip pain in running presents a diagnostic and therapeutic challenge to even the most skilled clinician, since the vague, nonspecific symptoms can originate from local, regional or distant sources.^[23-25] The differential diagnosis of hip pain is extensive, and affected athletes may note acute or chronic symptoms of widely ranging intensities, locations and durations. Moreover, clinical findings are highly variable, and numerous regional anatomical structures may be included by athletes and clinicians alike when discussing problems affecting the 'hip and groin', leading to further confusion.^[23]

Many factors are potentially associated with hip injuries in running (table I). These predisposing factors may be divided into extrinsic and intrinsic categories (table II), but injuries most likely result from complex interactions among the various factors. High degrees of hip external rotation and narrow tibial bone widths may predispose runners to hip injuries.^[26,27] A leg length discrepancy of >10 – 15 mm may also cause compensatory pelvic and lumbar misalignment that produces hip pain.^[28] Hip kinematic and kinetic gait pattern analyses have demonstrated significant differences between fe-

Table 1. Factors potentially associated with hip injuries in running (reproduced from van Mechelen,^[17] with permission)

Significantly associated

Previous injury

Inexperience

Competitive running

Running distance (>64km [40 miles] a week)

Excessive hip external rotation

Narrow tibial width

Regional muscle strength

Incomplete rehabilitation of prior injury

Running year-round

Related, but unclear or contradicting based on limited data

Inadequate warm-up or stretching routines

Taller body height

Lower extremity alignment

Poor flexibility

Running frequency

Recreational running

Running routine consistency

Shoes used for >400km of running

The use of orthoses

Foot hyperpronation

More aggressive or motivated running

Not significantly associated

Age

Sex

Body mass index

Hill or stair running

Running on hard surfaces

Cross-training

Time of the year or weather

Running in the morning vs other times of the day

Abnormal Q-angle

Pelvic obliquity

Femoral anteversion

male and male recreational runners.^[29] However, a recent review questioned whether a particular kinematic pattern noted during running actually increases the risk of injury.^[30] Obesity may also play a role, as running increases peak forces at the hip joint by 3–5.5 times one's bodyweight.^[21,31] Unlike the shoulder, hip pain is usually unrelated to laxity,

since the hip is an enarthrosis (ball and socket joint) that has substantial inherent stability from the articulation of the femoral head in the relatively deep acetabulum. In addition, the fibrocartilaginous labrum, iliofemoral ligament, pubofemoral ligament, ischiofemoral ligament and ligamentum capitis femoris provide stability.

Hip injuries in running are often related to extrinsic factors including improper technique, poor shoes or running surfaces, abrupt changes in running routines, inadequate nutrition or hydration, excessive mileage (>64km [40 miles] a week) or rapid intensity advancement.^[14,15,33-35] If these and similar factors are not addressed, hip injuries may reoccur when runners resume their previous training regimens.

2. General Approach

A complete history and physical examination should be part of the evaluation of any runner with hip or groin pain. The examiner should elicit information about the pain's onset, duration, character, intensity, location, exacerbating or ameliorating factors, prior history and treatment to date. It is also essential to ascertain the affected runner's weekly mileage, terrain and surfaces utilised and shoe condition.^[35] Relevant past medical, surgical, obstetrical, gynaecological, family and social histories may also yield important data.

The physical examination should focus on not only the affected hip but also the surrounding proximal and distal joints. Observation of gait, limb position and posture should be part of the initial examination to look for pelvic obliquity, significant scoliosis, weak supporting muscles (e.g. gluteus medius weakness presenting with an abductor lurch), leg-length discrepancies or limping.^[21] Next, the hip and groin region should be palpated for soft tissue abnormalities, starting with the least painful areas first. Since the hip joint itself is very deep, it is usually difficult or impossible to palpate it directly. Both active and passive range of motion (ROM) may then

be assessed. Table III lists the average values of adult female and male hip ROM limits.^[21,36-38] Notably, the amplitude of most hip motions typically decreases with age.^[36] In addition, the average hip ROM reported among various studies depends on the technique (e.g. active vs passive motion testing) and position (e.g. supine or prone, hip flexed or extended, knee flexed or extended) used for testing the subjects.^[36,39] There also is no clear correlation among height, weight and total hip rotation.^[36] Strength testing of the regional muscle groups should be performed and neurovascular status documented. Lower extremity alignment, leg lengths and foot conditions (e.g. pes planus, hyperpronation and excessive calcaneal eversion) should also be assessed.^[40] Some hip disorders may require specific clinical examination techniques that will be discussed later in sections 4.3.2, 4.6.2, 4.7.2 and 4.8.2.

Table II. Predisposing factors to overuse running injuries (reproduced from Brukner,^[32] with permission)

Extrinsic

Training errors (excessive volume, excessive intensity, rapid increase, sudden change, excessive fatigue, inadequate recovery, faulty technique)

Surfaces (hard, soft, cambered)

Shoes (inappropriate, worn out)

Equipment (inappropriate)

Environmental conditions (hot, cold, humid)

Psychological factors

Inadequate nutrition

Intrinsic

Malalignment (pes planus, pes cavus, rearfoot varus, tibia vara, genu valgum, genu varum, patella alta, femoral neck anteversion, tibial torsion, coxa vara)

Muscle imbalance

Muscle weakness

Lack of flexibility (generalised muscle tightness, focal areas of muscle thickening, restricted joint range of motion)

Sex

Body size

Body composition

Leg length discrepancy

Table III. Average hip range of motion values for adult females and males

Direction	Range of motion (°)	
	females	males
Flexion	119–141	115–137
Extension	12–26	16–23
Abduction	40–44	38–45
Adduction	26–33	27–29
External rotation	32–44	27–43
Internal rotation	29–52	27–38

Diagnostic imaging often plays an essential role in the evaluation and monitoring of runners with hip pain or injuries. Plain radiographs are usually the initial study and should include anteroposterior (AP) pelvis, AP hip and frog-leg lateral views.^[41] If plain radiographs are non-diagnostic, then additional testing with scintigraphy using triple-phase technetium-99m methylene diphosphonate (Tec-99m-MDP), ultrasound (USN), computed tomography (CT) or magnetic resonance imaging (MRI) may be considered. In some instances, hip arthroscopy may be necessary to make a definitive diagnosis.

3. General Treatment Principles

The most important initial step for runners with persistent or worsening hip pain, especially when it is present at rest, night time or during light activity, is the prompt discontinuation of running until a definitive diagnosis has been made. Returning a runner to sport will depend on the aetiology, location, chronicity and severity of the underlying condition. Unless there is a contraindication to weight bearing, gentle stretching and light load-bearing, exercises may be prescribed early using a carefully monitored progression that accounts for the runner's pre-injury conditioning.^[15] Cross training with sports such as bicycling, swimming, cross-country skiing or pool jogging may be incorporated into the recovery period to maintain fitness and aerobic capacity. Treatment programmes should also include trunk and postural muscle stabilisation exercises

that focus on strengthening the pelvic, spinal, upper thigh and lower abdominal muscles.^[18,42]

4. Specific Conditions

4.1 Muscle Strains and Tendonitis

4.1.1 Aetiology

Muscle strains and tendonitis account for up to 33% of sports injuries and are the most common aetiology of hip pain in runners.^[17,18,22,24,43-45] Muscle strain injuries often affect sprinters and occur at the myotendinous junction of biarticular muscles (e.g. rectus femoris and biceps femoris) during eccentric loading.^[43,46] They usually result from a sudden acceleration/deceleration manoeuvre, direction change or eccentric contraction in which the affected muscle fails to withstand a particular force.^[45,47] Risk factors include poor flexibility, inadequate warm up, fatigue, improper technique, increased age, prior injuries and regional weakness.^[48,49] In addition, overly vigorous stretching may also precipitate muscle injury.^[50]

The hamstrings, iliopsoas, rectus femoris and adductor muscles may all be affected by strain injuries, with the proximal myotendinous junction of the biceps femoris being the most common site of injury.^[41,43] The hamstring muscles, which extend the hip and flex the knee, may be injured during sprinting or hill climbing. Distal injuries can be more severe than proximal ones.^[43,51] The iliopsoas muscle acts as a strong hip flexor and may be injured during snow running, hill climbing or repetitive sit-ups.^[48] Strains of the iliopsoas are usually located near the muscle's insertion on the lesser trochanter.^[24] The rectus femoris muscle that extends the knee and flexes the hip may be injured during sprinting or jumping.^[18] Rectus femoris strains are frequently located at the proximal muscular origin near the anterior inferior iliac spine (AIIS).^[24] Traumatic abduction or external rotation manoeuvres may pre-

cipitate injuries of the adductor muscle group that includes the pectineus, adductor brevis, adductor longus, adductor magnus, obturator externus and gracilis muscles.^[24,49,52] Lower hip adduction/abduction strength ratios and previous adductor injuries are associated with adductor strains.^[49]

4.1.2 History, Physical Examination and Diagnostic Imaging

Muscle strains and tendonitis are primarily clinical diagnoses. Runners may report a history of localised pain, weakness, stiffness, swelling or bruising. With time, symptoms may radiate distally along the involved muscle group.^[24] Tenderness, regional weakness, oedema, ecchymoses, crepitus or limited ROM may be noted on physical examination.^[48] Diagnostic imaging is usually unnecessary for muscle strains or tendonitis unless an avulsion fracture is suspected. Muscle strains are typically classified as grade 1 (minimal fibre disruption), grade 2 (partial tear without muscle retraction) or grade 3 (complete rupture of the myotendinous unit).^[41] In some cases, USN or MRI may be used to differentiate the grades of muscle strain injuries.^[33,51]

4.1.3 Prognosis and Treatment

The prognosis for muscle strains and tendonitis is generally excellent with appropriate rehabilitation. The initial treatment includes rest, ice and protected weight bearing for more significant injuries. A brief course of NSAIDs may be considered for the associated pain and inflammation, although there is little evidence supporting the routine use of NSAIDs in treating acute soft tissue injuries or chronic tendonitis.^[53,54] Compression shorts may also be helpful for early pain control. Heat, gentle activity and regional isometric strengthening may be initiated after a few days. Functional and sport-specific activities can then slowly be introduced over the next 3–6 weeks with an increasing emphasis on eccentric strengthening exercises.^[55] Careful stretching significantly enhances the rehabilitation

programme of muscle strain injuries and enables some athletes to return to sport earlier.^[47] In some cases the assistance of a physical therapist or athletic trainer may be helpful because incomplete rehabilitation presents a risk for recurrent or more significant injuries at lower thresholds in the future.^[42,45,49]

Various recommendations have been suggested for returning runners to sport after strains or tendonitis. One approach advocates beginning with slow running for one-third of the usual distance alternating with a rest day after symptoms have significantly subsided and hip ROM has normalised. If pain free over the next 2 weeks, the runner may advance weekly mileage and slowly increase speed and intensity. Rest days should be continued for at least 4 weeks, and cross-training should be incorporated whenever possible.^[35,55] Technique errors and extrinsic factors should also be addressed, for many muscle strains and tendonitis episodes can be prevented with appropriate training, equipment and technique.^[24] Surgery, even for grade 3 tears, is often unnecessary but may be considered for athletes with symptoms persisting despite 6 months of conservative therapy.

4.2 Apophysitis and Avulsion Fractures

4.2.1 Aetiology

Apophyses are secondary ossification centres present in skeletally immature individuals that serve as insertion or origination sites for tendons and large muscles. The average ages of the appearance and fusion of the secondary ossification centres of the hips and pelvis are shown in figure 1. Apophysitis and avulsion fractures typically occur in runners during this adolescent growth period between 11 and 15 years of age. Limited flexibility poses a significant risk factor when rapid bone growth exceeds soft tissue development during the adolescent growth period. Historically, males have been affected up to nine times more often, but the increased participation of females in running at younger ages

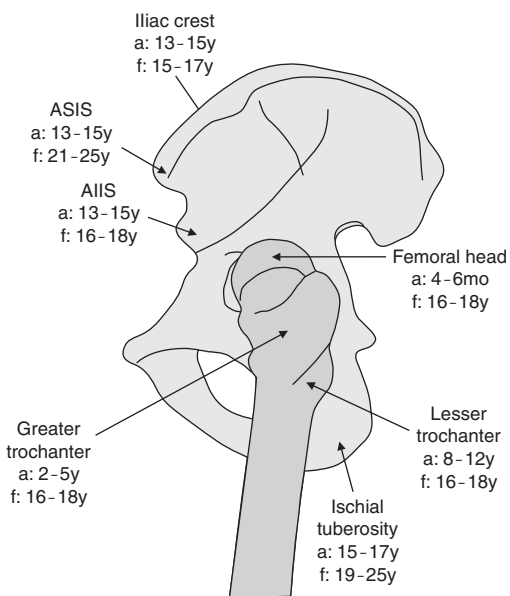


Fig. 1. The average ages of the appearance (a) and fusion (f) of the secondary ossification centres of the hips and pelvis (reproduced from Paletta and Andrich,^[57] with permission). **AIIS** = anterior inferior iliac spine; **ASIS** = anterosuperior iliac spine.

has diminished this ratio. Repetitive apophyseal microtrauma and stress may produce the traction cartilage abnormalities consistent with apophysitis.^[56] In contrast, avulsion fractures usually result from a forceful eccentric muscle contraction that disrupts apophyseal bony integrity, since osseous failure is more likely than tendon rupture in younger runners.^[22]

Several regional apophyses may be implicated in hip pain among younger runners. Figure 2 depicts several anterior and posterior hip muscular attachment sites where apophyseal or avulsion injuries may occur. Of these, the iliac crest, anterosuperior iliac spine (ASIS), AIIS, ischial tuberosity, greater trochanter and lesser trochanter are the sites most frequently involved.^[46] The iliac crest serves as the attachment for the abdominal oblique, transverse abdominal and gluteus medius muscles. Excessive force from accentuated arm motion across the trunk while running can cause significant irritation at the

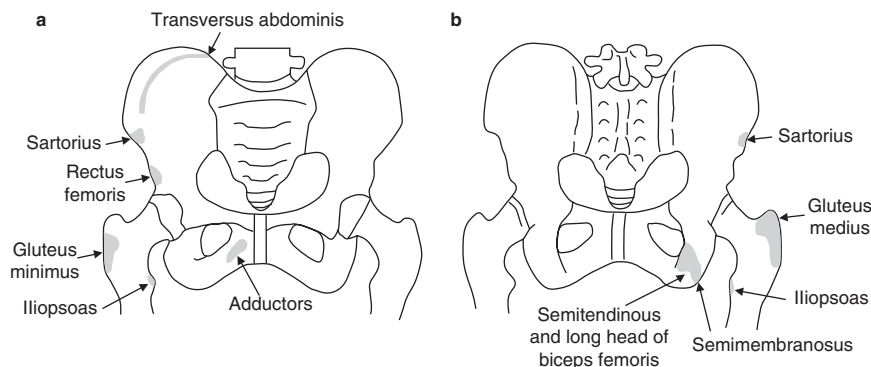


Fig. 2. Anterior (a) and posterior (b) schematics of the hips showing muscular attachment sites where apophyseal or avulsion injuries may occur in young athletes.

iliac crest bone-tendon interface. However, iliac crest avulsion fractures are rarely reported and seldom displace.^[56,57] The ASIS provides attachment for the sartorius muscle tendon and is frequently injured during sprinting or hurdling.^[57] The AIIS, the origin of the rectus femoris muscle, may also be affected during sprinting.^[41]

The ischial tuberosity serves as the origin for the medial and lateral hamstrings and is the most common site of pelvic avulsion fractures in young runners.^[21] Apophysitis or avulsion fractures of the ischial tuberosity often result from eccentric hamstring contraction with a flexed hip and extended knee.^[57] Ischial tuberosity avulsions may initially be misdiagnosed as hamstring tendonitis or bursitis.^[58] The gluteus medius, gluteus minimus and hip external rotator muscles insert on the greater trochanter, but insertional muscle strains are more common than avulsion injuries in this area. The lesser trochanter serves as the attachment site for the strong iliopsoas tendon. Although relatively uncommon, avulsion injuries may occur in sprinters or jumpers during vigorous hip flexion manoeuvres.

4.2.2 History, Physical Examination and Diagnostic Imaging

A runner with apophysitis usually presents with gradually increasing, localised, dull pain that is ex-

acerbated by running.^[35,58] In contrast, a forceful, eccentric muscle contraction during sprinting that produces immediate pain, swelling, limping and disability suggests an avulsion fracture.^[18] Affected runners may also hear or feel a pop.^[14,50] Runners with apophysitis or avulsion injuries often hold their hips in positions that put minimal tension on the involved muscles. Clinical examination may reveal localised pain, ecchymosis, swelling and tenderness near the tendon-bone interface.^[24,48] Resistance testing exacerbates the pain, and ROM is often diminished.^[18] Occasionally a palpable lump or nodule may be present.

Plain radiographs comparing the affected and unaffected sides should be obtained. While apophysitis is not associated with any displacement of an apophysis, avulsion fractures may be identified on radiographs by a displaced crescentic bony fragment that lies near its origin.^[21] Typically, most avulsion fractures are not significantly displaced due to the surrounding periosteum.^[48] Since oncological and infectious aetiologies should always be considered, CT, bone scanning or USN can confirm an uncertain apophyseal injury. Notably, MRI does not identify avulsion fractures as well as plain radiographs or CT.^[41]

4.2.3 Prognosis and Treatment

The prognosis for apophysitis and avulsion fractures is generally good with appropriate recognition and early treatment. Most runners with apophysitis can successfully be treated with gentle stretching and protected weight bearing after an initial period of rest, ice and analgesia.^[58] Care should be taken to avoid vigorously stretching the involved muscle group too early. Neoprene shorts may also be helpful to provide warmth and compression. Many athletes are able to return to sport within 4–8 weeks if strength and motion have been restored.^[56,57] Limited data are available to guide clinicians regarding conservative or surgical treatment for avulsion fractures.^[18] Some recommend a surgical approach if the bony fragment is >2cm in size or displaced >1–3cm (depending on the injury's location), as fibrous non-union may occur and result in prolonged disability.^[18,22,23,35,56-58]

4.3 Iliotibial Band Syndrome

4.3.1 Aetiology

Iliotibial band syndrome (ITBS) is the most common cause of lateral knee pain in runners but may also occasionally generate lateral hip pain. The iliotibial band is a strong tendinous continuation of the tensor fasciae latae and gluteus maximus muscle that originates near the iliac crest and inserts on the lateral tibia (Gerdy's tubercle), fibular head and lateral patellar retinaculum.^[59] At its tibial insertion, the ITB blends with the fibrous expansions of the biceps femoris and lateral quadriceps muscles. Irritation of the ITB is likely multifactorial, but excessive or sudden mileage increases, little running experience, leg length discrepancies, genu varum, cavus feet, regional muscle weakness, banked running surfaces, inappropriate footwear, hip inflexibility and shorter statures are most often implicated.^[34,59,60]

4.3.2 History, Physical Examination and Diagnostic Imaging

ITBS is characterised by sharp or burning pain along the lateral hip, thigh or knee that worsens with activity.^[17,61] The pain initially subsides after running but progresses to occur during light activity or rest.^[60] Hill climbing or stairs particularly exacerbate the symptoms of ITBS. On examination, tenderness to palpation may be noted over the ITB. Hip abductor strength deficits are often appreciated in the affected leg.^[60] An Ober's test, performed by abducting and extending the affected hip before allowing the thigh to adduct passively toward the midline, may be positive. The test is considered positive if the thigh does not return to at least a neutral position or lateral hip pain is reproduced. The modified Thomas test may also be helpful to measure ITB flexibility.^[62] In this test, both knees are initially brought up to the chest by a supine athlete lying on an examination table, and then the contralateral hip is held maximally flexed while the affected leg is slowly lowered toward the floor. ITBS is primarily a clinical diagnosis and diagnostic imaging typically only serves to exclude other potential aetiologies.

4.3.3 Prognosis and Treatment

The prognosis for ITBS is generally good with appropriate treatment and correction of precipitating factors. Initial treatment is conservative, using activity modification, ice and possibly NSAIDs, although there is little evidence supporting the routine use of NSAIDs in treating soft tissue injuries.^[53,54] Rehabilitation programmes should focus on regional strength and flexibility deficits. One recent study found that a comprehensive stretching protocol (as shown in figure 3) incorporating an overhead arm extension into the commonly performed standing ITB stretch significantly increased ITB flexibility.^[63] Addressing underlying biomechanical conditions or training errors is also an essential aspect of

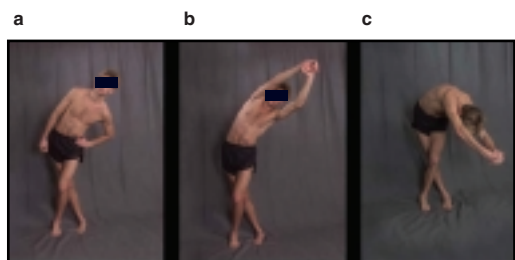


Fig. 3. Depiction of three iliobtibial band (ITB) stretches. Stretch (a) uses an upright stance with the affected leg extended and adducted behind the other leg as the athlete flexes the trunk toward the contralateral side. Stretch (b) is similar to (a), but the hands are clasped overhead and stretched toward the contralateral side. Stretch (c) is also similar to (a), but the clasped hands are instead extended diagonally downward toward the contralateral side. Stretch (b) appears to increase ITB length most effectively (reproduced from Fredericson et al.,^[63] with permission).

treatment. Corticosteroid injections and surgery are uncommon in the treatment of ITBS.^[57]

4.4 Bursitis

4.4.1 Aetiology

Bursae are fluid-filled sacs that provide cushioning between bony prominences and the surrounding soft tissues. Bursal inflammation (bursitis) may result from chronic microtrauma, arthritis, regional muscle dysfunction, overuse or acute injury.^[64-66] Although there are at least 13 bursae present in the hip and groin region, most runners develop symptoms around the trochanteric, ischial and iliopectineal bursae.^[24]

The trochanteric bursa is the most commonly affected hip bursa and overlies the lateral aspect of the greater femoral trochanter where it provides cushioning for the gluteus tendons, iliobtibial band and tensor fascia latae.^[64] The trochanteric bursa is composed of subgluteus minimus, maximus and medius components.^[41] Trochanteric bursitis may be more accurately referred to as greater trochanter pain syndrome, since typical inflammatory findings of erythema, oedema and warmth are uncommon.^[64,67] Greater trochanter pain syndrome affects

women four times more frequently than men and peaks between the fourth and sixth decades of life.^[64,67] Numerous factors may contribute to the onset of greater trochanter pain syndrome including gluteus medius insertional dysfunction, hip OA, lumbar spondylosis, excessive or rapidly increased mileage, frequent training on hard or banked running surfaces, poorly cushioned shoes, excessive pronation, leg length discrepancies and ITBS.^[15,22,28,64,65,67] Athletes who adduct their hips beyond midline while running are also at risk of developing greater trochanter pain syndrome.^[18]

The iliopectineal bursa underlies the iliopsoas muscle where it passes over the femoral head and inserts onto the lesser femoral trochanter. Chronic rubbing of the iliopsoas tendon on the iliopectineal bursa during sprinting, hill climbing or starting may cause symptomatic iliopsoas syndrome.^[66] Iliopectineal bursitis (with or without an associated snap) is less common than greater trochanter pain syndrome and often an unrecognised cause of anterior hip pain.^[18,25] Ischial bursitis is uncommon but may occur when a runner falls onto his or her ischial tuberosity.^[22,41] Proximal hamstring tendonitis, ischial apophysitis and avulsion injuries may all mimic ischial bursitis.

4.4.2 History, Physical Examination and Diagnostic Imaging

Runners with greater trochanter pain syndrome typically note persistent lateral hip pain that worsens when lying on the affected side, tenderness along the posterior aspect of the greater trochanter, difficulty climbing stairs or pain when transitioning from lying to standing.^[61,64,67] Pain radiating down the medial thigh that mimics lumbar disc herniation (pseudoradiculopathy) may be reported by some individuals.^[24,64] On physical examination, affected runners have diffuse or localised pain over the greater trochanter.^[22] Symptoms of greater trochanter pain syndrome may also be reproduced by abducting and externally rotating the hip.^[65,67]

Runners with iliopsoas syndrome may report anterior hip pain that is exacerbated by activity or resisted hip flexion.^[61,68] The pain may radiate down the medial thigh toward the knee and is often relieved by rest.^[66] Limping, hip internal and external rotational weakness, restricted hip extension or a shortened stride may all be noted on physical examination.^[66,68] Individuals with ischial bursitis may report localised pain or warmth that worsens with hill running, sprinting or prolonged sitting. Physical examination reveals localised tenderness over the ischial prominence that is exacerbated by resisted hamstring strength testing.

Hip bursitis is primarily a clinical diagnosis, and diagnostic imaging is often unnecessary. Plain radiography may demonstrate variably sized linear or round calcifications that are isolated or clustered adjacent to the greater trochanter with greater trochanter pain syndrome.^[64] Radiographs are typically normal in cases of iliopsoas syndrome or ischial bursitis. Bone scans are nonspecific and may demonstrate some increased uptake in the affected region.^[67] USN is primarily used to guide a diagnostic lidocaine (lignocaine) injection or to demonstrate transient subluxation of the iliopsoas tendon.^[66,69] MRI may demonstrate a homogenous focus of bright signal intensity on T₂-weighted or short echo time inversion-recovery images.^[46,64] Gluteus medius pathology (e.g. tears or tendonitis) may also be apparent on MRI with greater trochanter pain syndrome.^[67]

4.4.3 Prognosis and Treatment

The prognosis for bursitis is generally good with appropriate treatment and correction of precipitating factors, especially muscular imbalances. Management of hip bursitis includes rest, ice, gentle stretching and avoidance of excessive hip motion. NSAIDs may be considered, although inflammation and bursal distension are often not present.^[67] Many runners with hip bursitis have considerable regional muscle dysfunction (particularly the glutei muscles) and

would also benefit from a rehabilitation programme of hip rotational strengthening.^[66-68] An injection of corticosteroids and anaesthetics is often effective and frequently provides sustained improvement.^[64,70] In refractory cases, a bursectomy, bony prominence resection or tendon release can be considered.^[67]

4.5 Osteoarthritis

4.5.1 Aetiology

OA affects numerous individuals worldwide, produces significant disability and generates substantial economic costs.^[71-75] The considerable impact of advanced cases of OA on daily functioning has made total hip arthroplasty one of the most commonly performed orthopaedic surgeries.^[71,76] Obesity, genetic susceptibility, postmenopausal hormone deficiencies, occupational activities, educational level and advanced age all increase the risk of hip OA.^[72,75,77] In addition, prior injuries, hip trauma, acetabular dysplasia, slipped capital femoral epiphysis, osteochondritis desiccans and Legg-Calvé-Perthes disease are predisposing factors.^[14,71,75] Overall, women have higher rates of symptomatic OA than men, especially after 50 years of age.^[73,75]

Significant controversy exists in the literature concerning the relationship between running and hip OA.^[74,77-79] The repetitive mechanical loads from running may be a risk factor for subsequently developing hip OA.^[72,74] One retrospective cohort study of middle-aged, former female runners noted a 1.6-fold (CI 0.73, 3.48) increased risk of radiographic hip OA compared with controls.^[74] In addition, a recent case-controlled study of women 50–70 years of age found that mechanical loads from a variety of sporting activities are moderate risk factors for the development of severe clinical and radiographic hip OA.^[72] Some have suggested that a dose-response relationship exists between exercise duration and hip OA, since the relative risks of developing OA increase with higher exercise exposures (>800 ag-

gregate hours of sporting activities by age 50 years).^[72,74] However, one retrospective study of elite male endurance runners (mean distance 97 km/week) found that running pace was more predictive of radiographic hip OA than running duration (measured as total mileage).^[78]

In contrast, other researchers have found no significantly increased risk of hip OA due to running. A longitudinal case-controlled study of older male and female runners (mean age 66 years) observed no accelerated development of radiographic hip OA versus non-runner controls.^[79] Another large, longitudinal study of physically active men and women concluded that participation in moderate-intensity running did not increase the risk of self-reported or physician-diagnosed hip OA.^[77] In general, further research is definitely needed to assess whether running meaningfully increases the risk of hip OA.

4.5.2 History, Physical Examination and Diagnostic Imaging

Several symptoms and signs are suggestive of hip OA. Runners with hip OA are often older (>60 years) and report insidious, persistent (>3 months) groin pain or tenderness that is aggravated by sitting.^[80,81] The pain is frequently deep, aching and poorly localised with radiation into the anterior thigh.^[60] Affected runners may also note decreased hip adduction, internal rotation or external rotation that gradually intensifies. Symptoms typically worsen at the end of the day or after running. Brief morning stiffness (<60 minutes) may be reported, but the duration is shorter than that for rheumatoid arthritis.^[81] Over time, the pain often becomes more persistent and less responsive to analgesics.

Physical examination findings include painful and decreased hip ROM, particularly internal rotation ($\leq 15^\circ$).^[81,82] Regional muscle weakness is common with more advanced disease.^[80] Crepitus may be present, but warmth and swelling are uncommon. Serological tests are usually unnecessary except to exclude other conditions, and the erythrocyte sedi-

mentation rate is usually normal (<20 mm/hour).^[80,81]

In general, clinical symptoms and signs can predict radiographic OA of the hip moderately well.^[80,82] OA is typically associated with a heterogeneous radiographic disease development, but approximately 20% of people with hip OA progress radiographically after 1 year.^[83] Typical radiographic findings of OA include irregular joint space narrowing, osteophyte formation, cyst formation, subchondral sclerosis and femoral head deformation.^[81] Bony erosions or demineralisation are uncommon. Although osteophytes seen on radiographs best separate those with hip OA from controls, joint space narrowing measured at the narrowest interbone distance in millimeters may correlate better with hip pain.^[80,81,83,84] However, the grade of osteophytes or degree of joint space narrowing does not necessarily correlate with the severity of clinical symptoms in some patients.^[76] In some cases, CT or MRI may be helpful to characterise the articular cartilage defects and identify concomitant pathology such as labral or ligamentous abnormalities.

4.5.3 Prognosis and Treatment

The prognosis of hip OA is variable depending on the predisposing conditions, symptom severity and rate of disease progression. In general, many runners with mild-to-moderate hip OA can successfully be treated non-surgically. Relative rest and analgesics may initially be used as needed. Rehabilitation should focus on low- or non-impact activities. Soft, level training surfaces and pool-based activities may be particularly helpful. The affected athlete should also include ROM exercises in the early management of OA.^[18] Regional strength training may help to stabilise muscles, distribute forces and decrease loading around the hip.^[14,75] Obesity should aggressively be addressed because running may increase hip intra-articular forces by several times one's bodyweight.^[16,22,75] Educational or occupational conditions should be assessed to mini-

mise prolonged sitting, heavy lifting, bending or standing on hard surfaces.^[75]

Paracetamol (acetaminophen) and various NSAIDs are frequently prescribed for analgesia in the treatment of OA, but NSAIDs may be superior for reducing rest and walking pain compared with paracetamol for symptomatic hip OA.^[85,86] NSAIDs also have anti-inflammatory properties not present with paracetamol.^[53] However, paracetamol is associated with fewer adverse reactions, such as gastrointestinal ulceration or renal parenchymal disease, than NSAIDs.^[87] There may also be a significant correlation between NSAID consumption and radiological progression of hip OA among older adults.^[83] Notably, some individuals may be able to use paracetamol instead of NSAIDs, thereby avoiding prolonged treatment with NSAIDs.^[54,87,88]

Recently cyclo-oxygenase-2 (COX-2) enzyme-specific NSAIDs (valdecoxib, celecoxib, rofecoxib, etoricoxib) had been promoted as an equally effective but safer alternative to conventional COX-1 medications for OA.^[89-92] Both COX-1 and COX-2 inhibitors inhibit prostaglandin (a pro-inflammatory mediator) synthase, but COX-2 inhibitors more directly attenuate inflammatory responses with theoretically fewer gastrointestinal adverse effects.^[93] COX-2 is normally present in only small amounts, but its expression increases dramatically during inflammation.^[53] However, the COX-2 enzyme also plays an important role in the formation of prostaglandin I₂ (a vasodilator), and its inhibition enhances platelet aggregation, elevates blood pressure and increases the risk of thrombosis.^[93,94] Notably, rofecoxib was withdrawn from the market in late 2004 because of an increased risk of myocardial infarction and thrombotic stroke noted in the Adenomatous Polyp Prevention on Vioxx (APPROVE) study.^[94,95] In addition, valdecoxib and celecoxib have come under scrutiny regarding their potential cardiotoxicity.^[96-98] Valdecoxib was subsequently removed from the market at the request of the US

FDA in 2005. COX-2 inhibitors should be reserved for those with a history of significant gastrointestinal side effects while taking conventional NSAIDs who are at low risk for thrombotic cerebral or cardiovascular events.^[94,99-101]

Glucosamine with or without chondroitin sulphate has also been shown to have a moderate to large treatment effect for OA with a good safety profile.^[102] An intra-articular injection of corticosteroids using fluoroscopic guidance is another safe, effective treatment option for symptomatic hip OA.^[103] The efficacy of intra-articular hip viscosupplementation injections is under investigation but appears to be safe and relatively effective.^[104,105] The role of arthroscopic evaluation and debridement of hip OA is currently uncertain.^[18] Total hip arthroplasty should be considered as a last resort for runners with significant radiographic joint degeneration associated with unacceptable pain or disability.

4.6 Stress Fractures

4.6.1 Aetiology

Stress fractures constitute 10–20% of all injuries seen in sports medicine clinics, and 7–10% of these affect the femurs, pubic rami, iliac crests and sacroiliac joints.^[22,33,43,106-111] Women are 3–10 times more likely, in general, to sustain a stress fracture than men.^[33,107,111] The most common locations for stress fractures that cause hip and groin pain are the femoral neck and pubic rami.^[23] Femoral stress fractures may occur on the tension (superior) or compression (inferior) surface with dramatically different implications.^[57] Tension surface femoral neck stress fractures often affect older runners and are at significant risk of nonunion, deformity, malunion or avascular necrosis. In contrast, compression surface femoral neck fractures occur in younger runners and generally do well with protected activity followed by a gradual return to running.^[33]

Stress fractures do not typically result from sudden, traumatic impacts.^[112] Instead, they originate either from abnormal forces on normal bones (fatigue fractures) or normal forces on abnormal bones (insufficiency fractures). Most affected runners develop fatigue fractures, of which two-thirds are due to training errors, competitive racing and excessive mileage.^[43,108,113] Female endurance runners with amenorrhoea, disordered eating or osteoporosis may be at particular risk for stress fractures. However, some feel that there is no clear association between osteoporosis and stress fracture incidence.^[27] Narrow tibial bone widths (measured on AP and lateral radiographs) also appear to be significant risk factors for femoral stress fractures, since narrow bones are biomechanically weaker than wide bones.^[27] Additional risk factors include running shoes with excessive mileage, coxa vera (approximation of the femoral head to the femoral shaft due to shaft curvature) and rapid increases in training.^[32,48] Chronic glucocorticoid use, smoking, hyperparathyroidism, hyperthyroidism, malabsorption syndromes and calcium deficiencies also predispose runners to stress fractures.

4.6.2 History, Physical Examination and Diagnostic Imaging

A delay of at least 6 weeks between symptom onset and clinical diagnosis is not uncommon for stress fractures, as symptoms and signs may be subtle.^[106,114,115] It is important to obtain a thorough training history including weekly mileage, intensity, running surfaces, shoe wear, prior stress fractures and technique modifications. A history of menstrual or eating disorders should be pursued for female runners. Affected runners may describe vague, insidious, persistent pain that is exacerbated by activity and relieved by rest.^[32,65] Deep-seated hip pain following an increased training load merits particular attention. As a stress fracture progresses, pain often occurs earlier or at rest.

The physical examination may occasionally reveal localised tenderness in palpable bones. Since the hip joint itself is very deep, it is often difficult or impossible to palpate it directly. Hip ROM is typically abnormal and painful at the extremes, particularly with internal rotation, adduction and flexion.^[14] Pain may also be exacerbated by weight bearing (standing sign) or hopping (hop test) on the affected leg.^[108,111] An antalgic gait is common, and some affected runners may be unable to walk without the help of crutches.^[14,108,109] A fulcrum test (putting one arm under the affected leg and pushing downward on the distal thigh) may be positive with a femoral stress fracture.^[115]

Although plain radiographs are often the initial imaging study, they have a low sensitivity, and visible changes may take several weeks to occur.^[32,109,111,116] The classic radiographic findings consist of focal periosteal reaction, cortical disruption and trabecular sclerosis.^[41] If plain radiographs are non-diagnostic, then additional testing with scintigraphy, CT or MRI should be considered.

Compared with plain radiographs, bone scans may be positive within hours of a stress fracture. Triple phase bone scans consist of a flow phase (immediately following injection), a pool phase (5–15 minutes after injection) and a delayed phase (2–3 hours after injection). Tec-99m-MDP binds to areas of increased blood flow and reactive bone formation. Stress fractures classically manifest a focally increased uptake on the delayed phase.^[32] Bone scans generally have high sensitivities, but false negative results have been reported in runners.^[107,109,110] Also, bone scans have relatively lower specificities and positive predictive values. False positive results are common due to other regional abnormalities, such as infections, neoplasia, synovitis, stress reactions or soft tissue inflammation.^[21,32,116-118] Moreover, the clinical significance of mildly increased scintigraphic activity in diagnosing stress fractures has been questioned.^[118]

CT may be helpful to detect fracture lines that are not apparent on plain radiographs and to distinguish stress fractures from other conditions such as osteomyelitis or neoplasia that may produce false positive bone scans. Disadvantages of CT scanning include cost, availability and radiation exposure.

In many centres, MRI is considered the most useful study to evaluate suspected stress fractures. Magnetic imaging can define the extent and location of stress fractures with better specificity, structural visualisation and spatial resolution than other diagnostic imaging studies.^[33,110,116,119] An MRI can also suggest the fracture's chronicity. A stress fracture usually produces a decreased marrow signal intensity on T₁-weighted images (fluid is dark, fat is bright) and increased marrow signal intensity on T₂-weighted images (fluid is bright, fat is dark).^[32] Disadvantages of MRI include its cost, long study duration and availability. The presence of regional ferromagnetic material is a contraindication to MRI, but many modern implanted medical and surgical devices are made from non-ferrous materials. One notable exception is the presence of a pacemaker, which is currently incompatible with MRI.

4.6.3 Prognosis and Treatment

The prognosis for hip stress fractures is variable depending on the fracture's location, chronicity and

causative factors. Most pubic rami and compression surface femoral neck stress fractures heal well if recognised early and treated appropriately.^[23,32] The same is not true, however, for tension surface or displaced femoral neck stress fractures that are associated with a high risk of avascular necrosis, nonunion, malunion or progressive varus deformity.^[46,50] These fractures typically require prompt open reduction and internal fixation.^[22,110]

If a trial of conservative therapy is appropriate, the runner should discontinue activity and remain non-weight bearing on the affected leg until asymptomatic.^[113] A brief course of NSAIDs and cryotherapy may be helpful, although the reduced inflammatory response caused by NSAIDs may potentially lengthen the healing time.^[53] Once symptoms at rest have abated, the runner can begin protected weight bearing, regional muscular strengthening and flexibility enhancement. Non-impact exercises such as swimming, water jogging and cycling may be initiated to enhance conditioning.^[111,113] After follow-up diagnostic imaging studies have demonstrated good callus formation and bony alignment, running may slowly be resumed.^[32,35,113] Table IV outlines a typical regimen for resuming running after symptoms have completely abated for an uncomplicated lower extremity stress fracture. The treatment duration of

Table IV. A typical regimen for resuming running after a period of protected weight bearing and complete cessation of symptoms following an uncomplicated lower extremity stress fracture (reproduced from Brukner,^[32] with permission)

Week no.	Day no. (min)						
	1	2	3	4	5	6	7
1	Walk 5	Walk 10	Walk 15	Walk 20	Walk 25	Walk 30	Walk 35
2	Walk 20	Walk 15	Walk 15	Walk 10	Walk 10	Walk 5	Jog 45
	Jog 10	Jog 15	Jog 20	Jog 25	Jog 30	Jog 35	
	Walk 15	Walk 15	Walk 10	Walk 10	Walk 10	Walk 5	
3	Jog 40	Jog 35	Jog 30	Jog 25	Jog 40	Jog 35	Jog 30
	Stride 5	Stride 10	Stride 15	Stride 20	Sprint 5	Sprint 10	Sprint 15
4	Add jumping, hopping, skipping, twisting, and turning		Gradually increase all week				
5	Resume full training						

most uncomplicated stress fractures usually lasts 4–8 weeks. In cases of delayed union, electrical bone growth stimulation may be tried prior to surgery.^[107]

Modifiable risk factors and training errors should be corrected if possible. Orthoses and new shoes may minimise hyperpronation, excessive calcaneal eversion, pes cavus and pes planus that predispose an athlete to recurrent injury.^[16] Nutritional, hormonal and psychiatric needs of amenorrhoeic female runners should be addressed.^[48] Notably, runners with hip stress fractures are at increased risk for recurrence, and close follow-up is essential.

4.7 Snapping Hip Syndrome

4.7.1 Aetiology

Snapping hip syndrome is a benign condition in which a painful and/or audible snap occurs when a flexed, abducted and externally rotated hip is extended during running. Snapping hip syndrome is usually divided into internal and external types. The movement of a thickened iliotibial band, tensor fasciae latae or gluteus maximus tendon over the greater trochanter generates the more prevalent external type.^[69] The less common but more pronounced internal type is usually caused by the iliopsoas tendon's passing over the anterior hip capsule, lesser trochanter, femoral head or iliopectineal eminence.^[25,68] Internal snapping hip may also be caused by the biceps femoris' passing over the ischial tuberosity, the iliofemoral ligament's moving over the femoral head, iliopsoas bursitis, acetabular labral tears, recurrent hip subluxation, osteochondral fractures or intra-articular loose bodies.^[22,25,57,69]

4.7.2 History, Physical Examination and Diagnostic Imaging

The diagnosis of snapping hip syndrome is usually clinical. Runners report symptoms lateral to the greater trochanter with external snapping hip and

anterior to the hip with internal snapping hip.^[120] Moving the affected hip from flexion to extension may replicate external snapping. Internal snapping may be reproduced during the snapping hip manoeuvre in which a flexed, abducted and externally rotated hip is extended and internally rotated. Performance is rarely impaired in most affected runners with snapping hip syndrome.^[48]

Radiographs, MRI and CT are often normal but may help exclude intra-articular abnormalities.^[69,120] Dynamic ultrasonography or bursography may reveal abnormal lateral to medial movement of the iliopsoas tendon during internal snapping hip syndrome.^[25,57,69,121] In unclear cases of internal snapping hip syndrome, arthroscopy may be both diagnostic and therapeutic.

4.7.3 Prognosis and Treatment

The prognosis for snapping hip syndrome is generally excellent with appropriate treatment and rehabilitation. Treatment of snapping hip syndrome consists of relative rest, analgesia, iliotibial band stretching (figure 3), possibly NSAIDs and regional muscle strengthening. Stretching should focus on hip abduction and external rotation. Addressing biomechanical abnormalities or injecting corticosteroids and anaesthetics may be helpful.^[25] Uncommonly, persistent snapping hip syndrome may necessitate excision or transposition of the ITB for external causes or judicious lengthening of the posteromedial iliopsoas tendon for internal ones.^[18,121]

4.8 Acetabular Labral Tears

4.8.1 Aetiology

The acetabular labrum is a fibrocartilaginous rim that deepens the acetabulum and stabilises the femoral head. Injuries to the acetabular labrum have been increasingly recognised as a cause of persistent hip pain in runners.^[122] The posteromedial and anterosuperior aspects of the acetabular labrum are particularly vulnerable to injury due to mechanical

stresses or excessive twisting in sport.^[123,124] Affected runners may note a traumatic twisting or falling injury that was followed by worsening hip pain, but some athletes can not recall a specific inciting episode.^[125] Acetabular dysplasia is associated with a labral tear up to 30% of the time, and labral tears may also be related to recurrent hip subluxations.^[18,122] Anatomical femoral variations in which the proximal femur abuts the labrum lining the acetabular rim can produce a cam effect that leads to a labral tear.^[126] A shallow taper between the femoral head and neck and a significant reduction in femoral anteversion are two factors that contribute to the cam effect.

4.8.2 History, Physical Examination and Diagnostic Imaging

Runners with acetabular labral tears may note painful episodes of anteromedial snapping or clicking, intermittent hip instability and locking or decreased hip internal rotation that must be distinguished from OA, snapping hip syndrome and ITBS.^[122,124,127-129] In many cases, some specific clinical examination tests may be helpful to diagnose a labral tear. Bringing the affected hip from a flexed, abducted and externally rotated position to an extended, adducted and internally rotated one may reproduce the pain or clicking from an anterior labral tear.^[22,126] Moving an extended, abducted and externally rotated hip into a flexed, adducted and internally rotated position while applying a posterior load may produce pain in runners with a posterior labral tear.^[18] An injection of anaesthetics and corticosteroids under fluoroscopic guidance into the hip joint that temporarily alleviates painful symptoms can also confirm the location of the pain's origin.^[124,125]

Plain radiographs have a low sensitivity for labral tears but can help differentiate hip dysplasia from other conditions.^[122] As a result, runners with normal radiographs and mechanical symptoms or concerning signs should be evaluated with further diag-

nostic imaging. Bone scans may help to rule out or confirm other diagnoses such as infections, stress fractures or avascular necrosis.^[125] USN has a low sensitivity for labral tears.^[129] Conventional MRI, CT and arthrography have been used to evaluate suspected labral tears but poorly identify most labral tears, particularly posterior ones.^[125,130,131] However, the addition of gadolinium enhancement to MRI has significantly improved the test's accuracy with a reported sensitivity of 90%.^[18,41,125,129,131] Positive studies should be followed up with arthroscopy, currently the most effective way to diagnose and treat labral injuries.^[123,125,127,129,130]

4.8.3 Prognosis and Treatment

The prognosis is good for acetabular labral tears when an early diagnosis has been made and the femoral head and hip joint articular cartilage have not been damaged.^[124] However, most labral tears do not heal conservatively, and incomplete healing increases the risk of chondral defects and secondary OA.^[41,123,124] Some affected runners may consider a brief trial of limited weight bearing with crutches, analgesia and activity modification for 4–6 weeks.^[124] Physical therapy has no proven role in the treatment of labral injuries.^[122] If conservative therapy fails, open or arthroscopic surgery may be performed to repair or debride the torn labral fragment.^[122,124,127,132] Surgical repairs have excellent outcomes unless degenerative changes have already occurred.^[122,125,132]

4.9 Sports Hernia

4.9.1 Aetiology

A 'sports hernia' refers to groin pain in athletes originating from abnormalities of the conjoined tendon (falx inguinalis), internal abdominal oblique muscle, external abdominal oblique aponeurosis, inguinal ligament and/or transversalis fascia.^[23,133] Imbalances between the adductor longus, gracilis and lower abdominal muscles may also predispose

runners to sports hernias.^[23,42,44,134] The onset of transversus abdominus contraction appears to be delayed in some athletes with long-standing groin pain.^[135] Sports hernias are infrequently seen in straight-ahead activities such as running. Instead they most commonly occur in male athletes who are involved in activities such as hockey or soccer that require repetitive twisting and turning at speed.^[118,133,135]

4.9.2 History, Physical Examination and Diagnostic Imaging

Runners with sports hernias typically complain of localised, insidious inguinal pain that worsens during strenuous exercise.^[44] The pain becomes more intense as the condition progresses and may radiate into the scrotum or testicles.^[23] Sit-ups, Valsalva's manoeuvre, coughing, sneezing, rapid change of direction or kicking may exacerbate the pain.^[44,136] Symptoms improve with prolonged rest but typically recur with resumed training.^[136] Physical examination reveals tenderness over the pubic tubercle, inguinal ring and/or conjoined tendon.^[18] Regional numbness may also be present.^[28] In most cases a true hernia is not present, although the superficial inguinal ring may be dilated.^[23,133] The diagnosis of a sports hernia is usually clinical. Diagnostic imaging is frequently normal but can rule out other conditions.^[23,44] Herniography has a high false positive rate but may confirm the diagnosis or identify other abnormalities.^[133,136,137]

4.9.3 Prognosis and Treatment

The prognosis for sports hernias is generally poor without surgical therapy.^[42,133] Runners with sports hernias may initially be given a trial of conservative therapy aimed at improving the strength and coordination of the lower abdominal, pelvic and adductor muscles. This muscular training may stabilise the pelvic ring and alleviate some types of muscle-related groin pain.^[134,135] Conservative treatment is frequently disappointing, however, and enables only 20% of affected athletes to return to pre-injury activ-

ity levels.^[23,42,136] In contrast, open or laparoscopic herniorrhaphy with mesh reinforcement offers excellent success rates ranging from 63% to 93%.^[118,133,136] Sudden, sharp lower leg movements should be avoided during the recovery period, but sprinting without cutting may be started 3 weeks after surgery.^[23] With appropriate rehabilitation after surgery many runners subsequently return to full activity within 2–4 months.^[42,44,133]

4.10 Additional Conditions

Clinicians taking care of runners with hip pain should be mindful of several additional aetiologies. Although they are beyond of the scope of this discussion, nerve entrapment syndromes of peripheral nerves or innervated spinal structures may cause pain, numbness or burning dysesthesias in the hip and groin region.^[20,138] Regional nerves may become entrapped secondary to trauma, inflammation or external causes (e.g. tight pants, blunt trauma or prolonged hip flexion). Figures 4–6 depict the cutaneous sensory innervation of the lateral (figure 4), anterior (figure 5) and posterior (figure 6) hip and groin. Entrapment of the ilioinguinal nerve, which provides sensation along the medial thigh and scrotum, is common following lower abdominal surgery or herniorrhaphy.^[23] Compression of the lateral femoral cutaneous nerve as it crosses under the inguinal ligament (meralgia paresthetica) may produce pain or numbness along the anterolateral thigh.^[138] Piriformis syndrome may produce groin or thigh pain when a spastic or injured piriformis muscle compresses the sciatic nerve.^[92] Degenerative disc disease or a herniated lumbar disc may produce radicular thigh or groin pain.^[18,52] The diagnosis of nerve entrapments may be confirmed with nerve conduction studies and needle electromyography.^[20] Many athletes with nerve entrapment syndromes will improve with conservative treatment by addressing the causative disorders, but some ultimately require surgical decompression.^[18,20,23,138,139]

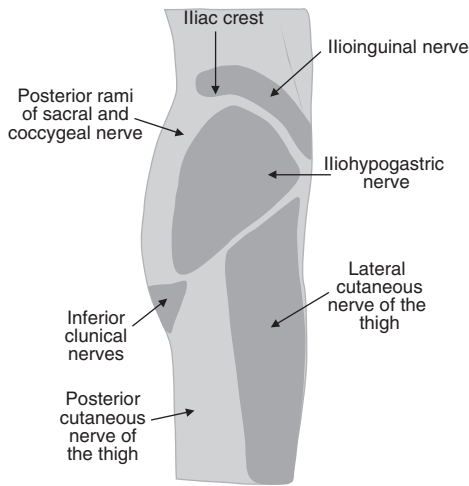


Fig. 4. Cutaneous sensory innervation of the lateral hip and groin (reproduced from McCrory and Bell,^[20] with permission).

Inguinal and femoral hernias may also generate pain that radiates throughout the hip region.^[24] Dysfunction of the sacroiliac (SI) joint has been implicated in hip pain due to pelvic obliquity and unequal tilting of the innominate bones.^[128] As a result, manipulating the SI joint may decrease the intensity and duration of hip pain in runners. Haemochromatosis, the most common inherited metabolic disorder in the Western world, is an autosomal recessive disorder of iron metabolism that may produce hip arthropathy and pain due to excess iron absorption and storage.^[140]

5. Injury Prevention

An essential component of evaluating and treating hip pain in runners relates to injury avoidance, since many injuries are potentially preventable.^[16,24] Most hip injuries in running are due to poor running technique, little prior running experience, inadequate nutrition or hydration, excessive mileage (>64 km/week), regional muscle dysfunction or rapid intensity advancement.^[15,16,33-35,59,60] Running on banked roads is also associated with some hip injuries in running.^[59] In general, runners should avoid

increasing the intensity, duration or pace of their training regimens too quickly. Moreover, runners targeting faster paces will require more focus on hip and knee flexibility and muscular coordination.^[141] Additionally, runners who utilise strides that incorporate lower impact forces and quicker pronation may reduce their risk of some overuse running injuries.^[16] Since running shoes can quickly lose their cushioning and stability, runners should consider regularly changing their shoes.

In some athletes, a therapeutic programme directed at strengthening the adductor muscles may effectively prevent adductor-related groin pain.^[49,134] Moreover, a programme targeting the strength and flexibility of muscles around the pubic rami may prevent some sports hernias.^[133] Training programmes may need to be different for male and female runners to account for the significantly different hip kinetic gait patterns.^[29] Compensating for a leg-length discrepancy of >10–15mm or minimising hyperpronation with shoe modifications or inserts

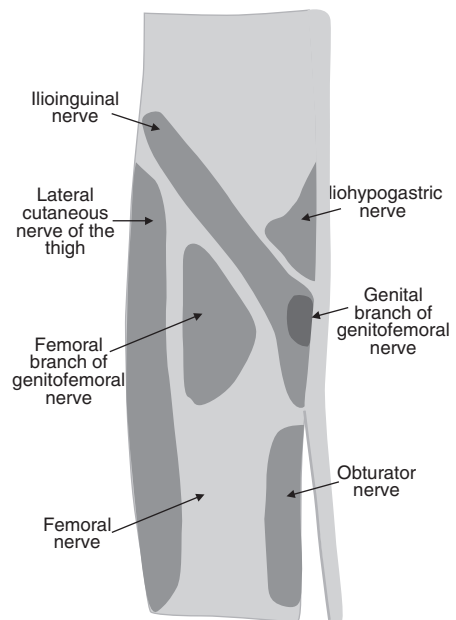


Fig. 5. Cutaneous sensory innervation of the anterior hip and groin (reproduced from McCrory and Bell,^[20] with permission).

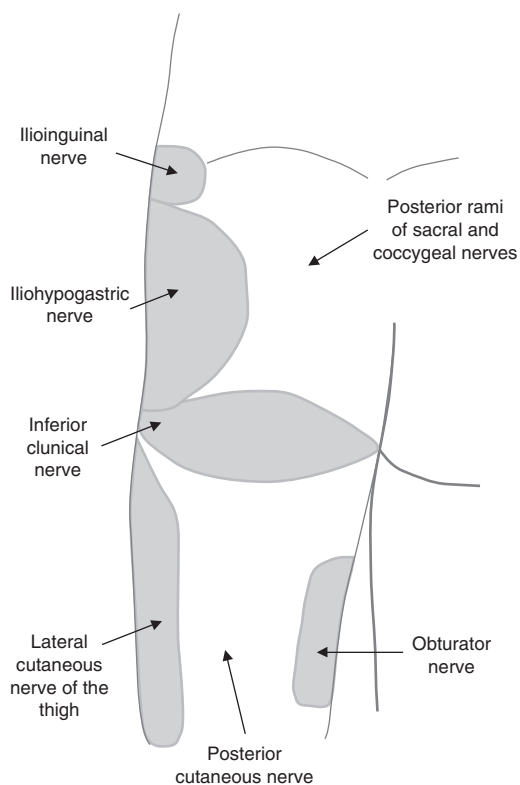


Fig. 6. Cutaneous sensory innervation of the posterior hip and groin (reproduced from McCrory and Bell,^[20] with permission).

may also decrease the number of overuse running-related injuries.^[16,26] Since running can increase peak forces at the hip by at least 5 times one's bodyweight, targeted weight loss might decrease the risk of hip injuries.^[31]

Disagreement exists in the literature concerning the benefits of routine stretching before and/or after running. Pre-exercise stretching increases flexibility and may be an important factor in preventing muscle strain injuries, the most common aetiology of hip pain in runners.^[45,142] However, some have argued that a muscle stretching programme before exercise does not produce clinically significant reductions in the risk of lower-limb injuries and can predispose athletes to injuries.^[143,144] The data regarding injury prevention and stretching in running-related hip in-

juries are limited, and additional large, well controlled studies are definitely needed.

6. Conclusions

An increasing number of people are participating in recreational and competitive running worldwide. Running is frequently recommended by clinicians for preventing or treating many conditions including diabetes, heart disease, obesity, hypertension, hyperlipidaemia and osteoporosis. Its low cost, versatility, convenience and minimal required equipment appeal to men and women of broad cultural, ethnic and economic backgrounds. Nonetheless, running may increase the risk of some musculoskeletal injuries. Most running-related injuries affect the lower extremities and are due to training errors. Hip injuries in running constitute an important minority of these lower extremity complaints and range from minor to serious in nature. A thorough history with detailed information about technique, shoe and surface conditions, mileage, competitions and running intensity combined with a comprehensive regional physical examination will often suggest the underlying disorder. In some cases, diagnostic imaging or arthroscopic evaluation may be necessary. Most causes of hip pain in runners are benign and can successfully be managed conservatively with rehabilitation. However, clinicians need to be aware of certain injuries, such as tension surface femoral neck stress fractures, that require prompt recognition and surgical stabilisation. Since many running injuries are potentially preventable, coaches, trainers and medical personnel who care for runners should advocate training programmes that minimise the risk of injury.

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