Rehabilitation of the Hip Following Sports Injury

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KEYWORDS

• Hip • Linkage • Pelvic stability • Eccentrics
• Gluteus medius • Muscular slings

An athlete often presents to the rehabilitation specialist with either a nonspecific referral, such as "hip pain," or with a diagnosis of a more specific hip condition. It is the role of the rehabilitation specialist to look at movement above and below the injured site, to observe and evaluate global movement, such as sit to stand, and fine tuning and neuromuscular control of smaller, more specific supportive muscles. It is the rehabilitation specialist's job to take the athlete from a basic level of function to the highest level of sport activity. The rehabilitation specialist considers several key elements: boney structure, forces produced by myofascial properties, and neuromuscular control. The highly skilled clinician is trained to look at the "linkage" between the trunk and all parts of the lower extremity. Why is the hip not transferring the load well? Where is the breakdown? The gluteus medius (GM), pelvic stability, and supportive muscular slings are of great importance when optimizing the function of the hip. The hip is subjected to forces equal to multiples of the body weight and requires osseous, articular, and myofascial integrity for stability. This is the mind set when devising an athlete's rehabilitative program, looking at all influential factors that affect joint movement and integrity. Injuries to the hip can vary significantly depending on the specific sporting activity involved. Contact sports will have a higher incident of traumatic injuries such as fractures, contusions, and dislocations, whereas endurance sports like running, swimming, and biking can lead to abnormal stress patterns and overuse injuries. Regardless of the injury, proper diagnosis and intervention is the key to the athlete returning to their sport. The importance of maintaining open communication with the referring physician is of great value to the rehabilitation specialist. A referral of all pertinent diagnoses can help guide effective treatment. With greater specificity, the athlete's impairments can be addressed in a more timely and specific manner.

The occurrence of injuries to the hip, pelvis, and thigh is low compared with the other lower extremity regions.[1–5] Although statistically less prevalent, a pathologic

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condition of the hip can cause immediate gait abnormalities, lead to chronic pain and premature degeneration in the hip joint itself. These injuries can vary significantly depending on the specific sporting activity involved.[6] Contact sports have a higher incident of traumatic injuries such as fractures, contusions, and dislocations, whereas endurance sports such as running, swimming, and biking can lead to abnormal stress patterns and overuse injuries. Regardless of the injury, proper diagnosis and intervention is the key to the athlete returning to their sport.

THE REFERRAL

The cause of hip pain in the absence of trauma may be more difficult to determine.[7] Often a new patient presents to the clinic for an evaluation with a nonspecific referral titled "hip pain." With an abundant list of differential diagnosis, it is important to rule out nonmusculoskeletal causes of hip pain. Some of these causes include but are not limited to genitourinary problems, endometriosis, ovarian cyst, peripheral vascular disease, infectious disease, metabolic disease, and tumor.[7] It is beyond the scope of this article to discuss the path to differential diagnosis, but it is important for the physician to know that the rehabilitation specialist has broad medical knowledge and is trained to recognize "red flags." These red flags are signs and symptoms that are outside the scope of "normal" musculoskeletal pain or dysfunction related to the diagnosis given. The rehabilitation specialist's ability to adequately screen for conditions requiring further examination by a physician can lead to more timely treatment of serious medical conditions.[8] A recent example follows: a patient was referred for rehabilitation with a diagnosis of lumbar spine and left hip osteoarthritis with possible trochanteric bursitis. After the specialist's examination, significant findings were: pain severity out of proportion to the reported injury, the presence of night pain, a positive "sign of the buttock," and empty end feels of all hip joint motions, which represented a noncapsular pattern of joint restriction. The specialist determined the patient should return to his referring physician. A computerized tomography scan of the left hip revealed a metastatic lesion at the left proximal femur.[8] Some of the modalities used to treat pain, spasm, and inflammation, such as therapeutic ultrasound, are contraindicated in cases such as metabolic disease and cancer. The importance of maintaining open communication with the referring physician is of great value to the rehabilitation specialist.

The specific referral can be paramount when the patient has overlapping conditions. Often the athlete with an adductor strain can have trochanteric bursitis and possible athletic pubalgia. In these cases, a specific referral of all pertinent diagnoses can help guide effective treatment; rather than a referral of "hip pain;" with greater specificity, the athlete's impairments can be addressed in a more timely and specific manner.

THE ROLE OF PELVIC STABILITY

The primary function at the hip joint is to support the weight of the head, arm, and trunk, while also serving as the connection between the lower extremities and pelvic girdle. The hip is subjected to forces equal to multiples of the body weight and requires osseous, articular, and myofascial integrity for stability. The anatomic design of the hip is well suited to handle this task and the increased loads that can be transmitted during athletic competition.[9]

Muscle forces are required to press the sacrum between the hip bones, also called self-bracing. Without this, shear loading is not tolerated and there is disruption of load transfer to the hip joint creating a canvas of potential injury and dysfunction. This is especially true for the athlete, undergoing intense levels of shear and tensile force at a microscopic level. The role of pelvic stability and recruitment of supportive musculature is of vital importance to the hip.

How well load transfers to the lumbopelvic-hip region dictates how efficient function will be. This is the mind set when devising an athlete's rehabilitative program, looking at all influential factors that affect joint movement and integrity. The rehabilitation specialist considers several key elements: boney structure, forces produced by myofascial properties, and neuromuscular control. It is the rehabilitation specialist's job to take the athlete from a basic level of function to the highest level of sport activity.

It is the role of the rehabilitation specialist to look at movement above and below the injured site, to observe and evaluate global movement, such as sit to stand, and fine tuning and neuromuscular control of small specific supportive muscles, such as multifidus and transverse abdominus. There is evidence that activation of trunk and gluteal muscles is different in those with pain than those without pain. In 1 study, surface electromyographic activity was recorded from 7 trunk and hip muscles for the supporting leg during hip flexion in standing. Onset of muscle activity relative to initiation of the task was compared between groups and between limbs. The results showed onset of obliquus internus abdominus and multifidi occurred before initiation of weight transfer in the control subjects. Yet, the onset of these muscles and gluteus maximus was delayed on the symptomatic side and onset of biceps femoris was earlier in subjects with joint pain.[10] This suggests alteration in strategy for lumbopelvic stabilization that may disrupt load transference through the pelvis.

This concept is often seen in postoperative spine patients. Postoperative rehabilitation goes well until a return to a more progressive strength training program results in onset of new symptoms, such as trochanteric hip pain. The underlying cause is the inability to recruit deep multifidi, therefore proximal stability is compromised and distal mobility is impaired. The inability to stabilize the pelvis while performing dynamic lower extremity movement, such as a lunge, produces shear force to the spine, creating a compensatory strategy of gluteal activation, piriformis spasm, and undue stress on the hip joints. The acute and painful bursae can be treated with modalities, myofascial release to the involved soft-tissue structures, and ice to calm the area. In addition, the patients are given a series of progressive exercises to recruit deep sacral multifidi, transverse abdominus, and pelvic floor muscles. Together, multifidi and transverse abdominus (along with their fascia) form a corset of support for the lumbopelvic region. Without addressing the need for pelvic stability, proper load transference to the hips does not occur and hip discomfort persists.

Another nonspecific referral often seen in the clinic is "bilateral trochanteric bursitis." This is a hallmark sign for the rehabilitation specialist to evaluate what is going on above the hips. The spine, whether an inert structure or neuromuscular in nature, is almost always involved.

The concept of linkage is the premise that a muscle contraction produces a force that spreads beyond the origin and insertion of the active muscle. This force is transmitted to other muscles, tendons, fascia, ligaments, capsules, and bones that lie in series and in parallel to the active muscle. In this manner forces are produced quite distant from the origin of the initial muscle contraction. These integrated muscle systems produce slings of forces that assist in the transfer of load. There are 4 slings of muscle systems that stabilize the pelvis regionally, between the thorax and legs. The posterior oblique sling contains connections between the latissimus dorsi and the gluteus maximus through the thoracodorsal fascia (**Fig. 1**). The anterior oblique sling contains connections between the external oblique, the anterior abdominal fascia and the contralateral internal oblique abdominal muscle and the adductor of

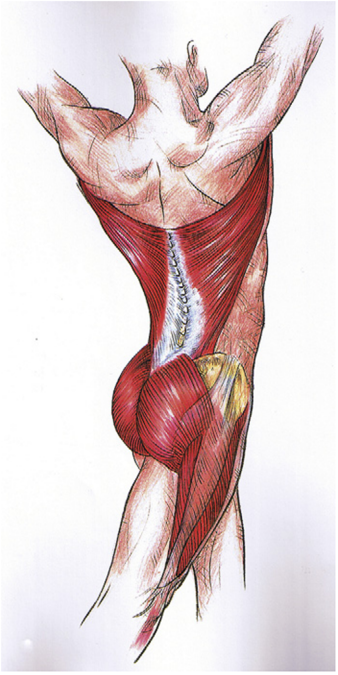

Fig. 1. The posterior sling provides pelvic stability through its connections with latissimus dorsi and gluteus maximus through the thoracolumbar fascia. (*From* Myers TW. Anatomy trains. Edinburgh: Churchill Livingstone; 2001; with permission.)

the thigh. The longitudinal sling connects the peroneii, the biceps femoris, the sacrotuberous ligament, the deep lamina of the thoracodorsal fascia and the erector spinae. The lateral sling contains the primary stabilizers for the hip joint, namely the GM or gluteus minimus and tensor fascia latae, and the lateral stabilizers of the thoracopelvic region.

The movement specialist is responsible for returning the athlete to the highest level of performance. When addressing the hip, the clinician is responsible for making sure these slings are engaged and pelvic stability is solid (**Fig. 2**).

All too often the rehabilitation specialist examine the patient in the frontal and sagittal planes but fails to look at movement pattern in the transverse plane. More importance has been given to the patient's ability to control hip rotation during functional movements. In patients with patellofemoral pain syndrome, it has been suggested that a theoretic mechanism for pathology may be weak femoral external rotators that allow the femur to be in relative internal rotation and influence patellar alignment and kinematics. The role of the hip rotator muscles is frequently overlooked when addressing prevention and rehabilitation of knee and lumbar spine injuries. Weak and/or shortened hip rotators may contribute to abnormal lumbopelvic posture and cause compensatory motion in the lumbar spine during daily activities. The detrimental effects of inadequately conditioned and prepared hip rotators may predispose the athlete to lumbar spine injuries. The small external rotators of the hip (piriformis, obturator internus, obturator externus, gemellus superior, gemellus inferior, and quadratus femoris) sometimes get fatigued or overpowered by the large internal rotators of the hip (gluteus maximus, GM, and gluteus minimus) creating muscle imbalance.

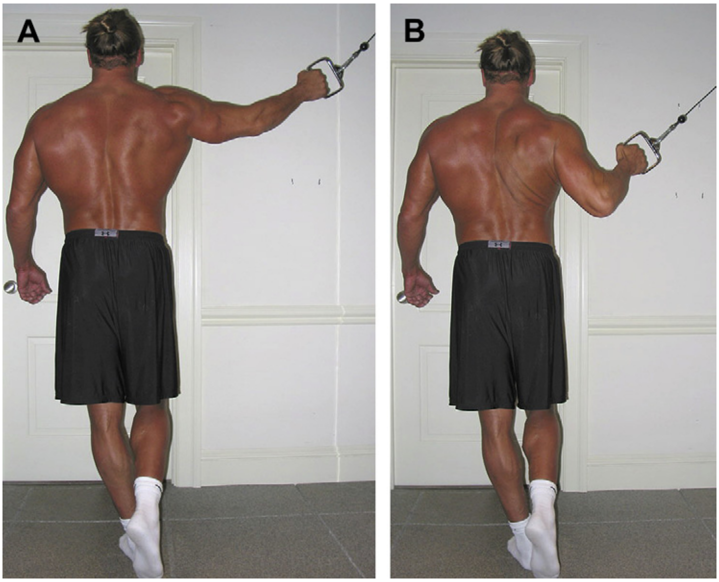

Fig. 2. (*A*) One-arm cable lateral pull with contralateral single limb stance: starting position. (1) Adjust the cable to slightly higher than the head. (2). The patient stands sideways with exercise arm closest to the pulley. (3) The patient grabs the pulley with 1 arm standing parallel to the cable column; upper extremity is in relative abduction. The patient is instructed to recruit and maintain engaged core muscles. (4) The patient then stands in single limb stance on the contralateral side. (*B*) Ending position. (1) The patient is asked to draw the scapula inward toward the spine first, then continue to perform a lateral pull. (2) The elbow should be drawn in as close to the trunk as possible, while keeping the upper arm within the frontal plane. (3) Good balance and posture should be maintained. (4) Note the posterior sling working together to create optimum pelvic stability.

A weak or dysfunctional GM has been linked to numerous injuries of the lower extremity and abnormalities in the gait cycle. The GM is responsible for preventing the opposite side of the pelvis from dropping during the stance phase of gait, commonly referred to as Trendelenburg gait, and plays a major role in providing frontal stability for the entire pelvis during walking and functional activities. The Trendelenburg gait has reduced gait efficiency and running speed; the athlete is at greater risk of developing lower back pain as a result of the pelvis not being stabilized during gait, jumping, and landing or when performing unilateral weight-training exercises.

A clinical pearl with regard to the GM is to manual muscle test each group of fibers to identify a more specific weakness. The anterior fibers, with connections to the tensor fasciae latae, are tested with the leg in abduction with femoral internal rotation (**Fig. 3**). The posterior fibers, with connections to the superior portion of the gluteus maximus, are tested with the leg in abduction with femoral external rotation. The posterior GM fibers, along with the gluteus maximus, contribute significantly to the vertical ground reaction force throughout the midstance phase of the gait cycle. The anterior fibers contribute little in the early stance phase of the gait cycle to support the hip, but then contribute greatly at the end of midstance. With assistance from joints and bones to gravity, the anterior and posterior medius/minimus generate nearly all the support evident in the midstance phase of the gait cycle.[11] One contributing factor to weak posterior fibers is the association with poor lumbopelvic posture.

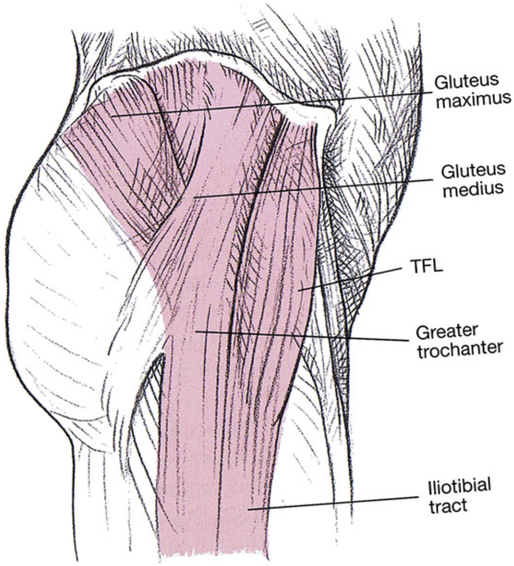

Fig. 3. Anterior and posterior fibers of the GM. (*From* Myers TW. Anatomy trains. Churchill Livingstone; 2001; with permission).

A patient in either an anterior pelvic tilt or posterior pelvic tilt has more difficulty recruiting the supportive musculature needed to maintain pelvic stability in the different phases of the gait cycle. In the running athlete, when the foot makes contact with the ground, the femur is in an abducted position in relation to the pelvis. Thus, the GM and tensor fascia latae are eccentrically loaded. As the running support phase progresses, these muscles must then contract as abduction at the hip occurs.[11] It is the role of the sports rehabilitation specialist to understand the biomechanical needs of the athlete, the timing, force, and recruitment patterns required of their task to achieve optimal performance from the musculoskeletal system.

An elementary exercise used to facilitate the posterior fibers of the GM is to have the patient prone with the knee flexed at 90°, isolate the GM with an isometric contraction (a manual cue is helpful), and then have the patient perform hip extension by lifting the thigh off the table. This position also inhibits the often contractured hip flexor muscle through reciprocal inhibition and aids in lengthening this muscle group; this facilitates better pelvic positioning and therefore improves the recruitment of the transversus abdominus and other core muscles. As timing and strength of the GM builds, progression of the exercise would move into more dynamic multiplanar functional training. As discussed with the runner, an eccentrically loaded GM may be targeted with a lateral step up exercise. A lateral rotational step up, as shown in **Fig. 4**, is a great functional exercise to isolate the posterior fibers of the GM and emphasize the transverse plane. Training the athlete to use the musculature as it would be used in sport-specific performance is the final goal.

GROIN PAIN

The evaluation and treatment of groin pain in athletes is challenging. The anatomy is complex, multiple pathologies often coexist, different pathologies may cause similar

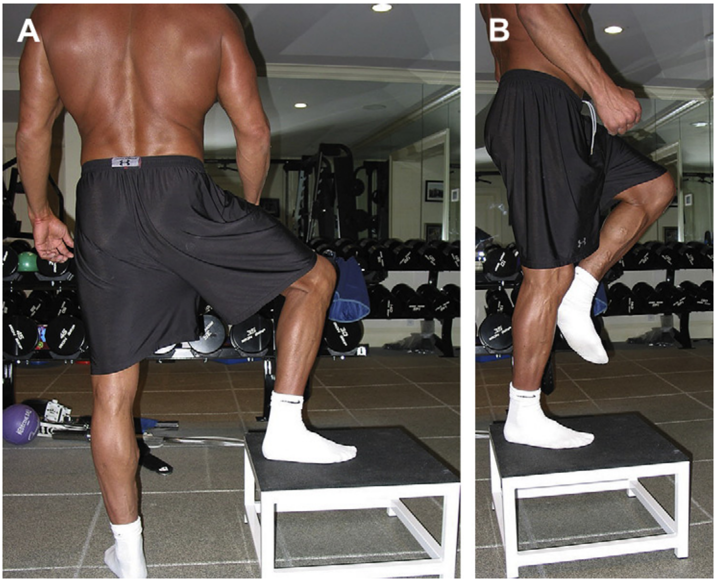

Fig. 4. (*A*) Facilitation exercise for GM posterior fibers: starting position: (1) The patient stands sideways parallel to the step. (2) The patient, without moving the position of the trunk, places the foot on the step in full hip external rotation. The foot will be at a 90° angle to the standing limb. (*B*) Ending position. (1) The patient is then asked to perform a step up. (2) The contralateral limb performs hip flexion to 90° to promote increased proprioception and dynamic balance. This limb is then placed back into the starting position on the floor. (3) The involved side with the foot in contact with the step is then placed back into starting position.

symptoms, and many systems can refer pain to the groin. Many athletes with groin pain have tried prolonged rest and various treatment regimens, and received differing opinions as to the cause of their pain.[12] The rehabilitation specialist is often given a nonspecific referral of "groin pain" or "anterior hip pain." The cause of pain could be as simple as the effects of a tight iliopsoas that requires stretching, or as complex as a sports hernia (SH).

An SH occurs when weakening of the muscles or tendons of the lower abdominal wall occur. This part of the abdomen is the same region where an inguinal hernia occurs, called the inguinal canal. When an inguinal hernia occurs, sufficient weakening of the abdominal wall exists to allow a pouch, the hernia, to be felt. In the case of an SH, the problem is caused by a weakening or tear in the abdominal wall muscles, but no palpable hernia exists.[13]

SH is a controversial cause of chronic groin pain in athletes. Most commonly seen in soccer and ice hockey players, SH can be encountered in various sports and in various age groups. Although there are several reports of SH in women, it is almost exclusively found in men. SH is largely a clinical diagnosis of exclusion. History of chronic groin pain that is nonresponsive to treatment should raise suspicion of SH, but physical examination findings are subtle and most diagnostic tests do not definitively confirm the diagnosis. Conservative treatment of SH does not often result in the resolution of symptoms. Surgical intervention results in pain-free return of full activities in most cases.[14]

The symptoms of SH are characterized by pain during sports movements, particularly twisting and turning during single limb stance. This pain usually radiates to the adductor muscle region and even the testicles, although it is often difficult for the patient to pinpoint. Following sport activity, the athlete is stiff and sore. The day after competition, mobility and practice is difficult. Any exertion that increases intraabdominal pressure, such as coughing or sneezing, can cause pain.[13]

A review based on the results of 308 operations for unexplained, chronic groin pain suspected to be caused by an imminent, but not demonstrable, inguinal hernia or an SH, were studied. No differences in perioperative findings between the cured and noncured athletes were found. It was characteristic that further clinical investigation of noncured operated athletes gave an alternative and treatable diagnosis in more than 80% of cases. Herniography was used consistently in the diagnostic process. In conclusion, the final diagnosis and treatment often reflects the specialty of the doctor and the present literature does not supply proper evidence for the theory that SH constitutes a credible explanation for chronic groin pain.[15] Nonoperative treatment usually involves a short period of rest followed by physical therapy focusing on abdominal strengthening, which may temporarily relieve the pain, but definitive treatment remains surgical repair and rehabilitation.[13]

A nonspecific referral of groin pain may be as serious as a labral tear. In a study of athletes undergoing arthroscopy, 60% were treated for an average of 7 months before it was recognized that the joint was the source of their problems. Most were initially diagnosed as various types of musculotendinous strains. Thus, it is prudent to include intraarticular pathology in the differential diagnosis when managing hip problems.[7] In a recent study, 90% of patients with a labral tear complained of groin pain. Direct MR arthrography is the best imaging modality for evaluation of underlying intraarticular disorders.[16] Researchers show a high positive predictive value of MR arthrography and higher sensitivity (90% and 91%) and accuracy (30% and 36%) compared with nonarthrogram MR images.[16] With increasingly sensitive MR imaging (MRI), today, a patient should not have to incur months of conservative treatment before realizing there is a chondral defect or a labral tear that must undergo hip arthroscopy to result in pain-free movement. The importance of open and professional communication between the physician and rehabilitation specialist is essential.

MUSCULAR STRAINS

Evaluation of hip bursitis, tendonitis, and muscle strains can be challenging when overlapping conditions exist. Certain exercises or specific stretches that stress the involved muscle can help determine which muscle is injured. In general, treatment and rehabilitation are designed to relieve pain, restore range of motion (ROM), and restore strength, in that order. Rest, ice, compression, elevation (RICE) is the standard protocol for mild to moderate muscle strains. Gentle massage to the area with ice helps to decrease swelling. Compression shorts or a wrap bandage may also be helpful in decreasing swelling and provide support. If walking causes pain, limited weight-bearing and crutches are considered for the first 1 or 2 days after the injury.

ADDUCTOR MUSCLE STRAINS

Adductor muscle strains can result in missed playing time for athletes in many sports, and are encountered more frequently in ice hockey and soccer.[17–19] These sports require a strong eccentric contraction of the adductor musculature during competition.[20,21] Recently, adductor muscle strength has been linked to the incidence of adductor muscle strains. Specifically, the strength ratio of the adduction to abduction muscles groups has been identified as a risk factor in professional ice hockey players.[22] Intervention programs can lower the incidence of adductor muscle strains but not avoid them altogether. Therefore, proper injury treatment and rehabilitation must be implemented to limit the amount of missed playing time and avoid surgical intervention.[23]

The main action of this muscle group is to adduct the thigh in the open kinetic chain and stabilize the lower extremity to perturbation in the closed kinetic chain. Each individual muscle can also provide assistance in femoral flexion and rotation.[24,25] The adductor longus is believed to be the most frequently injured adductor muscle.[26] Its lack of mechanical advantage may make it more susceptible to strain.

As discussed earlier, a thorough history and a physical examination is needed to differentiate groin strains from athletic pubalgia, osteitis pubis, hernia, hip-joint osteoarthrosis, rectal or testicular referred pain, piriformis syndrome, or the presence of a coexisting fracture of the pelvis or the lower extremities.

The exact incidence of adductor muscle strains in sport is unknown. This is due in part to athletes playing through minor groin pain and the injury going unreported. In addition, overlapping diagnosis can also skew the exact incidence. Groin strains are among the most common injuries seen in ice hockey players.[27–29] Groin strains accounted for 10% of all injuries in elite Swedish ice hockey players.[30] Furthermore, Molsa[31] reported that groin strains accounted for 43% of all muscles strains in elite Finish ice hockey players. Tyler and colleagues[22] published that the incidence of groin strains in a single National Hockey League (NHL) team was 3.2 strains per 1000 player-game exposures. In a larger study of 26 NHL teams, Emery and colleagues[18] reported that the incidence of adductor strains in the NHL has increased in the last 6 years. The rate of injury was greatest during the preseason compared with regular and post-season play. Prospective soccer studies in Scandinavia have reported a groin strain incidence between 10 and 18 injuries per 100 soccer players.[32] Ekstrand and Gillquist[19] documented 32 groin strains in 180 male soccer players representing 13% of all injuries in the course of 1 year. Adductor muscle strains, certainly, are not isolated to these 2 sports.

Previous studies have shown an association between strength and/or flexibility and musculoskeletal strains in various athletic populations.[19,33,34] Ekstrandt and Gillquist[19] reported that preseason hip abduction ROM was decreased in soccer players who subsequently sustained groin strains compared with uninjured players. This is in contrast to the data published on professional ice hockey players that found no relationship between passive or active abduction ROM (adductor flexibility) and adductor muscle strains.[22,35]

Adductor muscle strength has been associated with a subsequent muscle strain. Tyler and colleagues[22] found preseason hip adduction strength was 18% lower in NHL players who subsequently sustained groin strains compared with the uninjured players. The hip adduction to abduction strength ratio was also significantly different between the 2 groups. Adduction strength was 95% of abduction strength in the uninjured players but only 78% of abduction strength in the injured players. In addition, in the players who sustained a groin strain, the preseason adduction to abduction strength ratio was lower on the side that subsequently sustained a groin strain compared with the uninjured side. Adduction strength was 86% of abduction strength on the uninjured side but only 70% of abduction strength on the injured side. Conversely, another study on adductor strains on ice hockey players found no relationship between peak isometric adductor torque and the incidence of adductor strains.[35] Unlike the previous study, this study had multiple testers using a hand-held dynamometer, which would increase the variability and decrease the likelihood of finding strength differences. However, Emery and colleagues[35] showed that players who practiced during the off-season were less likely to sustain a groin injury as were rookies in the NHL. The final risk factor was the presence of a previous adductor strain. Tyler and colleagues[22] also linked pre-existing injury as a risk factor; in their study 4 of the 9 groin strains (44%) were recurrent injuries. This is consistent with the results of Seward and colleagues[36] who reported a 32% recurrence rate for groin strains in Australian Rules football.

Now that researchers can identify players at risk for a future adductor strain, the next step is to design an intervention program to address all risk factors. Tyler and colleagues[27] were able to show that a therapeutic intervention of strengthening the adductor muscle group could be an effective method for preventing adductor strains in professional ice hockey players. Before the 2000 and 2001 seasons, professional ice hockey players were strength tested. Thirty-three of these 58 players were classified as at risk, which was defined as having an adduction to abduction strength ratio of less than 80%, and placed on an intervention program. The intervention program consisted of strengthening and functional exercises to increase adductor strength (**Box 1**). The injuries were tracked over the course of the 2 seasons. In the present study there

Box 1
Adductor strain injury prevention program

Warm-up
- Bike
- Adductor stretching
- Sumo squats
- Side lunges
- Kneeling pelvic tilts

Strengthening program
- Ball squeezes (legs bent to legs straight)
  - Different ball sizes
- Concentric adduction with weight against gravity
- Adduction in standing on cable column or elastic resistance
- Seated adduction machine
- Standing with involved foot on sliding board moving in sagittal plane
- Bilateral adduction on sliding board moving in frontal plane (ie, bilateral adduction simultaneously)
- Unilateral lunges with reciprocal arm movements

Sports-specific training
- On ice kneeling adductor pull togethers
- Standing resisted stride lengths on cable column to simulate skating
- Slide skating
- Cable column crossover pulls

Clinical goal
- Adduction strength at least 80% of the abduction strength.

were 3 adductor strains, all of which occurred in game situations. This gives an incidence of 0.71 adductor strains per 1000 player-game exposures. Adductor strains accounted for approximately 2% of all injuries. In contrast, there were 11 adductor strains and an incidence of 3.2 adductor strains per 1000 player-game exposures the previous 2 seasons before the intervention. In those previous 2 seasons, adductor strains accounted for approximately 8% of all injuries. This was also significantly lower than the incidence reported by Lorentzon and colleagues[30] who found adductor strains to be 10% of all injuries. Of the 3 players who sustained adductor strains, none of the players had sustained a previous adductor strain on the same side. One player had bilateral adductor strains at different times during the first season. These data show that a therapeutic intervention of strengthening the adductor muscle group can be an effective method for preventing adductor strains in professional ice hockey players.

Despite the identification of risk factors and strengthening intervention for ice hockey players, adductor strains continue to occur in all sports.[6] The high incidence of recurrent strains could be a result of incomplete rehabilitation or inadequate time for complete tissue repair. Holmich and colleagues[23] showed that a passive physical therapy program of massage, stretching, and modalities were ineffective in treating chronic groin strains. By contrast, an 8 to 12 week active strengthening program consisting of progressive resistive adduction and abduction exercises, balance training, abdominal strengthening, and skating movements on a slide board proved more effective in treating chronic groin strains. An increased emphasis on strengthening exercises may reduce the recurrence rate of groin strains. An adductor muscle strain injury program progressing the athlete through the phases of healing has been developed by Tyler and colleagues[27] and seems to be effective. As seen in **Box 2**, this type of treatment regime combines modalities and passive treatment immediately, followed by an active training program emphasizing eccentric resistive exercise. This method of rehabilitation program has been supported throughout the literature.[6]

HAMSTRING MUSCULAR STRAINS

The hamstrings are primarily fast-twitch muscles, responding to low repetitions and powerful movements. Hamstring muscle strains commonly result from a wide variety of sporting activities, particularly those requiring rapid acceleration and deceleration. An eccentric load to the muscle causes most of these injuries. Garrett and colleagues[37,38] showed that, in young athletes, hamstring muscle strains typically involve myotendinous disruption of the proximal biceps femoris muscle. Other investigators have also shown experimentally that the weak link of the muscle complex is the myotendinous junction.[37,39] Although apophyseal fractures of the ischial tuberosity have been reported in young athletes, most hamstring muscle strains are first and second degree strains.[40]

Hamstring muscle strains are among the most common injuries in sports involving high-speed movement and physical contact, and are by far the most commonly seen muscle strains in Australian Rules football with an incidence of 8.05 injuries per 1000 player-game hours. Soccer players are also susceptible to hamstring strains with an incidence of 3.0 per 1000 player-game hours for hamstring strains. Overall, any athlete who sprints as part of their sport may contribute to the incidence of hamstring strains.[36]

Factors causing hamstring muscle injury have been studied for many years. Age and previous injury were identified as the main risk factors for hamstring strain injury among elite football players from Iceland.[41] It has been suggested that muscle weakness, strength imbalance, lack of flexibility, fatigue, inadequate warm-up, and dyssynergic contraction may predispose an athlete to a hamstring strain.[42]

Fatigue has been implicated in the pathogenesis of muscle strain injury. Because muscle strains have been observed to occur either late in training or late in competitive matches, muscle fatigue has been indicated as a risk factor. Another study suggests that the injuries occur either early in games or training or late in games or training with

Box 2
Adductor strain post injury program

Phase 1 (acute)

- RICE for the first ~48 hours after injury
- Nonsteroidal antiinflammatory drugs (NSAIDs)
- Massage
- Transcutaneous electrical nerve stimulation (TENS)
- Ultrasound
- Submaximal isometric adduction with knees bent to with knees straight, progressing to maximal isometric adduction, pain free
- Hip passive range of motion (PROM) in pain-free range
- Non–weight-bearing hip progressive resistive exercises (PREs) without weight in antigravity position (all except abduction), pain-free, low load, high repetition exercise
- Upper body and trunk strengthening
- Contralateral lower extremity strengthening
- Flexibility program for noninvolved muscles
- Bilateral balance board

Clinical milestone

- Concentric adduction against gravity without pain

Phase 2 (subacute)

- Bicycling or swimming
- Sumo squats
- Single limb stance
- Concentric adduction with weight against gravity
- Standing with involved foot on sliding board moving in frontal plane
- Adduction in standing on cable column or Thera-Band (Hygenic Corporation, Akron, OH)
- Seated adduction machine
- Bilateral adduction on sliding board moving in frontal plane (ie, bilateral adduction simultaneously)
- Unilateral lunges (sagittal) with reciprocal arm movements
- Multiplane trunk tilting
- Balance board squats with throwbacks
- General flexibility program

Clinical milestone

- Involved lower extremity PROM equal to that of the uninvolved side and involved adductor strength at least 75% that of the ipsilateral abductors.

Phase 3 (sports-specific training)

Phase 2 exercises with increase in load, intensity, speed, and volume

Standing resisted stride lengths on cable column to simulate skating

Slide board

On ice kneeling adductor pull togethers

Lunges (in all planes)

Correct or modify ice skating technique

Clinical milestone

Adduction strength at least 90% to 100% of the abduction strength and involved muscle strength equal to that of the contralateral side

inadequate warm-up and muscle fatigue, respectively, being the hypothesized reasons.[43] However, there are few quantitative data to support these statements. Croisier[44] has suggested that the persistence of muscle weakness and imbalance may lead to recurrent hamstring muscle injuries and pain. These investigators believe that when there is insufficient eccentric braking capacity of the hamstring muscles compared with the concentric motor action of the quadriceps muscles, the muscle may be at risk for injury.

Ekstrand and Gillquist[45] prospectively studied male Swedish soccer players and found hamstrings to be the muscle group most often injured. They noted that minor injuries increased the risk of having a more severe injury within 2 months. Others[46] have noted a recurrence rate of 25% for hamstring injuries in intercollegiate football players.

Most clinicians prescribe warm-up and stretching to help reduce the incidence of muscle strains. The evidence supporting this idea is weak and largely based on retrospective studies.[47] Following hamstring injury, the affected extremity and muscle group are significantly less flexible than the uninjured side, but there are no differences in isokinetic strength.[48] However, Jonhagen and colleagues[49] found decreased flexibility and lower eccentric hamstring torques in runners who sustained a hamstring strain compared with uninjured subjects matched for age and speed. The role of stretching and warm-up in injury prevention needs to be better understood so that optimal strategies can be developed.

There is no consensus for rehabilitation of the hamstring muscles after sustaining a strain. However, a rehabilitation program consisting of progressive agility and trunk stabilization exercises has been shown to be more effective than a program emphasizing isolated hamstring stretching and strengthening in promoting return to sports and preventing injury recurrence in athletes suffering an acute hamstring strain.[50] The aim of the physical therapy is to restore full pain-free ROM and strength throughout the ROM. In addition, as a complement to the usual restoration of function, the authors emphasize restoring eccentric muscle strength and correction of agonist/antagonist imbalances in the rehabilitation process. We recommend the inclusion of eccentric exercises at an elongated position of the hamstring muscles, submaximally, as soon as the patient can tolerate it. Our rationale is based on basic animal science research[51] and imaging studies of human muscle tissue[37] that have indicated incomplete healing following muscle strains. Fibrosis at the injury site is believed to be related to the risk of re-injury. Based on these observations, interventions aimed at remodeling the muscle tissue may be effective in reducing the risk associated with having had a prior muscle strain. Eccentric muscle contractions have been shown to result in muscle-tendon junction remodeling in an animal model,[52] and more recently have been shown to cause intramuscular collagen remodeling in humans.[53] Therefore, an eccentrically biased training program for previously injured muscles could theoretically reduce recurrence rates and would be worth studying in future research.

Rehabilitation would start with relative rest and protection of the injured muscle phase lasting from 1 to 3 days. Returning to exercise in this stage can lead to re-injury and disruption of the healing tissue. Multi-angle isometrics should be initiated to properly align the regenerating muscle fibers and limit the extent of connective tissue fibrosis. RICE, along with antiinflammatory medication, is helpful during the immediate stages of treatment. Heat, electrical stimulation, and ultrasound modalities can also be used in conjunction during the rehabilitation program to facilitate a return to competition. Heat is effective at increasing tissue temperature before stretching and exercise. Electric stimulation can be used to control edema and pain. Ultrasound is used as a deep-heating agent during the subacute phase to decrease spasm and prevent soft-tissue shortening. An effective strengthening program should treat the hamstrings as a 2-joint muscle and focus on concentric and eccentric contractions. Although lack of flexibility has been identified as a factor leading to hamstring injuries, the effectiveness of pre-exercise muscle stretching in reducing injuries has recently been questioned. In fact, recent studies cite decreased strength or power for up to 1 hour following passive stretching.[48] In theory, this decrease in force production is believed to result from the relaxation of the muscle-tendon unit. Therefore, before athletic competition, a general warm-up (jogging, cycling) to increase tissue temperature, followed by dynamic stretching that includes sports-specific movements is recommended. Examples of dynamic stretches for the legs include forward or backward lunges, high-knee marching and straight-leg kicks. Static stretching should be performed after the athletic activity.

LABRAL TEARS

Acetabular labral tears have become a commonly recognized source of intraarticular hip pain that affects athletes. Although strongly associated with athletes performing twisting pelvic motions and rotations of the hip that occur in sports such as soccer, golf, football, ballet, and hockey; athletes in all major sports (and even minor sports such as skateboarding and Olympic yachting) have been affected.[16] Isolated athletic injury or repetitive traumatic activity can lead to labral tears; however, underlying structural (femoroacetabular impingement) and developmental abnormalities predisposing athletes to labral lesions must be addressed. Recent studies have reported lesions associated with labral tears, and that labral tears rarely occur as isolated injuries. Return to sport is favorable in athletes who have labral tears if they are properly treated with arthroscopic intervention.[54] The incentive to return motivated athletes to a sport has proven fertile ground for advancement of arthroscopic techniques.[7] An emerging surgical trend, hip arthroscopy, is becoming more common, especially among athletes. The application of this minimally invasive technique, combined with advances in MRI, is considered a significant advancement in treating labral tears.

The hip is generally considered a statically stable joint because of large bony contact areas.[16] The femoral and acetabular surfaces correspond well to each other, but given the increased need for stability at this joint, an accessory structure is needed. The labrum not only deepens the socket, but increases the concavity of the socket through its triangular shape. This structural stability is reinforced by the hip joint capsule and its ligaments.

The onset of pain with an acute labral tear is immediate and usually located at the front of the hip joint. As with all hip problems, the pain may become diffuse and difficult to pinpoint. If the front of the hip joint is affected there may be a pinching sensation when the patient flexes the hip by bringing the knee up to the chest. A catching or giving way sensation in the hip may also occur. Symptoms usually occur when the hip is changing position. The pain may be reproduced in sport during activities that require concomitant weight-bearing and twisting (eg, driving a golf ball).[55]

Nonoperative treatment of labral tears can be successful if the tear is small and stable. The labrum (like the meniscus) has been shown to contain nerve endings (presumably related to nocioceptive and proprioreceptive function) and is believed to have low intrinsic healing ability because of low vascularity primarily obtained from the capsule.[7] If nonoperative means are not successful, the results of hip arthroscopy have been reported to have good results.[56] A return to sports is usually possible between 2 and 3 months after the operation.

Although the surgery is new and emerging, the rehabilitation progression should take into consideration the basic science principles of soft-tissue healing. As seen in **Box 3**, following surgery, the patient is instructed to use bilateral crutches with partial weight-bearing as tolerated for the first 2 weeks. Then, they are progressed to 1 crutch for 1 week, until they regain normal gait. Gait training to restore normal gait is paramount at this point in the rehabilitation. Some surgeons use a hip brace to restrict hip flexion ROM. During the second week the patient may also begin some easy pool walking and stationary biking without resistance. Independent ambulation is encouraged after 3 weeks. Aerobic activity is increased to 30 minutes along with active assistive hip ROM exercises. Any explosive movements or rotational hip torque could be potentially damaging to the hip capsule and labrum. For the first 4 to 6 weeks pain-free exercise is recommended to avoid a synovitis, tendonitis, or overstretch. At 2 weeks, light hip isotonics and more weight-bearing exercises such as bridges and single-leg bridges are initiated.

Strengthening of the hip extensors, abductors, and external rotators are emphasized along with light stretching for hamstrings, hip flexors, quadriceps, and the iliotibial band. The straight-leg exercise is avoided until the fourth week following surgery. Range of motion is pushed for internal rotation but progressed more slowly for external rotation. Trunk strengthening is begun at this time with emphasis on the transverse abdominus and the back extensors.

Six weeks after surgery, the patient begins light internal-external hip rotation stretching, the first time of stretching the postoperative hip beyond the active ROM. Eight weeks following surgery lower extremity strength work, which include squats, Romanian dead lifts, 4-way hip exercises, lunges, and lateral step work, is initiated. The lifting program, emphasizing lighter weights and higher repetitions, is designed to build endurance and avoid positions that could potentially aggravate the hip. It is important to avoid anything that causes either anterior or lateral impingement.

The rehabilitation specialist should be aware of any overlapping conditions such as low back pain and sacroiliac dysfunction. In addition, monitoring for the onset of flexor tendonitis and abductor tendonitis can help prevent failures. Patients with preoperative weakness in proximal hip musculature are at increased risk for postoperative tendonitis.[57]

Box 3
Arthroscopic hip labral repair rehabilitation guidelines

Weight-bearing status

- Foot flat with 20 lb of pressure
- Duration 2 to 4 weeks

Continuous passive motion

- Start 30 to 70°
- Increase as tolerated 0 to 90°
- Duration 2 weeks

Sleeping

- Ace wrap feet when sleeping for 2 weeks

Brace

- Daytime use
- Set at 0 to 90° of hip flexion

Stationary bicycle

- Immediate postoperation
- 1 to 2 times daily for 15 to 20 minutes
- * Avoid pinching in front of hip by setting seat high

Pool exercises: begin on postoperative day 14 or as soon as sutures are removed and wound is healed

ROM

- Examination stool internal rotation: day 3 (may push early internal rotation within pain limits)
- Examination stool external rotation: day 7 (limit to 30° external rotation)
- 2 to 3 sets of 12 to 15 repetitions
- Quadriceps rocking: day 7
- AROM: within limits of brace or as tolerated if no brace is worn
- PROM: within available pain-free limits after brace is removed

Strength

- Quad sets/ankle pumps: day 1
  - Isometrics in neutral day 7 (*within painful limits)
  - Bridges: day 7 to 10
  - Isotonic weight equipment: day 14
    - * Except for leg press, begin at 6 weeks
    - * Shuttle or pilates, begin at 3 to 4 weeks dependent on weight-bearing
- Trunk strength
  - * Transverse abdominus
  - * Side supports
  - * Trunk and low back stabilization as tolerated

Function

- No straight-leg raises for 4 weeks

May begin pool walking in chest high water

Avoid antalgic gait

Be aware of weakness of GM, side supports, and transverse abdominus strength in sagittal, coronal, and transverse planes

Balance

As soon as weight-bearing is permitted, begin working on double- and single-leg balance with eyes open and eyes closed

10 repetitions for 5 seconds is a good place to start

General considerations:

- Typically requires 3 months of supervised therapy
- Month 1: tissue healing phase (1–2 per week)

Goals:

Pain control

Decrease tissue inflammation

Decrease swelling

Maintenance of motion (flexion 0–90°; internal rotation as tolerated; external rotation 0–30°)

- Month 2: early functional recovery (2–3 per week)

Goals:

Full PROM

Progress to full AROM

Early strength gains

AVOID FLEXOR TENDONITIS AND ABDUCTOR TENDONITIS!

- Month 3: late functional recovery (2–3 per week)

Goals:

Advance strength gains, focus on abductor and hip flexor strength

Balance and proprioception

Continue to monitor for development of tendonitis

Progress to sport-specific activity in months 3 and 4 depending on strength

Do not progress to running until abductor strength is equal to contralateral side

Progression to sport-specific activities requires full strength and muscle coordination

Precautions:

- Avoid anything that causes either anterior or lateral impingement
- Be aware of low back or sacroiliac joint dysfunction
- Pay close attention for the onset of flexor tendonitis and abductor tendonitis
- Patients with preoperative weakness in proximal hip musculature are at increased risk for postoperative tendonitis
- Modification of activity with focus on decreasing inflammation takes precedence if tendonitis occurs

Following hip arthroscopy patients should avoid weight-bearing twists and turns on the hip for up to 3 months after surgery. Although not evidence-based, similar to a healing meniscus, this compression with rotation cannot be beneficial to a healing labrum in all age groups and all occupations. It is recommend that patients keep their movements within the midline, certainly for a 6-week period. They can then gradually introduce rotational movements to the hip, but such movements must be under their own control. Rotational therapeutic exercises should start with non–weight-bearing exercises and progress to full weight-bearing. After 3 to 4 months, assuming all is well, patients are allowed to return to unprotected, full activities provided full strength and coordination have returned.

SUMMARY

The rehabilitation specialist is often given the diagnosis of a specific hip condition. With the use of modalities and manual techniques, pain can be reduced and function restored. However, the highly skilled clinician is trained to look at the "linkage" between the trunk and all parts of the lower extremity. So much of the hip has to do with the quality of energy transfer: concentric versus eccentric, pronation (collapsing of the limb) versus supination (ability to reabsorb the energy that is transmitted through ground reaction forces). These questions are most significant when looking at injuries that are cumulative over time. Thus, when restoring normal pain-free function is difficult, the areas above and below the hip joint can provide the answers.

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