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Current Clinical Concepts: Exercise and Load Management of Adductor Strains, Adductor Ruptures, and Long-Standing Adductor-Related Groin Pain

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Adductor-related groin pain is a common problem in sports. Evidence-based management of athletes with adductor strains, adductor ruptures, and long-standing adductor-related groin pain can be approached in a simple yet effective and individualized manner. In most cases, managing adductor-related pain in athletes should be based on specific exercises and loading strategies. In this article, I provide an overview of the different types of adductor injuries, from acute to overuse, including their underlying pathology, functional anatomy, diagnosis, prognosis, mechanisms, and risk factors. This information leads to optimal assessment and management of acute to long-standing adductor-related problems and includes primary, secondary, and tertiary prevention strategies that focus on exercise and load-based strategies. In addition, information on different options and contexts for exercise selection and execution for athletes, athletic trainers, and sports physical therapists in adductor injury rehabilitation is provided.

Key Words: muscle, tendon, exercise and loading, return to sport

Key Points

- Injuries to the hip-adductor muscles and tendon complexes are the most common problems in athletes presenting with acute and long-standing groin pain.
- These injuries can present either in isolation or with associated groin injuries, and the differential diagnosis is important to understand the prognosis and management.
- Measuring symptoms, strength, and performance can assist with early detection and monitoring, exercise progression, and return-to-sport decisions in athletes with adductor problems.
- Addressing hip-adductor, gluteal, and trunk strength, as well as balance, coordination, and plyometrics, using specific exercises and loading strategies is mandatory in primary, secondary, and tertiary prevention of adductor-related injury and groin pain.
- Progressive strength training and sport-specific loading is the treatment with the highest level of evidence for both acute and long-standing adductor-related problems.

Adductor-related groin pain is the most common groin problem in multidirectional team sports.[1,2] The adductor longus muscle-tendon complex is often involved in acute and gradual-onset injuries.[2] Most adductor-related groin pain experienced in team sports is short-lived and resolves in a few weeks.[1,2] However, when an athlete with an adductor injury attempts to play through the injury or does not receive or follow through with appropriate management, a long-standing adductor injury can develop.[2–4] Early detection and appropriate management of adductor injuries is of great importance to prevent these injuries from becoming long-standing problems.[3–5] This is further highlighted by the fact that short periods of relative rest during the season or the ever-shrinking off-season are usually insufficient to permit recovery from longer-standing adductor problems.[3–5] If early identification and rehabilitative management fail and long-standing problems develop, more time off for adductor-injury rehabilitation will be needed to manage the more severe injury and associated impairments that may have developed.

Adductor-injury management has advanced substantially during the past 20 years because of a better understanding of the anatomy, underlying pathologies, optimal rehabilitation, and outcome measures.[5] This has led to stronger study designs, including prospective cohort studies, randomized controlled trials, and meta-analyses, in the past decade.[6,7] Current literature suggests that magnetic resonance imaging (MRI),[8] 3-dimensional motion-capture analysis,[9] and extensive testing[10] are important for evidence-based management of athletes with groin pain. However, in most cases, optimal management of adductor-related pain in athletes does not require expensive technology or extensive testing. Instead, it can be based on simple principles, including up-to-date scientific information, sound clinical reasoning, and consistent exercise and loading strategies.[5]

The purpose of this article is to highlight typical adductor-related groin pain scenarios in athletes, relevant functional anatomy, strategies to reduce injury risk, and current concepts for individualizing evidence-based assessment and management according to the specific athlete, injury, and sport. Furthermore, these concepts are presented so that they can be implemented in different settings, enabling everyone to easily adhere, including fully equipped gymnasiums and rehabilitation settings such as athletic training clinics, home-based settings with limited space and equipment, and even the playing field or sidelines. Management of adductor-related problems from acute to long-standing cases is presented, and evidence is rated using the Strength of Recommendation (SOR) Taxonomy.[11] Strength of Recommendation *A* is based on reproducible outcomes across multiple well-controlled studies with results that are meaningful to patients. Strength of Recommendation *B* is based on outcomes that are meaningful to patients but were from studies that were not well controlled, produced conflicting or dissimilar results, or were limited in number. Strength of Recommendation *C* is based on clinical experience, outcome data that are important to clinicians, or observations of patients with similar exposure or treatment.

ADDUCTOR INJURY AND ASSOCIATED PATHOLOGY IN SPORTS

Sports such as soccer and ice hockey include stressful muscle actions and movements of and loads on the hip-adductor muscles and tendons and the pubic bone that contribute to the high incidence, prevalence, and burden of adductor injury in these sports.[1,2,12] Injuries to the adductor longus complex may involve different structures and tissue interfaces, such as the myotendinous junction or the musculotendinous insertion at the pubic bone. In an MRI study, Serner et al[13] showed that most acute adductor strains affected the adductor longus myotendinous junction and that partial and full adductor longus avulsion ruptures also occurred at the pubic bone, although less often (19% of acute adductor longus injuries were grade 3, avulsion or complete musculotendinous disruption). Adductor strains at the myotendinous junction are usually acute, whereas adductor injuries near the musculotendinous insertion can have an acute (adductor strain, rupture, or complete avulsion) or gradual (insidious long-standing adductor-related groin pain such as from adductor enthesopathy[14] or pubic apophysitis[15,16]) onset. Although most (90%) adductor longus injuries resolve in 1 to 3 weeks,[1,2] long-standing adductor-related groin pain, including adductor-related apophysitis and enthesopathy, also occurs. Such conditions are usually more challenging because they last >6 weeks and full recovery often is not achieved until much later (6–9 months in some cases). *SOR: B*

Although debate and uncertainty surround the exact underlying pathology of long-standing adductor-related groin pain, some evidence has suggested that adductor-related enthesopathy,[14] apophysitis,[15,16] pubic bone marrow edema,[17] or symphyseal disc protrusion[17] are possible culprits. Thus, long-standing adductor-related pain can coexist with pathology at the pubic symphysis and the adjacent bone. Other common imaging findings, such as primary and secondary cleft signs or adductor tendinopathy, may also be present but need to be interpreted with caution, as they are often visible to the same degree in asymptomatic, sport-specific activity-matched individuals.[17] *SOR: B*

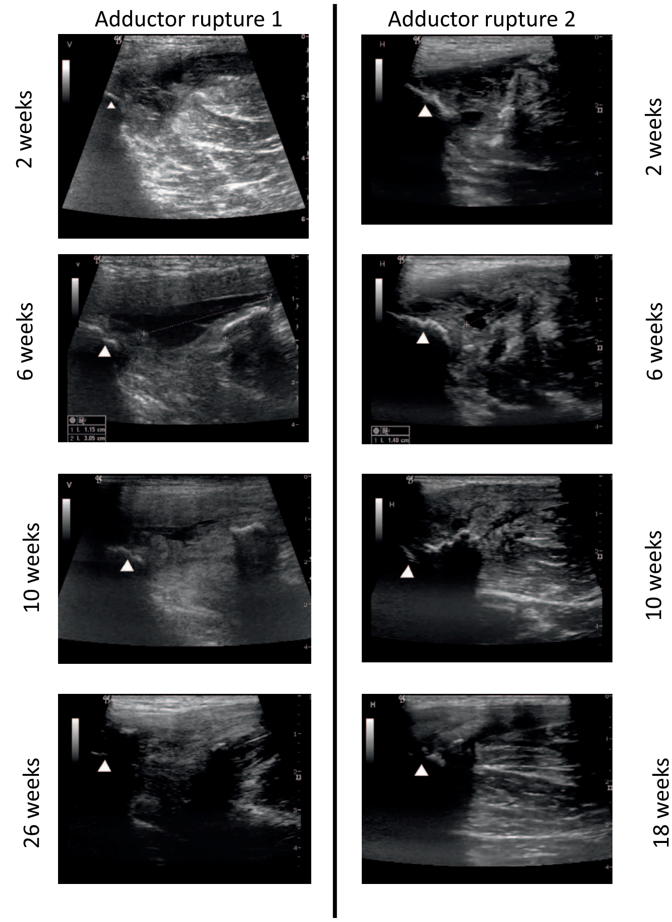


Figure 1. Ultrasonographic assessment and time of anatomic recovery after adductor longus ruptures. White arrowhead indicates insertion on pubic bone. Reprinted from Thorborg K, Petersen J, Nielsen MB, Hölmich P. Clinical recovery of two hip adductor longus ruptures: a case-report of a soccer player. *BMC Res Notes.* 2013;6:205. doi:10.1186/1756-0500-6-205.[21]

In skeletally immature and growing athletes, pubic apophysitis needs to be considered as a cause of pain,[18] and in rare cases (<5%), avulsion fractures involve the pubic apophyses. This includes the area from the superior corner of the pubic symphysis extending distally and laterally, including the fibrocartilaginous insertions of the adductor longus, brevis, and gracilis (distally) and the rectus abdominis and perhaps the area of the conjoined tendon and the inguinal ligament insertion (more laterally).[15,16,19] Adductor-related groin pain is the most common concern (prevalence of 22%) in young, skeletally immature male soccer players.[20] In skeletally mature athletes with partial ruptures or avulsions, new tissue takes 10 to 12 weeks to replace ruptured or avulsed tissue, as identified on ultrasound imaging (Figure 1).[21] In skeletally mature athletes with partial ruptures or avulsions, return to sport (RTS) usually takes 2 to 3 months, whereas in athletes with long-standing adductor-related groin pain without partial ruptures or avulsions, RTS usually takes 3 to 4 months.[22,23] When long-standing adductor-related groin pain is combined with an underlying pubic symphysis or bony reaction such as apophysitis or severe pubic bone

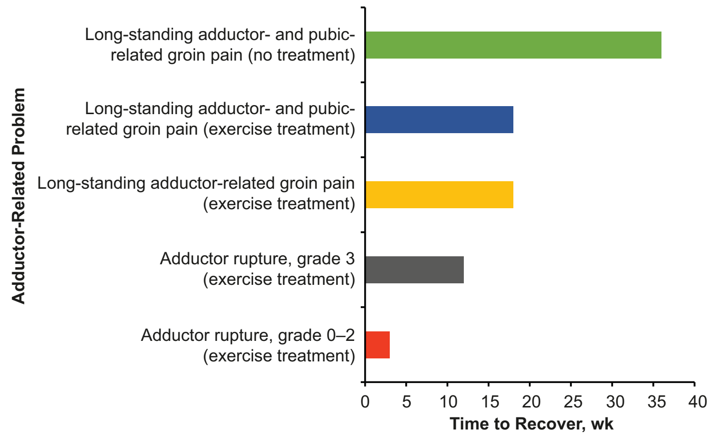


Figure 2. A general guide on weeks for recovery from different adductor-related problems.

stress, recovery times can be prolonged,[15,16,24] and if the condition is not addressed and managed appropriately, recovery can easily take >6 months.[24] Although reports exist of athletes who were able to RTS much earlier than these general and average timelines,[9,25–27] the timelines provided in this paper are based on average RTS times from studies in which players returned without symptoms or large strength or performance impairments (Figure 2). Given the large individual variations in RTS times, individual assessments should be included in the decision-making and treatment process. In cases that do not respond to the first line of treatment and do not follow the usual prognosis, a reevaluation or second opinion may be needed. The goal of rehabilitating athletes with adductor problems is to help them not only RTS but also achieve symptom-free preinjury performance levels and reduce the risk of recurrence. Athletes with adductor ruptures, avulsions, and long-standing problems can sometimes RTS after 6 to 10 weeks despite continuing to have strength and functional deficits.[9,26,27] These deficits often include adductor-muscle weakness (especially adductor squeeze and eccentric weakness more than isometric weakness)[28,29] and an inability to train or compete at the same level of performance as before injury.[9,26–28] Both nonoperative and operative treatment approaches can provide satisfactory results in most pelvic apophyseal fractures, with athletes returning to sport about 2 to 6 months after injury.[18] Whereas athletes with nondisplaced apophyseal avulsion fractures do not require surgical treatment, athletes with fragment displacements >15 mm and high functional demands may benefit from operative over nonoperative treatment.[18] *SOR: B*

ADDUCTOR ANATOMY AND FUNCTION IN SPORT

The anterior tendinous part of the adductor longus inserts into the pubic bone and has superficial fibers that continue across to the front of the symphysis and fuse with the distal rectus abdominis and external oblique and their aponeurosis.[30] This aponeurosis also fuses into the pubic symphysis joint capsule and disc.[30] The adductor longus attaches to the inferior part of the pubic crest and the deep part of the anterior pubic ligament. It contains a fibrocartilaginous enthesis that can partially or completely detach in adductor longus ruptures.[31,32] The adductors have multiple functions but are highly involved in sports that include kicking, skating, and change of direction.[1] Interestingly, adductor forces in young soccer players are higher when changing direction with the foot planted on the ground than when short passing a soccer ball.[33] The hip-adductor muscles are important in stabilizing and decelerating the body and pelvis during activities that require changes of direction and fast near-isometric and eccentric contractions during musculotendinous lengthening, such as in skating, sprinting, and kicking actions.[34–38] Researchers in biomechanics have suggested that electromyographic activity of the hip adductors is highest during the eccentric phase of high-speed soccer kicking (during the backswing of the kicking leg)[35] and skating (during the lateral skating push)[34] and that loading substantially increases as kicking or skating velocity increases and when sudden, unplanned movements occur. In fact, the velocity of the kick influences electromyographic activity of the adductor longus and magnus more than whether the soccer kick is performed as a side-foot or an in-step kick.[38] *SOR: C*

High forces on the adductor muscle and tendon during kicking seem mainly driven by higher kicking velocity and moment of force around the hip joint. This affects the distal segments with high proximal-to-distal energy transferred downward from the hip to the thigh and then to the ankle and foot in a whiplike fashion.[39] High force development of the hip and groin muscles is required for kicking, especially during eccentric movements. It puts elevated strain demands on muscles, tendons, and other related connective tissue around the pubic symphysis during high-velocity kicking and other sporting movements in which the musculotendinous complex is being stretched during forceful contraction, such as in skating and lower limb "reaching."[34,39,40]

Whereas the adductor longus is important for hip flexion during kicking and propulsion during sprinting and skating, the adductor magnus plays an important role as a hip extensor from a more flexed hip position.[36–38] This is relevant in the stance limb during the push-off phase, such as in initial acceleration during sprinting and skating, and when the limb is functioning as the stance limb opposite to the kicking side.[36–38] In this way, the adductors almost work as a pair of scissors and a bilateral force couple during sprinting, kicking, and skating, having critical stabilizing and primary movement roles in different specific and repetitive movement patterns, depending on the sport. Understanding adductor anatomy and function has important implications for how we understand, build, and progress exercise and sport-specific load capacity in athletes presenting with adductor injuries. *SOR: C*

DIAGNOSING ADDUCTOR INJURY

Taking a detailed history with questions related to the mechanism of injury is important in the clinical examination of patients with an adductor injury.[5] Visual inspection of the thigh and groin may also be helpful because acute adductor rupture often results in a hematoma in the medial thigh within 24 to 48 hours, sometimes progressing distally to the popliteal space. Clinical examination of the adductor longus tendon via pain provocation tests (muscle contraction against resistance, stretch, and palpation testing) is an accurate way to determine the presence of acute adductor longus injury (positive and negative predictive values range from 80% to 95% compared with MRI).[41] With more long-standing and adductor-related groin pain, palpation of the adductor longus tendon's insertion should also reproduce the athlete's symptoms.[5] Most injuries to the adductors, acute or overuse, involve the superior part of the adductor longus tendon and its insertion (up to 70% of all groin problems).[2,5,12,20] The ability to palpate the adductor longus and its exact location, beginning at its insertion on the pubic bone and following the intramuscular myotendinous junction that extends approximately 10 cm down from this point centrally in the muscle belly is key.[5,13,19] Adductor-related pain is confirmed if the investigator reproduces the known pain from the adductor longus via the isometric adductor squeeze performed on straight limbs and it coexists with adductor longus tenderness on palpation.[5] Common mistakes clinicians make are not following the adductor longus tendon all the way to its pubic attachment when performing palpation or testing the adductors only via the isometric squeeze on bent knees. In both cases, an adductor-related problem may be missed, appear less obvious, or both. *SOR: B*

When concomitant structures are thought to be involved, diagnostic imaging including ultrasonography for differential soft tissue injury and MRI for pelvic and pubic bone status and stress reaction is relevant.[5] Injuries to the rectus femoris, iliopsoas, and other hip-adductor muscles cannot be diagnosed by palpation alone with sufficient diagnostic accuracy, and only the absence of pain with iliopsoas palpation seems to indicate that this structure is not involved.[5] Clinical suspicion of intra-articular hip injury should prompt radiologic and sometimes MRI assessment to facilitate an appropriate differential diagnosis. *SOR: C*

ADDUCTOR INJURY MECHANISMS

Acute adductor strains can also involve other musculotendinous structures and connective tissue.[13,31,32] In most cases, the lesion is in the myotendinous junction, but in some cases, the site of injury is the tendon itself or the enthesis where the tendon inserts into the bone.[13,31,32] These injuries happen during forceful actions, such as in kicking, skating, and change of direction, and with other sporting movements that involve the muscle being stretched during forceful contraction, such as lower limb "reaching."[40] Furthermore, hip-adductor forces change dramatically during adolescent growth, which seems to increase the stress on the adductor muscle-tendon complex[42] and may explain the increased risk of groin problems seen during this period.[43] For this reason, extra attention should be given to young, growing athletes in sports in which eccentric forces and total load suddenly increase on the adductors and their insertional area and underlying pubic bone because of maturation and increasing training volumes.[43] These growth-related increases in force production and limb leveraged together with increasing training volumes are highly suspected to be connected to apophyseal overload and overuse problems. *SOR: C*

Long-standing problems involving the hip adductors often have a typical overuse pattern, with no single incident recollected as causing the pain, but they may be caused by a sudden increase in activity level or a change of playing or technical style. Sometimes, a substantial workload over a sustained period may cause a long-standing problem. An overuse pattern can also emerge in athletes returning to sport after an initial acute adductor injury without receiving appropriate or enough treatment and rehabilitation. *SOR: C*

RISK FACTORS FOR ADDUCTOR-RELATED PROBLEMS IN ATHLETES

Sex, age (younger and older), previous injury, pain in the previous season, hip-adduction weakness, and hip-abduction weakness are substantial risk factors for developing groin problems.[44–47] Risk factors related to training load also are especially present during the preseason and after low levels of off-season sport-specific activities[44–47] because of rapid changes in training volume. These risk factors represent focus points and warning signs in specific groups of athletes that need extra attention in the multidirectional sport environment. Although men seem more prone to groin injuries than women, adductor injuries are still one of the most common injuries in both men's and women's soccer and ice hockey, with the seasonal groin pain prevalence ranging between 20% and 60% and a large number of adductor reinjuries (15%–30%).[1,3,4] Specifically, in male athletes, an eccentric hip-adductor to -abductor strength ratio of <0.8 seems to be associated with an increased risk for acute adductor strains in ice hockey, whereas weak eccentric strength (>1 SD below the mean) is associated with an increased risk for adductor-related groin pain in soccer.[44–47] Interestingly, eccentrically strong adductors (>1 SD above the mean) seem to increase the risk of other hip and groin injuries in soccer, such as inguinal and iliopsoas-related problems.[47] Research and information on risk factors for groin pain in female athletes is currently scarce, and more knowledge is needed in this area. *SOR: A*

Importantly, although poor hip-adductor squeeze strength has been identified as a risk factor for groin problems in men's soccer,[44–46] it has not been identified as a consistent risk factor for all types of groin problems in ice hockey.[44–47] This highlights the complexity of groin problems and the fact that a sole focus on adductor strength is not the way to solve all types of groin problems. Instead, a systems approach, including general load management, strength training, optimization of sport-specific pelvic load transfer, and individual screening of athletes concerning their adaptation to loads, is the current key to managing adductor-related problems.[48] *SOR: A*

ASSESSMENT OF FUNCTION AND PERFORMANCE AFTER ADDUCTOR INJURY

The use of validated outcome measures is important in this developing field and should be encouraged.[5] The Copenhagen Hip and Groin Outcome Score (HAGOS) is a reliable, valid, and responsive self-reported measurement tool developed for athletes with hip pain, groin pain, or both.[49] It is not restricted to a specific pathology or entity, and reference values for soccer players have been established.[5] The HAGOS measures 6 relevant subsets related to groin pain in athletes: pain, symptoms, activities of daily living, sports, participation/performance, and quality of life. Reference values (95% of healthy values) range from around 75 to 100 points on the sports, participation/performance, and quality-of-life subscales, with minimal important changes of 10 to 15 points and minimal detectable changes of 20 to 30 points at the individual level, meaning that individual changes always need to be interpreted with caution concerning their accuracy.[5,50] Reference values and ranges have been given for soccer players without groin pain and HAGOS was validated in 2021 across different languages in multidirectional-sport athletes and modified slightly using Rasch analyses.[51] Both the original and modified versions are available at https://www.hvidovrehospital.dk/sorc-c/hagos/Pages/default.aspx and can be used without a license and free of charge. *SOR: A*

Assessing muscle strength and the numeric rating of pain during maximal adductor activation provide a better understanding of the degree of impairment in athletes with groin pain. In particular, squeeze and eccentric adductor strength are usually impaired in athletes with adductor-related groin pain (20% deficit) measured with handheld dynamometry (HHD),[28] whereas athletes with pubic-related groin pain have also demonstrated large eccentric abdominal deficits (37% deficit) tested with isokinetic-strength equipment.[52] Although abdominal strength can be difficult to assess clinically with HHD, adductor strength can be reliably assessed clinically using HHD and quantified either unilaterally or during a squeeze-strength test.[5] For isometric and eccentric adductor- and abductor-strength measures and adductor-squeeze and abductor-press measures, the minimal detectable change when using the same tester is around 10% to 15% for peak torque measures, 20% for adduction/abduction ratio measures, and 40% for rate-of-force development measures.[5,53] Isometric and eccentric adductor and abductor symmetry index, ratios, baseline values for reference, and normative values are therefore the most useful items to include for a comprehensive and individualized evaluation of adductor and abduction strength in athletes with an adductor injury. In addition, quick screens of adductor squeeze and abductor press can be useful or easier to implement in the busy clinical schedule (Table 1). Athletes with an adductor injury have usually not completely recovered adductor strength and function when returning to training. Therefore, actual adductor strength needs to be monitored during rehabilitation and when athletes RTS to optimize function and reduce the risk of reinjury (Figure 3).[21] Numeric pain rating (range = 0–10) during maximal adductor-muscle testing and activation, such as the Copenhagen 5-second squeeze and the traffic-light approach (Figure 4), is reliable, valid, and responsive to clinical changes.[54] *SOR: B*

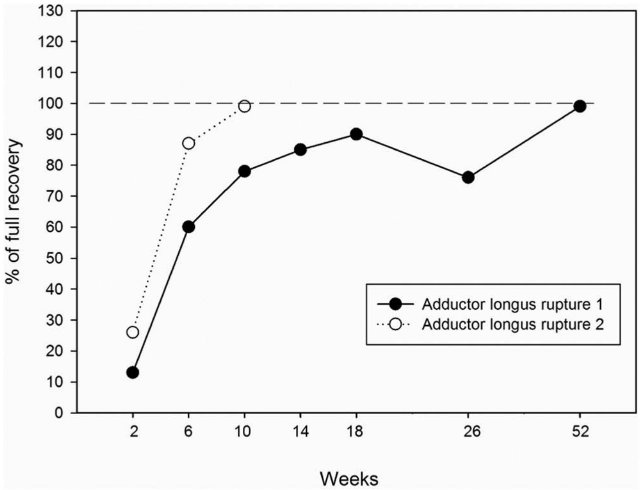
Passive flexibility and hip range of motion can also be reliably measured clinically using a goniometer or inclinometer. Severe restrictions in passive range of motion are more closely related to early impairment and muscle guarding immediately after serious muscle-tendon rupture or avulsion and intra-articular hip conditions. Passive range of motion does not seem to play an important role in the later phase of rehabilitation when considering RTS in athletes with long-standing adductor-related groin pain, at least in outfield players in multidirectional sports,[28,55] as opposed to goalkeepers, for whom regaining full flexibility and outer-range strength may be highly important for optimal performance. Although self-reported decreased functional performance can be documented and applied clinically using HAGOS, physical impairments related to performance are documented primarily in laboratory settings.[5] Kinematic and kinetic changes seem to occur after rehabilitation and may be associated with improved performance.[9] However, the extent to which these changes are influenced by decreasing clinical symptoms, improved biomechanics, or both is unknown. Time-based performance measures that include acceleration and deceleration via turns, different degrees of change of direction, or both can be performed reliably and applied across different sports and surfaces,[5] and they are worth considering in the

Table 1. Hip-Strength Testing Dynamometry and Examples of Benchmarking Before Entering the Return-to-Sport and Performance Phases

	Individual			Group[a]		
		Lower Limb Symmetry Index			Mean Strength, N·m/kg Body Weight	
Benchmark	Present/Preseason, %	Adduction	Abduction	Adduction- to-Abduction Ratio	Adduction	Abduction
Isometric	100	1 : 1	1 : 1	1.0	2.0	2.0
Eccentric	100	1 : 1	1 : 1	1.2	3.0	2.5
Bilateral squeeze	100	NA	NA		3.0	NA
Bilateral press	100	NA	NA		NA	2.0

Abbreviation: NA, not applicable.

[a] Group means are based on values of subelite and elite adult male soccer players and ice hockey players, who were approximately 10% to 20% stronger than their female counterparts when strength was normalized, with male youth players down to U-15 having similar values as male adults. One SD around the means is close to ±20% of the mean values presented in this table.



B

	Adductor Rupture 1	Adductor Rupture 2
Walking	2 weeks	2 weeks
Jogging	4 weeks	5 weeks
Running	5 weeks	6 weeks
Sprinting	11 weeks	8 weeks
Sudden change of direction	12 weeks	10 weeks
Kicking	13 weeks	11 weeks
Full training session	15 weeks	12 weeks

Figure 3. A, Hip-adduction strength recovery after two adductor longus rupture cases. B, Pain-free activity level reported on a weekly basis. Reprinted from Thorborg K, Petersen J, Nielsen MB, Hölmich P.21 Clinical recovery of two hip adductor longus ruptures: a case-report of a soccer player. *BMC Res Notes.* 2013;6:205. doi:10.1186/1756-0500-6-205 with permission.[21]

elite setting using tests such as the V test, the T test, and the Illinois Agility Test. *SOR: C*

ADDUCTOR INJURY MANAGEMENT

Adductor injuries in athletes are optimally managed using a systems approach including primary, secondary, and tertiary prevention to address and accommodate their complex nature.[5,48] Primary prevention is aimed at preventing or reducing the injury burden, whereas secondary prevention is aimed at reducing the effect of injury that has already occurred by detecting and treating it as soon as possible to prevent further progression. Tertiary prevention is aimed at reducing the effect of an ongoing injury through treatment and long-term management.

Primary and Secondary Prevention

Managing off-season, preseason, and in-season training loads is key to optimizing adductor musculotendinous health in athletes. Muscle strength and coordination exercises for the hip, groin, and pelvis have shown promise in preventing acute adductor strains in men's ice hockey and hip and groin problems and injuries in men's soccer.[56,57] The best-documented and most time-efficient approach uses these progressive strengthening programs. In addition, the Fédération Internationale de Football Association (FIFA) 11+ program, which includes warm-up, strengthening, balance and coordination, and plyometrics, seemed to reduce groin injuries in soccer to a similar extent (up to 40%) across a mixed cohort of women and men.[58]

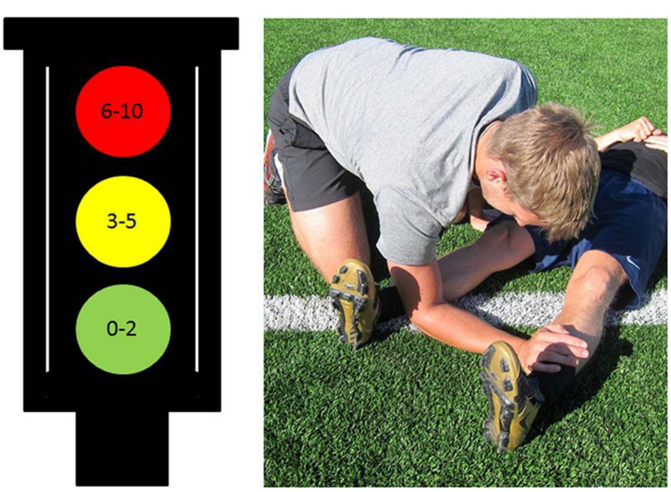


Figure 4. Numeric pain rating (0–10) during the Copenhagen 5-second squeeze (right) and the traffic-light approach (left). Reprinted with permission.[54]

The most time-efficient approach involves implementing the Copenhagen adductor exercise in the preseason. The Copenhagen adductor exercise program can apply to both primary and secondary prevention because it can be regressed and progressed to fit all levels of exercise capacity and impairments in athletes with or without current adductor-related groin pain. This program targets adductor strength, with special emphasis on eccentric muscle function, one of the main risk factors for a groin injury. Interestingly, the Copenhagen adductor exercises also target hip-abductor and trunk-muscle activity and strength, most likely because of coactivation of the muscles around the hip joint and pelvis in relation to the femur.[59,60] This suggests the program may also have benefits that extend beyond hip-adductor strength and adductor-related pain, but this possibility needs to be examined in future studies. *SOR: A*

Several types of exercise can be implemented to improve hip-adductor function and decrease the risk of adductor reinjury, but the Copenhagen adductor exercise progression appears to offer the best evidence for positive outcomes and should be a consistent exercise component. This program is simple and easy to progress (by increasing volume) and seems to increase eccentric hip-adduction strength in a dose-response fashion (Figure 5).[59] *SOR: A*

An important approach when addressing athletes at high risk for adductor injury is to include early-detection strategies in the prevention framework (Figure 6).[48] Secondary prevention can be achieved through an early-detection approach by applying periodic clinical screenings,

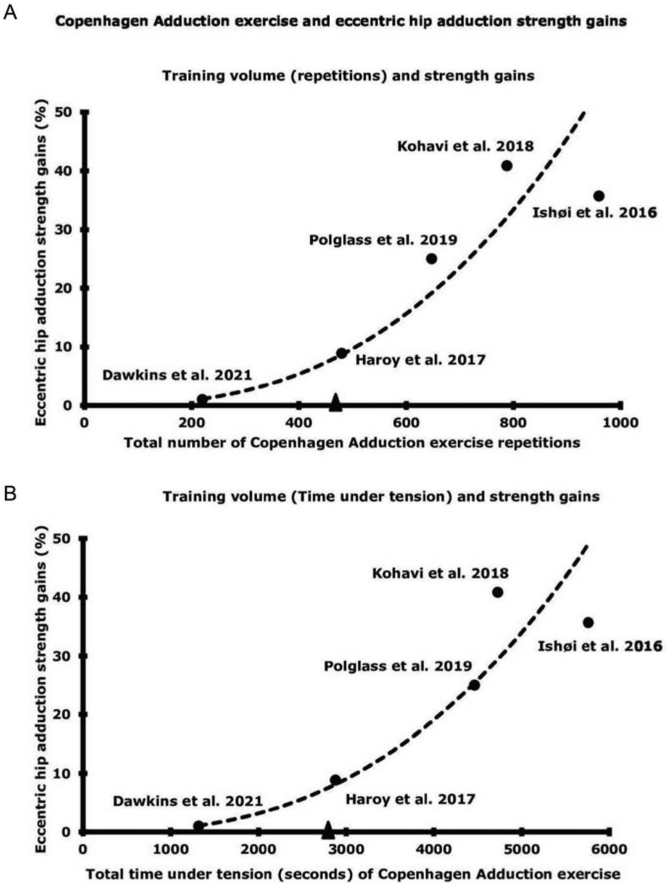


Figure 5. Dose-response relationship derived from 5 trials[61–65] (black dots) between training volume, A, number of repetitions, and B, time under tension during a 6- to 8-week training intervention using the Copenhagen adduction exercise and percentage change in eccentric hip adduction strength gains. Reprinted with permission.[59]

including strength, pain, and performance assessments. This approach has shown promise and proof of concept in clinical practice by building adductor capacity in adolescent athletes while minimizing symptoms.[48] *SOR: C*

Tertiary Prevention

Rehabilitation programs for adductor-related groin pain using active exercises are much more effective than those using passive modalities (odds ratio = 12.7) in allowing athletes to RTS without groin pain.[22] Hölmich et al[22] were the first to identify active exercises as the key to rehabilitating adductor-related problems. Tyler et al[56] developed an exercise program that targeted eccentric adductor strength to prevent acute adductor strains. Furthermore, researchers have shown that adding even more focused strengthening of both adductors and abductors to the Hölmich program, including the Copenhagen adductor exercises, exercises with cables or elastic bands, and side planks, affects the eccentric strength capacity of both the hip adductors and abductors.[66] Such exercises are now an important part of current rehabilitation and adductor injury-prevention programs. Recently, this approach was also applied successfully in a prospective study of athletes who had acute adductor injuries, with fast RTS times, no requirement of subsequent surgery for grade 3 injuries, and a low reinjury rate at the 1-year follow-up (8%).[10] In general, the rehabilitation of adductor injuries should focus on isolating the specific impaired tissues and working toward integrating these structures in sport-specific movement, function, and gradual RTS.[10,22] This approach should be based on and guided by individual and continuous assessments.[5,10,48] In general, these programs include approximately 6 to 10 exercises per session, progressive loading, and substantial time under tension, ranging from 6 to 30 seconds for each exercise repetition during 2 to 3 sets. For example, each repetition of isometric squeezes and balance exercises is usually performed for 10 to 30 seconds, whereas each repetition of the more dynamic and heavy strengthening exercises lasts up to 6 seconds (2-second concentric phase, 2-second isometric phase, and 2-second eccentric phase). Finally, more explosive and sport-specific exercises are of much shorter duration.[10,22] The programs should ideally be performed every other day in the gymnasium, at home, at the training ground, or at the rehabilitation facility. The total exercise duration of each session ranges from 30 to 120 minutes depending on the phase, starting with 30 minutes and building up to 120 minutes and the actual training session and game time to which the athlete is aiming to return. Because the rehabilitation requires progressive overload and good compliance and may last a long time, rehabilitating athletes must show commitment and effort in order to RTS effectively.[10,22] *SOR: A*

CURRENT CLINICAL CONCEPTS AND CLINICAL REASONING IN ADDUCTOR INJURY REHABILITATION

During rehabilitation, clinicians should monitor the patient's tissue irritability reactions and strength adaptations when using an applied loading program and adjust accordingly. This is especially relevant in the rehabilitation of long-standing adductor-related problems in which "high condition irritability," such as with pubic apophyseal and bone stress reactions, may exist. High condition irritability should be considered when the Copenhagen 5-second squeeze value is >5 of 10[54] and if this high-intensity pain or discomfort increases notably during exercise or postexercise for up to 48 hours. In these cases, the monitoring approach suggested by Wollin et al[48] may be a better place to start (Figure 6), with strengthening exercises not being a focus until the Copenhagen 5-second squeeze test is <5 of 10 and ideally when pain is minimal (0–2 of 10; Figure 4). In athletes without signs of high irritability, the following rehabilitation approach is usually not problematic if the general principles are followed, and athletes can even train with pain ratings >2 (eg, from 3 to 5) if pain and discomfort do not persist or worsen notably afterward.

The rehabilitation program can usually be divided into 3 exercise phases and 3 RTS phases, each focusing on the load and strength components of exercise.[67] However, all foci should be addressed throughout all phases with different intensities and functional demands. The strength-training concept for athletes with adductor-related injury and pain is structural isolation to functional integration and can be followed irrespective of whether the athlete has access to (1) a fully equipped gymnasium-based athletic training and rehabilitation setting, (2) a simple sideline or athletic field option, or (3) only a home-based setting with

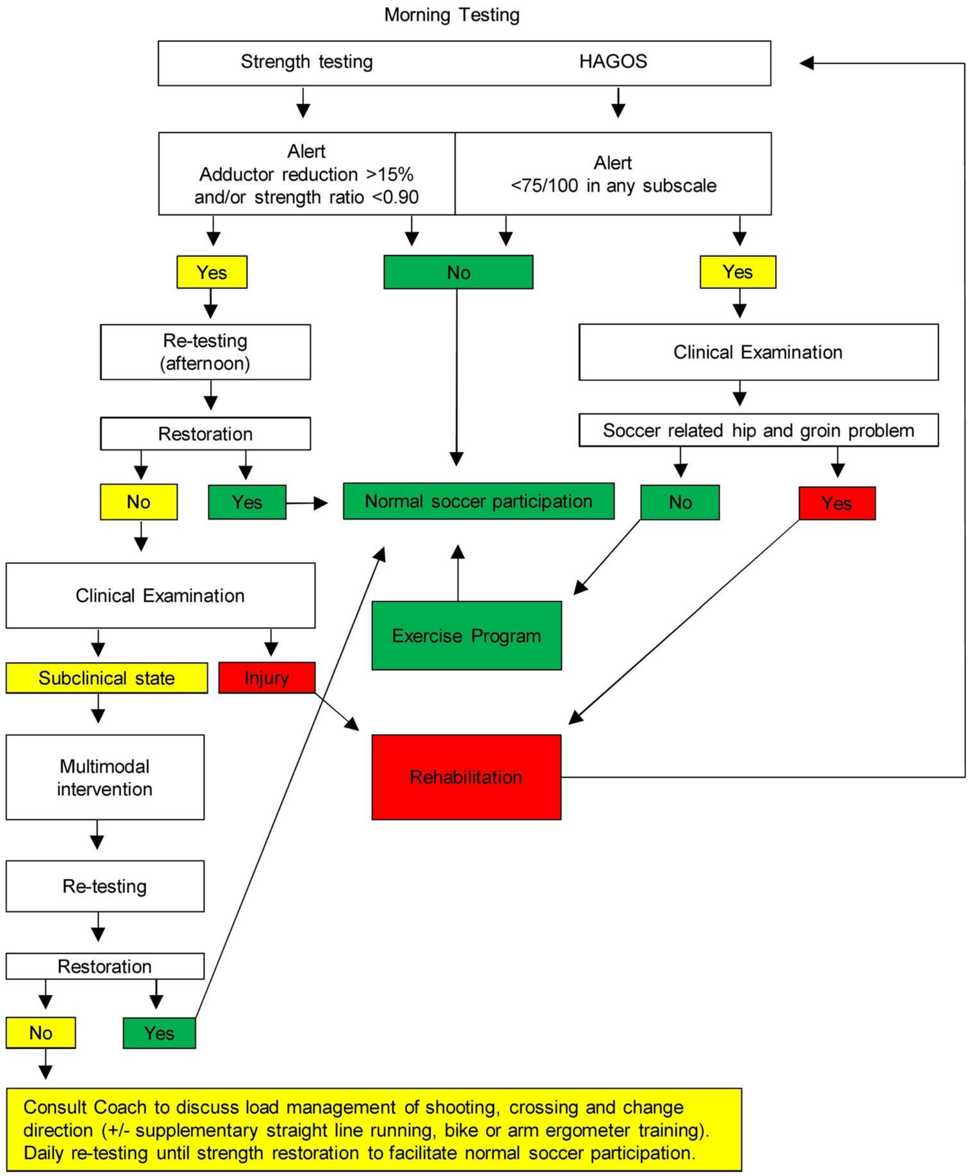


Figure 6. Monitoring of hip and groin strength, health, and function in soccer. Abbreviation: HAGOS, Copenhagen Hip And Groin Outcome Score in athletes. Reprinted with permission.[48]

limited training space and equipment (Figure 7). It allows flexibility and the opportunity for all athletes with an adductor injury to optimize their rehabilitation. Changes can be made as necessary, but general recovery times (Figure 1) and criteria (Tables 1 and 2) both need to be considered in the RTS phases without regard to the training setting.[72] *SOR: C*

The exercise and RTS phases follow.[67,72]

Acute/Subacute Phase

The acute/subacute phase not only involves the initiation of tissue repair, regeneration, or both but also the effects of possible disuse because of injury. The primary goals during this phase are protection of the injured structure, pain control, reducing inflammation and edema, normalization of flexibility if limited, and prevention of excessive muscular inhibition using exercises with no or minimal pain provocation. Light to moderate loads are mainly applied in this phase, and clear adductor-muscle activation during isometric contractions with minimal or no pain needs to be achieved.

Conditioning Phase

In the conditioning phase, gradual and progressive loading of the adductors is commenced to repair and regenerate the tissues. This is generally performed using light to moderate loads while still respecting the structural injury and underlying healing processes depending on the location of the injury (myotendinous junction, tendon, and bone) at this early stage. Strength-training machines, side-lying exercises with the weight of the limb, and standing exercises with elastic bands or cables can be used to target all hip and pelvic muscles. The bilateral activation in these exercises makes them ideal for maximal strength and movement of the prime movers as well as dynamic stabilization of the opposite stabilizing and force-generating side. Irrespective of whether the injury is unilateral or bilateral, performing these exercises on both sides is

A

Exercise Program and Phase	Adductor Work	Gluteal Work	Trunk Work	Balance, Coordination, and Plyometric Work
Home-based				
Acute/subacute	Side-lying adductions Adductor squeezes	Side-lying abductions Elastic-band abductions	Traditional planks Abdominal curls	One-legged balance Squat
Conditioning	Sliding abduction/extension Elastic-band adductions	Side-lying abductions Elastic-band abductions	Long-lever planks Abdominal curls	Skiing Lunges
Sport-specific	Sliding abduction/extension Chair Copenhagen adductions	Side-plank abductions Elastic-band abductions	Long-lever planks Folding knives	Skiing Twist lunges Side-to-side jumps
Return to sport	Sliding abduction/extension Chair Copenhagen adductions	Side-plank abductions Elastic-band abductions	Long-lever planks Folding knives	Skiing Split-squat jumps 180° turn jumps
Gymnasium-based				
Acute/subacute	Adductor squeezes Machine adductions	Cable abductions Machine abductions	Traditional planks Abdominal curls	One-legged balance Squat
Conditioning	Sliding abduction/extension Cable adductions	Cable abductions Side-plank abductions	Long-lever planks Swiss ball curls	Skiing Lunges Slideboard
Sport-specific	Cable adduction/flexion Bench Copenhagen adductions	Cable abductions Side-plank abductions	Long-lever planks Swiss ball curls	Skiing Twist lunges Side-to-side jumps
Return to sport	Cable adduction/flexion Bench Copenhagen adductions	Cable abductions Side-plank abductions	Swiss ball curls Long-level planks	Skiing Split-squat jumps 180° turn jumps
Field-based				
Acute/subacute	Adductor squeezes Side-lying adductions	Side-lying abductions Partner abductions	Traditional planks Abdominal curls	One-legged balance Squat
Conditioning	Sliding abduction/extension Partner adductions	Side-plank abductions Partner abductions	Long-lever planks Folding knives	Skiing Lunges
Sport-specific	Sliding abduction/extension Partner Copenhagen adductions	Side-plank abductions Partner abductions	Long-lever planks Folding knives	Skiiing Twist lunges Side-to-side jumps
Return to sport	Sliding abduction/extension Partner Copenhagen adductions	Side-plank abductions Partner abductions	Long-lever planks Folding knives	Skiing Split-squat jumps 180° turn jumps

B

Effort	Rating	Load Category	Load Repetition Maximum
Extremely strong	≥7	Near maximum	<8
Strong to very strong	≥5–<7	Heavy	10–8
Moderate to somewhat strong	>2–<5	Moderate	15–12
Nothing at all to weak	≤2	Light	>15

Figure 7. A, Home-based, gymnasium-based, and field-based exercise programs with shading according to B, perceived loading with Borg CR10 Scale (2016 version) and repetition maximum. The Borg CR10 Scale (2016 version) is a continuous scale, and the terms on the scale cover several values on the scale (see Figure 8). Further explanation of the Borg CR10 Scale was provided in previous research.[68–71] Future research should be done to study the categorization used for the Borg CR10 Scale as presented in this paper.

important to stimulate the adductors as either prime movers or stabilizers/force generators. Static and dynamic muscle-strengthening exercises are continued from light (≥15-repetition maximum [RM]; rating of perceived exertion on the Borg CR10 Scale [2016 version], 0–2) to moderate (12–15 RM; Borg CR10 Scale, 3–5; Figures 7 and 8) loads.[60,73,74] Musculotendinous conditioning should focus on slow concentric, isometric, and eccentric contractions during these exercises in the beginning to avoid placing excessive load on the myotendinous structures. Focus on both static and dynamic activation of the adductors is important because weakness often manifests as compensation and off-loading strategies, in which the adductors do not clearly activate, contract, and engage in the movement as they normally would. The clinician needs to distinguish whether habitual off-loading by athletes is due to excessive tissue stress or a pain response or is driven more by subconscious avoidance or fear of movement. The former calls for adjustment of the exercise load by the clinician, whereas the latter requires an increased focus on making athletes aware of their off-loading patterns and how to work on changing them. Balance and coordination exercises using sliding boards, unstable surfaces, or wobble boards and

Table 2. Clinical Milestones Before the Return-to-Sport Phase and for Achieving the Optimal Outcome

Clinical Milestones
No or minimal pain (0–2/10) during or after the following:
1. Clinical examination including adductor palpation, stretching, and squeeze
2. Adductor strength training at heavy loads (10-repetition maximum) and 10 repetitions of Copenhagen adductor exercises
3. Sport-specific training including maximal actions of running, sprinting, change of direction, skating, and kicking, depending on sporting relevance for the individual athlete

upper and lower limb swinging exercises should also be included and continued throughout both the sport-specific and RTS phases.

Sport-Specific Exercise Phase

The sport-specific exercise phase focuses on dynamic exercises of the adductors and abductors with proper execution (compensation strategies that minimize or avoid the loading of specific and important structures are not allowed). The primary goals during this phase are to restore musculotendinous endurance and strength, aerobic and anaerobic capacity, and neuromuscular control, balance, and coordination in movements that mimic the athlete's sport. Dynamic muscle-strengthening exercises are continued from moderate (12–15 RM; Borg CR10 Scale, 3–5) to heavy (8–10 RM; Borg CR10 Scale, >5–<7; Figures 7 and 8) loads.[60,73,74] Musculotendinous conditioning at the beginning should still emphasize slow and heavy concentric, isometric, and eccentric contractions during these exercises to avoid placing excessive load on the myotendinous structures and should slowly build up into faster and faster movements without changing the resistance. Focus on eccentric strength and control becomes more important as the movements become faster because eccentric weakness often manifests as "letting go" of the resistance early during the eccentric phase of the movement. Given that maximal kicking normally demonstrates larger segmental range of motion and engagement of the full-tension arc, concentrating on the full-tension arc, including both eccentric adductor and abdominal strength, is important if the injury reproduces symptoms during sport-specific movements such as kicking or the ice hockey slap shot.[10] A strong focus on exercises that use the stretch-shortening cycle and the quality of their execution is thus also important during the reintroduction of these powerful actions.

Plyometric exercises should also be introduced at this stage. Plyometric training via different jumping exercises affects neuromuscular coordination and timing around the hip and knee.[75] Specifically, it increases the preactivity of the hip-adductor muscles just before landing and taking off (ground contact) during jumping and increases the hip adductor-to-abductor muscular coactivation ratio toward 100%, promoting agonist and antagonist muscle activation and synchrony, which can increase both muscle and joint stiffness.[75] Increased muscle and joint stiffness around the hip and knee may decrease hip-adduction and -abduction moments and enhance dynamic restraint during functional activities such as kicking or shooting, sprinting or fast skating, braking or cutting, and jumping or landing. Interestingly, less sagittal-plane and vertical stiffness has been found in athletes with groin pain than in healthy control individuals.[76] This may represent a compensatory mechanism to reduce the reinjury risk or could be the consequence of detraining. Thus, plyometric training seems important to address in athletes with groin pain and may restore and optimize hip- and knee-joint stiffness and sport-specific performance.

Return-to-Sport Phases

Return to Participation. Returning the athlete to sport participation should be a gradual process.[72] Athletes should perform agility drills with proper form and maximal and forceful actions such as accelerating, decelerating, twisting, turning, jumping, landing, and kicking with no visible compensations. Furthermore, no or minimal pain or discomfort should be present during execution, as well as during the next 24 to 48 hours. Athletes often have not fully recovered normal strength capacity at this stage, but they should aim for ≥80% to 90% of full muscle strength (Table 1) and reach the clinical milestones of functional recovery (Table 2) before entering the RTS phase.

Return to Sport. Athletes should focus on returning to their specific sports, on an individual level or with the rest of the team,[10,22,67,72] progressing from 30 to 90 minutes of training and participating in 1 to 3 weeks of full training before full RTS (match or competition activity) can be commenced, depending on the severity of the initial injury (the more severe the injury, the longer the participation period should be before full RTS). If not yet achieved, full muscle and functional recovery, including achieving baseline or normative scores, should be a main goal during this phase.

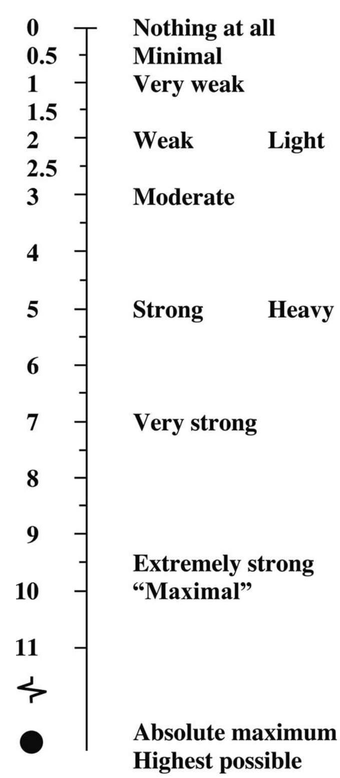


Figure 8. The Borg CR10 Scale (2016 version). Copyright Gunnar Borg 1982, 1998, 2004, 2016. Scale printed with permission. The scale and full instruction can be obtained through BorgPerception (https://borgperception.se/).

Return to Performance. Full performance is often not achieved until 3 to 6 months after RTS[67] and requires consistent training and competition or match play with no major setback or reinjuries. The muscle-strengthening program should be continued at least 3 days per week until the preinjury performance level has been reached. At this point, the athlete can decrease the program to a maintenance frequency of 1 session per week. Although this volume is usually enough for the next 2 to 3 months, further strength work and boosting with heavy loads (8–10 RM; Borg CR10 Scale, >5–<7; Figures 7 and 8)[60,73,74] are needed if the newly acquired or regained strength capacity is to be maintained or potentially further improved. Only at this point is introducing adductor strength training at near-maximal loading (<8 RM; Borg CR10 Scale, >7; Figures 7 and 8)[60,73,74] an option if further maximal strength and rate of force development are desired by athletes or coaches for performance gains. Such high loads have not been proven necessary for preventing adductor injury and reinjury and may provide extra and unnecessary high stress to the myotendinous and bony structures at the pubic symphysis when athletes have returned to competition. *SOR: C*

SUMMARY

Adductor-related groin pain is the most common groin problem in sports. Evidence-based care for athletes with adductor strains, adductor ruptures, or long-standing adductor-related groin pain can be addressed in a simple, individualized manner. These injuries can present in isolation but are often found with other associated groin symptoms and injuries, making the differential diagnosis important for understanding the prognosis and appropriate management. Testing for symptoms, strength, and performance helps with the early detection and monitoring of adductor problems. Addressing any hip-adductor and -abductor weakness through exercise and loading strategies is mandatory in the primary, secondary, and tertiary prevention of adductor-related injuries and groin pain. Strength training and sport-specific loading principles have the highest level of evidence for managing both acute and long-standing adductor-related problems. They can be applied in a variety of settings using different exercises and equipment, all with the same goal: to provide progressive exposure to loads in the relevant pelvic muscle, tendon, and bone structures, as well as to progress athletes through sport-specific movements to improve their capacity at both the tissue functional and performance levels. Only in rare cases are adjunct treatments, more invasive interventions such as surgery, or both needed. If required, such interventions should mainly be used and considered as supplements to an existing and individualized exercise and loading plan.

REFERENCES

1. Eckard TG, Padua DA, Dompier TP, Dalton SL, Thorborg K, Kerr ZY. Epidemiology of hip flexor and hip adductor strains in National Collegiate Athletic Association Athletes, 2009/2010–2014/2015. *Am J Sports Med*. 2017;45(12):2713–2722. doi:10.1177/0363546517716179
2. Werner J, Hägglund M, Ekstrand J, Waldén M. Hip and groin time-loss injuries decreased slightly but injury burden remained constant in men's professional football: the 15-year prospective UEFA Elite Club Injury Study. *Br J Sports Med*. 2019;53(9):539–546. doi:10.1136/bjsports-2017-097796
3. Thorborg K, Rathleff MS, Petersen P, Branci S, Hölmich P. Prevalence and severity of hip and groin pain in sub-elite male football: a cross-sectional cohort study of 695 players. *Scand J Med Sci Sports*. 2017;27(1):107–114. doi:10.1111/sms.12623
4. Wörner T, Thorborg K, Eek F. Hip and groin problems in the previous season are associated with impaired function in the beginning of the new season among professional female ice hockey players—a cross sectional study. *Int J Sports Phys Ther*. 2020;15(5):763–769. doi:10.26603/ijspt20200763
5. Thorborg K, Reiman MP, Weir A, et al. Clinical examination, diagnostic imaging, and testing of athletes with groin pain: an evidence-based approach to effective management. *J Orthop Sports Phys Ther*. 2018;48(4):239–249. doi:10.2519/jospt.2018.7850
6. Almeida MO, Silva BN, Andriolo RB, Atallah AN, Peccin MS. Conservative interventions for treating exercise-related musculotendinous, ligamentous and osseous groin pain. *Cochrane Database Syst Rev*. 2013;6:CD009565. doi:10.1002/14651858.CD009565.pub2
7. Serner A, van Eijck CH, Beumer BR, Hölmich P, Weir A, de Vos RJ. Study quality on groin injury management remains low: a systematic review on treatment of groin pain in athletes. *Br J Sports Med*. 2015;49(12):813. doi:10.1136/bjsports-2014-094256
8. Falvey ÉC, King E, Kinsella S, Franklyn-Miller A. Athletic groin pain (part 1): a prospective anatomical diagnosis of 382 patients—clinical findings, MRI findings and patient-reported outcome measures at baseline. *Br J Sports Med*. 2016;50(7):423–430. doi:10.1136/bjsports-2015-094912
9. King E, Franklyn-Miller A, Richter C, et al. Clinical and biomechanical outcomes of rehabilitation targeting intersegmental control in athletic groin pain: prospective cohort of 205 patients. *Br J Sports Med*. 2018;52(16):1054–1062. doi:10.1136/bjsports-2016-097089
10. Serner A, Weir A, Tol JL, et al. Return to sport after criteria-based rehabilitation of acute adductor injuries in male athletes: a prospective cohort study. *Orthop J Sports Med*. 2020;8(1):2325967119897247. doi:10.1177/2325967119897247
11. Ebell MH, Siwek J, Weiss BD, et al. Strength of recommendation taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician*. 2004;69(3):548–556.
12. Mosler AB, Weir A, Eirale C, et al. Epidemiology of time loss groin injuries in a men's professional football league: a 2-year prospective study of 17 clubs and 606 players. *Br J Sports Med*. 2018;52(5):292–297. doi:10.1136/bjsports-2016-097277
13. Serner A, Weir A, Tol JL, et al. Characteristics of acute groin injuries in the adductor muscles: a detailed MRI study in athletes. *Scand J Med Sci Sports*. 2018;28(2):667–676. doi:10.1111/sms.12936
14. Schilders E, Bismil Q, Robinson P, O'Connor PJ, Gibbon WW, Talbot JC. Adductor-related groin pain in competitive athletes: role of adductor enthesis, magnetic resonance imaging, and entheseal pubic cleft injections. *J Bone Joint Surg Am*. 2007;89(10):2173–2178. doi:10.2106/JBJS.F.00567
15. Koh E, Boyle J. Pubic apophysitis in elite Australian Rules football players: MRI findings and the utility of VIBE sequences in evaluating athletes with groin pain. *Clin Radiol*. 2020;75(4):293–301. doi:10.1016/j.crad.2019.12.022
16. Sailly M, Whiteley R, Read JW, Giuffre B, Johnson A, Hölmich P. Pubic apophysitis: a previously undescribed clinical entity of groin pain in athletes. *Br J Sports Med*. 2015;49(12):828–834. doi:10.1136/bjsports-2014-094436
17. Branci S, Thorborg K, Bech BH, Boesen M, Nielsen MB, Hölmich P. MRI findings in soccer players with long-standing adductor-related groin pain and asymptomatic controls. *Br J Sports Med*. 2015;49(10):681–691. doi:10.1136/bjsports-2014-093710

18. Eberbach H, Hohloch L, Feucht MJ, Konstantinidis L, Südkamp NP, Zwingmann J. Operative versus conservative treatment of apophyseal avulsion fractures of the pelvis in the adolescents: a systematical review with meta-analysis of clinical outcome and return to sports. *BMC Musculoskelet Disord*. 2017;18(1):162. doi:10.1186/s12891-017-1527-z
19. Davis JA, Stringer MD, Woodley SJ. New insights into the proximal tendons of adductor longus, adductor brevis and gracilis. *Br J Sports Med*. 2012;46(12):871–876. doi:10.1136/bjsports-2011-090044
20. DeLang MD, Garrison JC, Hannon JP, et al. Midseason screening for groin pain, severity, and disability in 101 elite American youth soccer players: a cross-sectional study. *Clin J Sport Med*. 2022;32(5):501–507. doi:10.1097/JSM.0000000000000987
21. Thorborg K, Petersen J, Nielsen MB, Hölmich P. Clinical recovery of two hip adductor longus ruptures: a case-report of a soccer player. *BMC Res Notes*. 2013;6:205. doi:10.1186/1756-0500-6-205
22. Hölmich P, Uhrskou P, Ulnits L, et al. Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial. *Lancet*. 1999;353(9151):439–443. doi:10.1016/S0140-6736(98)03340-6
23. Weir A, Jansen JA, van de Port IG, Van de Sande HB, Tol JL, Backx FJ. Manual or exercise therapy for long-standing adductor-related groin pain: a randomized controlled clinical trial. *Man Ther*. 2011;16(2):148–154. doi:10.1016/j.math.2010.09.001
24. Eberbach H, Fürst-Meroth D, Kloos F, et al. Long-standing pubic-related groin pain in professional academy soccer players: a prospective cohort study on possible risk factors, rehabilitation and return to play. *BMC Musculoskelet Disord*. 2021;22(1):958. doi:10.1186/s12891-021-04837-x
25. Schlegel TF, Bushnell BD, Godfrey J, Boublik M. Success of nonoperative management of adductor longus tendon ruptures in National Football League athletes. *Am J Sports Med*. 2009;37(7):1394–1399. doi:10.1177/0363546509332501
26. Tak I, Langhout R, Bertrand B, et al. Manual therapy and early return to sport in football players with adductor-related groin pain: a prospective case series. *Physiother Theory Pract*. 2020;36(9):1009–1018. doi:10.1080/09593985.2018.1531096
27. Schöberl M, Prantl L, Loose O, et al. Non-surgical treatment of pubic overload and groin pain in amateur football players: a prospective double-blinded randomised controlled study. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(6):1958–1966. doi:10.1007/s00167-017-4423-z
28. Thorborg K, Branci S, Nielsen MP, Tang L, Nielsen MB, Hölmich P. Eccentric and isometric hip adduction strength in male soccer players with and without adductor-related groin pain: an assessor--blinded comparison. *Orthop J Sports Med*. 2014;2(2):2325967114521778. doi:10.1177/2325967114521778
29. Yousefzadeh A, Shadmehr A, Olyaei GR, Naseri N, Khazaeipour Z. Effect of Holmich protocol exercise therapy on long-standing adductor-related groin pain in athletes: an objective evaluation. *BMJ Open Sport Exerc Med*. 2018;4(1):e000343. doi:10.1136/bmjsem-2018-000343
30. Robinson P, Salehi F, Grainger A, et al. Cadaveric and MRI study of the musculotendinous contributions to the capsule of the symphysis pubis. *AJR Am J Roentgenol*. 2007;188(5):W440–W445. doi:10.2214/AJR.06.1238
31. Schilders E, Bharam S, Golan E, et al. The pyramidalis-anterior pubic ligament-adductor longus complex (PLAC) and its role with adductor injuries: a new anatomical concept. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(12):3969–3977. doi:10.1007/s00167-017-4688-2
32. Schilders E, Mitchell AWM, Johnson R, Dimitrakopoulou A, Kartsonaki C, Lee JC. Proximal adductor avulsions are rarely isolated but usually involve injury to the PLAC and pectineus: descriptive MRI findings in 145 athletes. *Knee Surg Sports Traumatol Arthrosc*. 2021;29(8):2424–2436. doi:10.1007/s00167-020-06180-5
33. Dupré T, Tryba J, Potthast W. Muscle activity of cutting manoeuvres and soccer inside passing suggests an increased groin injury risk during these movements. *Sci Rep*. 2021;11(1):7223. doi:10.1038/s41598-021-86666-5
34. Chang R, Turcotte R, Pearsall D. Hip adductor muscle function in forward skating. *Sports Biomech*. 2009;8(3):212–222. doi:10.1080/14763140903229534
35. Charnock BL, Lewis CL, Garrett WE II, Queen RM. Adductor longus mechanics during the maximal effort soccer kick. *Sports Biomech*. 2009;8(3):223–234. doi:10.1080/14763140903229500
36. Mann RA, Moran GT, Dougherty SE. Comparative electromyography of the lower extremity in jogging, running, and sprinting. *Am J Sports Med*. 1986;14(6):501–510. doi:10.1177/036354658601400614
37. Montgomery WH III, Pink M, Perry J. Electromyographic analysis of hip and knee musculature during running. *Am J Sports Med*. 1994;22(2):272–278. doi:10.1177/036354659402200220
38. Watanabe K, Nunome H, Inoue K, Iga T, Akima H. Electromyographic analysis of hip adductor muscles in soccer instep and side-foot kicking. *Sports Biomech*. 2020;19(3):295–306. doi:10.1080/14763141.2018.1499800
39. Andersen LL. Risk factors for groin injury during football kicking. *Aspetar Sports Med J*. June 2014;3:252–256.
40. Serner A, Mosler AB, Tol JL, Bahr R, Weir A. Mechanisms of acute adductor longus injuries in male football players: a systematic visual video analysis. *Br J Sports Med*. 2019;53(3):158–164.
41. Serner A, Weir A, Tol JL, et al. Can standardised clinical examination of athletes with acute groin injuries predict the presence and location of MRI findings? *Br J Sports Med*. 2016;50(24):1541–1547. doi:10.1136/bjsports-2016-096290
42. Dupré T, Lysdal FG, Funken J, et al. Groin injuries in soccer: investigating the effect of age on adductor muscle forces. *Med Sci Sports Exerc*. 2020;52(6):1330–1337. doi:10.1249/MSS.0000000000002243
43. Light N, Johnson A, Williams S, Smith N, Hale B, Thorborg K. Injuries in youth football and the relationship to player maturation: an analysis of time-loss injuries during four seasons in an English elite male football academy. *Scand J Med Sci Sports*. 2021;31(6):1324–1334. doi:10.1111/sms.13933
44. Kloskowska P, Morrissey D, Small C, Malliaras P, Barton C. Movement patterns and muscular function before and after onset of sports-related groin pain: a systematic review with meta-analysis. *Sports Med*. 2016;46(12):1847–1867. doi:10.1007/s40279-016-0523-z
45. Whittaker JL, Small C, Maffey L, Emery CA. Risk factors for groin injury in sport: an updated systematic review. *Br J Sports Med*. 2015;49(12):803–809. doi:10.1136/bjsports-2014-094287
46. Esteve E, Casals M, Saez M, et al. Past-season, pre-season and in-season risk assessment of groin problems in male football players: a prospective full-season study. *Br J Sports Med*. 2022;56(9):484–489. doi:10.1136/bjsports-2020-102606
47. Mosler AB, Weir A, Serner A, et al. Musculoskeletal screening tests and bony hip morphology cannot identify male professional soccer players at risk of groin injuries: a 2-year prospective cohort study. *Am J Sports Med*. 2018;46(6):1294–1305. doi:10.1177/0363546518763373
48. Wollin M, Thorborg K, Welvaert M, Pizzari T. In-season monitoring of hip and groin strength, health and function in elite youth soccer: implementing an early detection and management strategy over two consecutive seasons. *J Sci Med Sport*. 2018;21(10):988–993. doi:10.1016/j.jsams.2018.03.004
49. Thorborg K, Hölmich P, Christensen R, Petersen J, Roos EM. The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med*. 2011;45(6):478–491. doi:10.1136/bjsm.2010.080937

50. Thorborg K, Branci S, Stensbirk F, Jensen J, Hölmich P. Copenhagen Hip and Groin Outcome Score (HAGOS) in male soccer: reference values for hip and groin injury-free players. *Br J Sports Med*. 2014;48(7):557–559. doi:10.1136/bjsports-2013-092607
51. Christensen KB, Clausen MB, King E, et al. Validation of the Copenhagen Hip and Groin Outcome Score (HAGOS) using modern test theory across different cultures and languages: a cross-sectional study of 452 male athletes with groin pain. *Br J Sports Med*. 2021;56(6):333–339. doi:10.1136/bjsports-2021-104412
52. Sayed Mohammad W, Ragaa Abdelraouf O, Abdel-aziem AA. Concentric and eccentric strength of trunk muscles in osteitis pubis soccer players. *J Back Musculoskelet Rehabil*. 2014;27(2):147–152. doi:10.3233/BMR-130429
53. Ishøi L, Hölmich P, Thorborg K. Measures of hip muscle strength and rate of force development using a fixated handheld dynamometer: intra-tester intra-day reliability of a clinical set-up. *Int J Sports Phys Ther*. 2019;14(5):715–723.
54. Thorborg K, Branci S, Nielsen MP, Langelund MT, Hölmich P. Copenhagen five-second squeeze: a valid indicator of sports-related hip and groin function. *Br J Sports Med*. 2017;51(7):594–599. doi:10.1136/bjsports-2016-096675
55. Serner A, Hölmich P, Tol JL, et al. Progression of strength, flexibility, and palpation pain during rehabilitation of athletes with acute adductor injuries: a prospective cohort study. *J Orthop Sports Phys Ther*. 2021;51(3):126–134. doi:10.2519/jospt.2021.9951
56. Tyler TF, Nicholas SJ, Campbell RJ, Donellan S, McHugh MP. The effectiveness of a preseason exercise program to prevent adductor muscle strains in professional ice hockey players. *Am J Sports Med*. 2002;30(5):680–683. doi:10.1177/03635465020300050801
57. Harøy J, Clarsen B, Wiger EG, et al. The Adductor Strengthening Programme prevents groin problems among male football players: a cluster-randomised controlled trial. *Br J Sports Med*. 2019;53(3):150–157. doi:10.1136/bjsports-2017-098937
58. Thorborg K, Krommes KK, Esteve E, Clausen MB, Bartels EM, Rathleff MS. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: a systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *Br J Sports Med*. 2017;51(7):562–571. doi:10.1136/bjsports-2016-097066
59. Ishøi L, Thorborg K. Copenhagen adduction exercise can increase eccentric strength and mitigate the risk of groin problems: but how much is enough! *Br J Sports Med*. 2021;55(19):1066–1067. doi:10.1136/bjsports-2020-103564
60. Serner A, Jakobsen MD, Andersen LL, Hölmich P, Sundstrup E, Thorborg K. EMG evaluation of hip adduction exercises for soccer players: implications for exercise selection in prevention and treatment of groin injuries. *Br J Sports Med*. 2014;48(14):1108–1114. doi:10.1136/bjsports-2012-091746
61. Dawkins J, Ishøi L, Willott JO, Andersen LL, Thorborg K. Effects of a low-dose Copenhagen adduction exercise intervention on adduction strength in sub-elite male footballers: a randomised controlled trial. *Transl Sports Med*. 2021;4(4):447–457. doi:10.1002/tsm2.238
62. Harøy J, Thorborg K, Serner A. Including the Copenhagen adduction exercise in the FIFA 11+ provides missing eccentric hip adduction strength effect in male soccer players: a randomized controlled trial. *Am J Sports Med*. 2017;45(13):3052–3059. doi:10.1177/0363546517720194
63. Polglass G, Burrows A, Willett M. Impact of a modified progressive Copenhagen adduction exercise programme on hip adduction strength and postexercise muscle soreness in professional footballers. *BMJ Open Sport Exerc Med*. 2019;5(1):e000570. doi:10.1136/bmjsem-2019-000570
64. Kohavi B, Beato M, Laver L, Freitas TT, Chung LH, Dello Iacono A. Effectiveness of field-based resistance training protocols on hip muscle strength among young elite football players. *Clin J Sport Med*. 2020;30(5):470–477. doi:10.1097/JSM.0000000000000649
65. Ishøi L, Sørensen CN, Kaae NM, Jørgensen LB, Hölmich P, Serner A. Large eccentric strength increase using the Copenhagen adduction exercise in football: a randomized controlled trial. *Scan J Med Sci Sports*. 2016;26(11):1334–1342. doi:10.1111/sms.12585
66. Yousefzadeh A, Shadmehr A, Olyaei GR, Naseri N, Khazaeipour Z. The effect of therapeutic exercise on long-standing adductor-related groin pain in athletes: modified Hölmich protocol. *Rehabil Res Pract*. 2018;2018:8146819. doi:10.1155/2018/8146819
67. Weir A, Hölmich P, Thorborg K. Groin pain. In: Brukner P, Clarsen B, Cook J, et al, eds. *Brukner & Khan's Clinical Sports Medicine*. 5th ed. McGraw-Hill Education; 2017:629–658.
68. Borg G, Borg E. A new generation of scaling methods: level-anchored ratio scaling. *Psychologica*. 2001;28:15–45.
69. Borg E. Placing verbal descriptions on a ratio scale. In: Algom D, Zakay D, Chajut E, Shaki S, Mama Y, Shakuf V, eds. *Fechner Day 2011: Proceedings of the 27th Annual Meeting of the International Society for Psychophysics*. International Society for Psychophysics; 2011:199–124.
70. Borg GAV, Lindblad I. *The Determination of Subjective Intensities in Verbal Descriptions of Symptoms*. University of Stockholm; 1976. Reports from the Institute of Applied Psychology 75.
71. Borg G. A category scale with ratio properties for intermodal and interindividual comparisons. In: Geissler HG, Petzold P, eds. *Psychophysical Judgment and the Process of Perception*. VEB Deutscher Verlag der Wissenschaften; 1982:25–34.
72. Ardern CL, Glasgow P, Schneiders A, et al. 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*. 2016;50(14):853–864. doi:10.1136/bjsports-2016-096278
73. Brandt M, Jakobsen MD, Thorborg K, Sundstrup E, Jay K, Andersen LL. Perceived loading and muscle activity during hip strengthening exercises: comparison of elastic resistance and machine exercises. *Int J Sports Phys Ther*. 2013;8(6):811–819.
74. Krommes K, Bandholm T, Jakobsen MD, et al. Dynamic hip adduction, abduction and abdominal exercises from the Holmich groin-injury prevention program are intense enough to be considered strengthening exercises—a cross-sectional study. *Int J Sports Phys Ther*. 2017;12(3):371–380.
75. Chimera NJ, Swanik KA, Swanik CB, Straub SJ. Effects of plyometric training on muscle-activation strategies and performance in female athletes. *J Athl Train*. 2004;39(1):24–31.
76. Gore SJ, Franklyn-Miller A, Richter C, Falvey EC, King E, Moran K. Is stiffness related to athletic groin pain? *Scand J Med Sci Sports*. 2018;28(6):1681–1690. doi:10.1111/sms.13069

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